



XXXIV IULTCS  
2017 - INDIA

# PROCEEDINGS OF THE XXXIV IULTCS CONGRESS

5-8 February 2017,  
Chennai, India

## “Science and Technology for Sustainability of Leather”



INTERNATIONAL UNION OF LEATHER  
TECHNOLOGISTS AND CHEMISTS SOCIETIES

### ORGANIZERS



CSIR-Central Leather  
Research Institute  
(CSIR-CLRI)



Indian Leather  
Technologists'  
Association (ILTA)

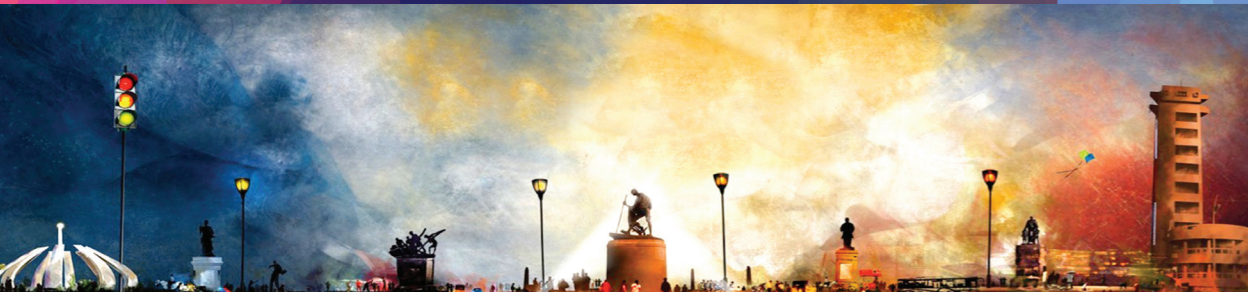
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Council for  
Leather Exports  
(CLE)



Indian Finished Leather  
Manufacturers & Exporters  
Association (IFLMEA)



Organizers



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O R G A N I Z E R S



CSIR-Central Leather  
Research Institute  
(CSIR-CLRI)



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I N D I A P A R T N E R S



Council for  
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VOLUME - 1

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# MESSAGES





## M E S S A G E



### **A Hearty Message from a die-hard Leather Chemist**

As the President of the Congress of International Union of Leather Chemists and Technologists, it is pleasurable privilege and honourable duty to invite every one of the members of the Global leather fraternity attending the session at Chennai, a leather land part of the world in February 2017. The congress is promising to be a special one on account of the quality and the type of participation and the vastness of the nature of topics planned to be discussed on Science and Technology sustainability of leather processing. Indian Leather Technologists Association and Central Leather Research Institute by working Closely with all arms of the Indian Leather industry has strived to put together a wonderful conference taking every step to make the occasion memorable and enjoyable. Let me extend hearty welcome every sister, brother and member of the family of International leather world on behalf of the Indian leather sector and wish the congress a resounding success. Let me salute the Apex Body of Leather chemists, technologists and Professionals of leather world (IULTCS) for their unifying effort in serving the cause of leather world. Let the congress of 2017 pave a way for science lead way for sustainability of leather processing in the only planet that the humanity has known to survive and prosper in. Thank you and best regards to all.



### **Dr. T. Ramasami**

Congress President, XXXIV IULTCS

Former Secretary to the Government of India

Ministry of Science and Technology, New Delhi &

Member of ABEO, Organization for the Prohibition of Chemical Weapons

The Hague, The Netherlands

Honorary Professor

Indian Institutes of Science Education and Research, Mohali and Kolkata, India

dstsec@yahoo.co.in and samirisailam@gmail.com



## M E S S A G E

**Dear Friends,**

The 34th IULTCS congress is held in India. This is the second time this international event is hosted by India. Indian Leather Technologists Association (ILTA) and Central Leather Research Institute are jointly organizing this event. Which two organizations could be more competent than ILTA and CLRI could organize this event in India? With the rich technologist member base, ILTA the biggest conglomeration of leather experts in India and CLRI, the world largest leather research organization joining hands for organizing this event itself is indicative of the quality and class of this event. This is one of the few proceedings that would find an important place in the calendar of all the members of global leather fraternity. As an entrepreneur, it gives me immense pleasure to be part of this function and also to write this. The congress has always been the place that provides the opportunity to listen to the proficient experts of different avenues of leather and leather products. It has been a festivity to all the members of the leather world, as they could understand not only what has eventuated in the recent past but also what might supervene in the future. It brings about more pleasure that the event is conducted this time in India. I understand that participants from different countries all over the world enrolled for the 34th IULTCS congress. I take this opportunity to extend a warm welcome to all the participants. I also learnt that the sessions would cover almost all the contemporary themes connected to leather and leather products. I have no wee bit of doubt that the presentations, speeches and deliberations would be a bounty of information and knowledge to all those who are connected to leather and leather products. Also, I am certain that this would bring you memorable times in India and you will take back pleasant memories that you would cherish for long. I invite each and everyone from the research fraternity, industry and trade, who is associated with leather and leather products to participate in the congress and avail the fodder for your brain. I wish all the participants an enchanting spell during this IULTCS. I also wish the 34th congress all the great success.



Warm regards

**Shri Rafeeqe Ahmed**

Chief Patron, XXXIV IULTCS & Farida Group

## M E S S A G E



**Dear Leather Fraternity,**

Indian Leather Technologists' Association (ILTA) is delighted to invite the World Leather Research in the city of leather Research to participate in the XXXIV IULTCS Congress during 5th to 8th Feb, 2017.

For quite some years, the question of sustainability has evolved for the trade and industry at different dimension and magnitude. The scientists and technologists are putting forward their efforts to develop and establish the possible and feasible processes and systems to combat the challenge. Several practicing chemists and technologists and intellectuals of the allied subjects have submitted their research findings. They will be presented orally or by poster. The presentations are peer reviewed by the experts. The abstracts are being printed and distributed through a book giving reference of the concerned researchers. Thus, the congress will create an ambience to form strong linkages between intelligence, research and industry to achieve the goal.

This IULTCS Congress is a joint presentation of the Central Leather Research Institute (Premier Research Laboratory) and Indian Leather Technologists' Association - the Member Society of IULTCS with full efforts and support of CLRI. Council for Leather Exports and Indian Finished Leather Exporters and Manufacturers' Association have extended their hands as partners. Support is also extended by different govt bodies, Industry associations, Advertisers and IULTCS Executive Committee.

I, wholeheartedly believe that the participants attending this XXXIV IULTCS Congress in Chennai, India will enjoy both technical and social program, stimulating and interesting.



**Mr Arnab Jha**

President, Indian Leather Technologists' Association



M E S S A G E



**Dear Friends from World Leather Sector,**

It is a privilege and honour to invite you all to the XXXIV IULTCS Congress during 5th to 8th February 2017 in Chennai, India a major scientific and technical event of World Leather Sector.

Indian Leather Technologist Association (ILTA) which is one of the largest technical and scientific member forum having long association with IULTCS has organized the IULTCS Congress for the second time in India jointly with CSIR-Central Leather Research Institute (CLRI), Chennai, India the biggest research institute in the world.

As the longest served past Chairman of the International Union of Environment (IUE) Commission of IULTCS and Present Coordinator of the Asian International Forum & Liaison, I am very much impressed on the theme of the congress and highly valued scientific papers for presentations and interactions with participants. During the congress various scientific commissions of IULTCS and Asian International Forum & Liaison for Leather Sector will have their meetings and present the latest developments in the sessions.

In short, I thank all your support and contribution in the endeavour of ILTA in close association with CSIR-CLRI, CLE, LSSC, IULTCS, UNIDO, Asian International Forum & Liaison and others by all possible means including sponsorship and make this event a memorable and grand success.

With best wishes,

**Dr. S. Rajamani**

Working President – XXXIV IULTCS Congress - 2017 &  
Coordinator - Asian International Forum & Liaison  
Email : dr.s.rajamani@gmail.com

## M E S S A G E



**Dear R&D community of the Leather Industry,**

the 34th congress is only a few days away from us. The organizing committee is extremely busy to finalize the last preparations. It looks like everything is well addressed and ready to go.

We will have three busy and intensive days to exchange each other, to learn from each other, and to discuss new ideas and conceptual approaches.

Beside this I'm sure our colleagues from India will be honored to introduce all of us in their vibrant cultural life.

I'm looking forward to meet you all in Chennai.

A handwritten signature in blue ink that reads 'Dietrich Tegtmeier'.

**Dietrich Tegtmeier**  
President IULTCS





M E S S A G E



**Dear Friends of Global Leather Sector,**

I am delighted to welcome you to Chennai after 18 years for the 34th IULTCS Congress, which brings together experts and academicians from around the leather world.

The congress has several keynote, oral and poster presentations that will be presented by eminent academicians, researchers and students around the leather world. We are honoured to have Dr. John A M Ramshaw, Honorary Fellow, The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia for Heidemann lecture and Dr. T. Ramasami, Former Secretary to the Government of India for popular lecture. Therefore, this will give participants a platform to exchange ideas, discover novel opportunities, reacquaint with colleagues, meet new friends, and broaden their knowledge.

I am happy to see all our old partners with whom we have had a good relationship for years and I hope that our cooperation with new partners will be as fruitful as before. I would like to thank our lead partner, the Indian Leather Technologists Association (ILTA) and all the leather fraternities from India and abroad, whose support has built up this network and brought people here from all over the world.

I hope that you will find the conference and your stay in Chennai both valuable and enjoyable.

Regards

**Dr NK Chandrababu**  
Congress Convenor

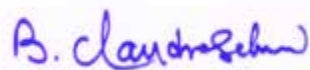
**M E S S A G E**

On behalf of the IULTCS 2017 Congress Organizing Committee and as the Director of CSIR-Central Leather Research Institute, I am honoured and delighted to welcome you all to the 34th edition of IULTCS Congress at Chennai, India. We join hands with Indian Leather Technologists' Association (ILTA) for the second time after 1999 to organize this mega event along with fraternal support from Indian and Global leather industries.

The Congress has intense technical programs with 6 keynote speeches, 42 oral and about 200 visual presentations spanning through 8 sessions over a period of two and a half days. Besides, a popular lecture and Prof. Heide-mann lecture will add more vibrancy to the participants. There will be plenty of opportunities for making connections between peers.

While the Congress aims to address the technological challenges towards sustaining the leather manufacturing activity, key points such as raw material availability and ensuring low environmental footprints from the industry will also be deliberated. CSIR-CLRI would like to take lead in forming global alliance with the stakeholders of all leather and product manufacturing countries towards sustainable development of the Sector.

On behalf of the Organizing Committee and on my own behalf, I extend wishes for a rewarding experience and a memorable stay at Chennai



**Dr. B. Chandrasekaran**  
Director, CSIR-CLRI



## M E S S A G E



### Dear Friends of Leather World!

It is a great pleasure and honour to extend to you a warm invitation to attend the 34th International Union of Leather Technologists & Chemists (IULTCS) Congress, to be held at Chennai, India for the second time between February 5 and 8, 2017. I believe we have been chosen as organizers to guarantee a successful technical conference amid the culture and scenery of Chennai. The 2017 Conference is jointly organized by CSIR- Central Leather Research Institute (CSIR-CLRI) and Indian Leather Technologists Association (ILTA). Our scientific program is rich and varied with keynote speeches, several oral and poster presentations and a public lecture. We also expect to provide few technical demonstrations and numerous opportunities for informal networking.

As a member of organizing committee, I know that the success of the conference depends ultimately on many people who have worked with us in planning and organizing both the technical program and supporting social arrangements. In particular, we thank the Program Chair for brilliantly organizing the technical program; the Scientific Committee for their thorough and timely reviewing of the papers, and our sponsors who have helped us to keep down the costs of IULTCS 2017 for all participants. Recognition should go to the Local Organizing Committee members who have all worked extremely hard for the details of important aspects of the conference programs and social activities.

We hope you will join us for a symphony of outstanding science, and take a little extra time to enjoy the spectacular and unique beauty of this region.

With best wishes,

**Shri NR Jaganathan**  
President, ILTA (South)

## M E S S A G E



### Dear Friends

I am so proud that the 34th IULTCS congress is being held in Chennai, India for the second time after a gap of 18 years. This reminds us of the successful 1999 congress and brings back sweet memories. We will have very interesting discussions on important and relevant issues concerned with the global leather sector. With many innovative things planned, this congress will raise the bar for future congresses. The congress theme is Science and technology for sustainability of leather, which is very relevant to us as we have a great challenge in making leather industry sustainable in the present day context. I wish the congress a great success.

Regards

A handwritten signature in blue ink, appearing to be 'Shri Mukhtarul Amin'.

**Shri Mukhtarul Amin**  
Chairman, CLE



M E S S A G E



**Dear Friends,**

On behalf of the organizing committee, it is my great pleasure to welcome you all to the 34th IULTCS congress 2017. It is organized by CSIR- Central Leather Research Institute (CSIR-CLRI) in association with Indian Leather Technologists Association (ILTA) for the second time in Chennai. This time, the theme of the congress is “Science and Technology for Sustainability of Leather”. The theme has been designed to provide R & D focus of research institutes, chemical companies and organizations around the world for the sustainable development of the leather sector. In this scenario, the Congress will address various technological challenges on raw material availability, sustained leather manufacture and environmental regulations ensuring low environmental footprints from the leather industry through various papers and posters that will be presented on various themes as highlighted above. I am sure you will find very important works and latest improvements in the leather industry along the event. I personally hope that you will enjoy the Congress and will be benefited from the interactions and exchange of ideas with research and industry experts from many different countries. I wish this Congress a grand success.

Regards

**Shri N Shafeeq Ahmed**  
Chairman, IFLMEA

**M E S S A G E**

Dear Friends of **Global Leather Fraternity!**

It gives me immense pleasure in welcoming you all for the 34th IULTCS congress, which is happening in Chennai, India during 5th to 8th February 2017. The theme of the Congress “Science and Technology for Sustainability of Leather” has been suitably chosen keeping in view the current scenario of the leather sector. The Congress has been designed in having eminent and renowned personalities from around the globe to deliver lectures, which would enrich our knowledge. Major topics of discussion in the Congress will be on fundamentals in leather science, innovation and value addition for leather, chemicals for smart and intelligent leathers, design innovations and so on in the form of oral and visual presentations. I also believe that the city of Chennai is an excellent venue for a perfect meeting, which will provide us with cherished and enduring thoughts, friendship and memories. I wish this Congress a grand success.

Regards



**Shri PR Aqeel Ahmed**  
Vice Chairman, CLE



## 2017 IULTCS MERIT AWARD WINNER

The Executive Committee of the IULTCS has awarded Professor Mariliz Gutterres Soares, Head of the Laboratory for Leather and Environment Studies (LACOURO) at the Federal University of Rio Grande do Sul (UFRGS) in Brazil, the 2017 IULTCS Merit Award for Excellence in the Leather Industry.

After receiving her degree in chemical engineering in 1984, Mariliz started work in the leather industry and today her technical and scientific contributions span more than 30 years.

In congratulating her, the current IULTCS President, Dr Dietrich Tegtmeier of Germany, said: "Mariliz has been very active in supporting various initiatives from the IULTCS for many years and we trust that she will continue serving the industry with her broad knowledge and experience".

Upon hearing of her selection Mariliz responded: "To work between students and industry is a privilege and a source of constant growth. I thank all my dear IULTCS and industry friends who have challenged and supported me. This is a unique moment, the most important of a professional career."

The IULTCS Award was established in 2005. Mariliz joins an exclusive list of six previous winners of the Merit Award. The ceremony recognizing Professor Gutterres will take place during this IULTCS World Congress in Chennai, India from 5-8 February 2017.



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Organizing Committee	Role	Affiliation
Dr T Ramasami	Congress President	Former Secretary to the Government of India
Shri Rafeeqe Ahmed	Chief Patron	Farida Group
Dr NK Chandrababu	Congress Convenor	Chief Scientist, CSIR-CLRI
Dr S Rajamani	Working President	Coordinator - Asian International Forum & Liaison
Mr Arnab Jha	Chair, Coordination	President, ILTA
Dr J Raghava Rao	Program Chair	Chief Scientist, CSIR-CLRI
Dr KJ Sreeram	Congress Secretary	Principal Scientist, CSIR-CLRI
Shri NR Jaganathan	Member	President, ILTA (South)
Dr Dietrich Tegmeyer	Member	President, IULTCS
Dr B Chandrasekaran	Member	Director, CSIR-CLRI
Shri N Shafeeq Ahmed	Member	Chairman, IFLMEA
Shri PR Aqeel Ahmed	Member	Vice Chairman, CLE
Shri Mukhtarul Amin	Member	Chairman, CLE
Dr Luis A Zugno	Advisor	IULTCS-IUR Chairman



Review Committee	Country
<b>Dr J Raghava Rao (Chair)</b>	<b>India</b>
Dr Mrs. Patricia Casey	Argentina
Dr Luis Zugno	Brazil
Dr Bi Shi	China
Dr Jianzhong Ma	China
Mr Wondu Legesse	Ethiopia
Dr Mwinyikione Mwinyihija	Ethiopia
Dr Micheal Meyer	Germany
Dr.-Ing. Heinz-Peter Germann	Germany
Dr NK Chandrababu	India
Dr BN Das	India
Dr S Rajamani	India
Dr S Sadulla	India
Dr Buddhadeb Chattopadhyay	India
Dr Sanjoy Chakraborty	India
Dr Keiji Yoshimura	Japan
Dr Richard G. Haverkamp	New Zealand
Dr Altan Afsar	Turkey
Dr Elton Hurlow	UK
Dr Juan-Carlos Castell	USA



<b>Local Organizing Committee</b>		
<b>Program</b>	<b>Chair</b>	<b>Team</b>
<b>Accommodation &amp; Transport</b>	Shanmugasundaram G	Dinesh Kalyanam Murugan D Nagaswamy R Ravikumar B Srinivasan K
<b>Advertisements</b>	Krishnaraj K	Bhattacharya PK Dipankar Chaudhari Mishra SK
<b>Commission Meetings &amp; Invitations</b>	Sanjeev Gupta	Chandrasekar R Mohan R Srinivasan SV Swarna V Kanth
<b>Conference Secretariat</b>	Sreeram KJ	Balasubramanian AC Chandrasekar G Sathiyamoorthi G Thangarasu K Vijayakumar C Vijayalakshmi R
<b>Event Management</b>	Nishad Fathima N	Ganesh G Gowthaman MK Jayakumar GC Kanimozhi B Madhan B Phebe John Shakila Shobana Yasmin Khambhaty

Program	Chair	Team
<b>Foreign Delegates Facilitation</b>	Gnanamani A	Ayyadurai D Karthik V Latha P
<b>Helpdesk, Cultural events</b>	Saravanan P	Murugan L Suresh Kumar PS
<b>Press/Newsletters/ Documentation of Activities</b>	Md Sadiq	Anantha Narayanan P Karthikeyan K Suresh Kumar D
<b>Registration</b>	Subhendu Chakrabarti	Geethalakshmi Balaji Guruprasath E Krishnaveni Bhaskar Nithyananda Vasagam S Sribalakameswari K
<b>Scientific Posters</b>	Narasimhaswamy T	Easwaramoorthy S Kanakaraj K Kiran MS
<b>Proceedings/ Souvenirs</b>	Thanikaivelan P	Aravindhan R
<b>Sponsor Benefits</b>	Das BN	Malathy Jawahar

**XXXIV IULTCS CONGRESS**

6-8 FEB 2017, CHENNAI INDIA

**PROGRAM SCHEDULE**

<b>DAY 1 : 6<sup>th</sup> February 2017</b>		
09.00 - 09.45 hrs	Inaugural Session	
<b>Timings</b>	<b>Heidemann Lecture</b> Chairman: T Ramasami	
09.45 - 10.30 hrs	<b>Title</b>	<b>Speaker</b>
	Probing collagen structure and function	John A M Ramshaw
10.30 - 11.00 hrs	Tea Break	
11.00 - 12.45 hrs	<b>Fundamentals in leather science</b> Chairman: T Ramasami / N K Chandra Babu	
	<b>Title</b>	<b>Speaker</b>
<b>Keynote</b>	Fundamentals of leather science	Anthony Covington
<b>FLS 1</b>	Site-specific interaction of polyphenols on collagen using model collagen peptide	Madhan B
<b>FLS 2</b>	Measuring the heritability of traits in sheep and deerskin	Geoffrey Holmes
<b>FLS 3</b>	Chrome-tanned leather shrinkage probed with modulated temperature differential scanning calorimetry	Richard Leslie Edmonds
<b>FLS 4</b>	Influence of naphthalenesulfonic acid derivatives on the properties of the hide. Part II	Olga Ballús
<b>FLS 5</b>	Surface area gain of leathers dried under different conditions	Hüseyin Karavana
12.45 - 13.45 hrs	Lunch Break	
13.45 - 15.30 hrs	<b>Advances in chemicals for smart and intelligent leathers</b> Chairman: Mukhtarul Amin / Campbell Page	
	<b>Title</b>	<b>Speaker</b>
Keynote	Tanning strategies for sustainable leather production	Ing Heinz-Peter Germann
<b>ACSIL 1</b>	Waste to wealth approach adhesive from the unused goat head skin	Md Abul Hashem

<b>ACSIL 2</b>	Fabrication of antibacterial casein-based ZnO nanocomposite for leather finishes through in-situ route	Wang Yanan
<b>ACSIL 3</b>	Ionic liquids new age designer chemicals for leather processing	Nishad Fathima N
<b>ACSIL 4</b>	A new age chromium-melamine syntan towards quality upgradation of lower-end raw materials	Sathish Murali
<b>ACSIL 5</b>	Novel surfactants in leather processing	Vijayabaskar V
<b>ACSIL 6</b>	Tanning with a Gallic extract in combination with a cationic ester for the production of high performance leathers.	Eric Poles
15.30 - 16.00 hrs	Tea Break and Poster Session	
16.00 - 17.45 hrs	<b>Innovation and value addition for leather</b> <b>Chairman: N Shafeeq Ahmed / Sanjoy Chakraborty</b>	
	<b>Title</b>	<b>Speaker</b>
<b>Keynote</b>	Study of the variation of chromium VI content inside the leather	Jean-Claude Cannot
<b>IVL 1</b>	Intelligent real time leather defect detection system using image processing technique	Malathy J
<b>IVL 2</b>	Analysis of characteristic odor compounds in leather by GC-MS and GC-Olfactometry	Hirohiko Washiya
<b>IVL 3</b>	Method for determining the optimized exhaustion of fatliquors to minimize the ETP-inflow	Dirick von Behr
<b>IVL 4</b>	Artificially induced collagen fibril orientation affects tear propagation in leather	Susyn Kelly
<b>IVL 5</b>	Chrome-free tannage suede garment leathers from rural vegetable sheep crust leathers	Ali Elnaeim Musa
<b>IVL 6</b>	Effect of binder selection on topcoat property retention after accelerated weathering	Joseph Hoefler
18.00 hrs	<b>Visit to Kalakshetra</b>	



**DAY 2 - 7<sup>th</sup> February 2017**

<b>DAY 2 - 7<sup>th</sup> February 2017</b>		
09.00 - 10.30 hrs	<b>Strategies for sustainability</b> <b>Chairman: Luis Zugno / R Ramesh Kumar</b>	
	<b>Title</b>	<b>Speaker</b>
<b>Keynote</b>	Advances in bio-based polyurethanes for leather finishing	Michael Costello
<b>SFS 1</b>	Enzymatic unhairing permeability assay of bovine skin epidermis with enzyme extracts	Betina Galarza
<b>SFS 2</b>	Preparation and characteristics of surface modified PAN fiber by collagen	Ding Zhiwen
<b>SFS 3</b>	Study on the recycling technology of unhairing-liming and tanning wastewater	Liqiang Jin
<b>SFS 4</b>	Different pre-treatments of chrome tanned leather waste and their use in the biogas production	Carolina Scaraffuni Gomes
10.30 - 11.00 hrs	Tea Break and Poster Session	
11.00 - 12.30 hrs	<b>Strategies for sustainability</b> <b>Chairman: Israr Ahmed / N R Jaganathan</b>	
<b>SFS 5</b>	Sustainable leather management: A mass balance bench mark of different chromium tanning technologies	Dietrich Tegtmeier
<b>SFS 6</b>	Formaldehyde and acetaldehyde in leather: similarities and discrepancies	Jochen Ammenn
<b>SFS 7</b>	Redefining chrome tanning: A waterless approach	Thanikaivelan P
<b>SFS 8</b>	Concept of sustainability - looking forward	Anne Lama
<b>SFS 9</b>	The elimination of effluent from liming acid/salt pickling and chromium tanning verified by five years high-volume wet blue leather manufacture.	Richard Daniels
<b>SFS 10</b>	Probiotic solutions for sustainable leather	Juan Carlos Castell Escuer
12.30 - 13.30 hrs	Lunch Break	

13.30 - 15.30 hrs	<b>Emission control technologies</b> <b>Chairman: P R Aqeel Ahmed / Arnab Jha</b>	
	<b>Title</b>	<b>Speaker</b>
<b>Keynote</b>	Controlling emissions in leather manufacture	Jurgen Christner
<b>ECT 1</b>	Clean salt recovery and water recycling using Nanofiltration and Reverse Osmosis	Wolfram Scholz
<b>ECT 2</b>	Biodecolorization and biodetoxification of leather dyes from aqueous solution and dye-containing effluents by native white-rot fungi strains	Santiago Ortiz Monsalve
<b>ECT 3</b>	Novel formaldehyde scavenger containing active methylene for efficient removal of formaldehyde in leather	Zhang Ting
<b>ECT 4</b>	Analysis of flow and energy aspects of Zero Liquid Discharge (ZLD) technology in treatment of tannery effluents in Tamil Nadu India	Jakov Buljan
<b>ECT 5</b>	Studies on simultaneous removal of nitrogen and organic carbon from tannery wastewater using airlift sequencing batch reactor	Aysanew Gorems Melesse
<b>ECT 6</b>	Microbial fuel cell a novel technology for effluent treatment and electrical energy generation	Divyalakshmi P
<b>ECT 7</b>	Technological developments for total dissolved solids (TDS) management and environmental sustainability in Asian leather sector	Rajamani S
15.30 - 16.30 hrs	Tea Break and Poster Session	
16.30 - 17.00 hrs	<b>Peep through into XXXV, XXXVI IULTCS &amp; AICLST Congresses</b>	
18.00 - 20.00 hrs	<b>Popular Lecture</b> <b>Chairman: M Rafeeque Ahmed</b>	
	<b>Leather and Isthmus:                  In Tribute to Nagappan</b>	T Ramasami U K Sivaraman
20.00 - 21.30 hrs	Dinner	

**DAY 3 - 8<sup>th</sup> February 2017**

<b>Design innovation for lifestyle leather products</b> <b>Chairman: D Tegtmeier / B N Das</b>		
	<b>Title</b>	<b>Speaker</b>
08.30 - 09.45 hrs		
<b>DIP 1</b>	New dimensions in children shoes	Md Sadiq
<b>DIP 2</b>	Dynamic plantar pressure analysis of persons with diabetic, an approach to improve the design of therapeutic footwear	Sathish Babu G
<b>DIP 3</b>	Reduction of skin disorders by HCHO in leather products	Daisuke Murai
<b>DIP 4</b>	Comparison of visual assorting process and spectral photometer usage in leather apparel production	Mehmet Mete Mutlu
09.45 - 11.00 hrs	<b>Enriching human capacity / Global research alliances and partnerships</b> <b>Chairman: Habib Hussain / Thomas Yu</b>	
	<b>Title</b>	<b>Speaker</b>
<b>Keynote</b>	Coopetition in leather engineering education - A Strategy for a Win situation for concerned stakeholders	Sayeed Sadulla
<b>EHC 1</b>	eLearning and blended training in the leather professional education	Ivan Kral
<b>EHC 2</b>	Role of CSIR-CLRI in Skill India initiative enriching primary level human resource through artisanal skill development	Kanimozhi B
<b>GRAP 1</b>	Indo-Ethiopian alliance for transformation of Ethiopian leather sector	Wondu Legesse
<b>GRAP 2</b>	Development of an international proficiency testing by inter-laboratory comparison applied to physical and chemical test methods for mineral tanned leather 2016	Carlos Amador Meza Moya
11.00 - 11.30 hrs	Tea Break	
11.30 - 12.30 hrs	<b>Council Meeting</b>	
12.30 - 13.00 hrs	<b>Closing Ceremony</b>	
13.00 - 14.00 hrs	Lunch	

## HEIDEMANN LECTURE

### HEIDEMANN LECTURE 2017: PROBING COLLAGEN STRUCTURE AND FUNCTION

**John A M Ramshaw**  
*Melbourne, Australia*

*\*Email: john.ramshaw@csiro.au*

Collagen, the main protein of connective tissues, is of considerable economic importance, being the material from which leather and gelatin, and more recently a range of medical products, are derived, with a value to the world economy of between 4 to 5 USD billion. In many commercial areas, to get full value for the raw collagenous materials, particularly hides and skins, knowledge of a variety of properties can be used to provide improved processes and products.

The variations in properties of the hides and skin from different species were known to the ancients who appear to have been selective in using materials that were fit for purpose. However, research on collagen's structure and function, and application to improving existing products or development of new products, emerged mostly during the 20th century. Nageotte in the late 1920's studied acetic acid soluble collagen, while in the late 1940's Tustanovskii and colleagues in Russia extended this to citrate soluble collagen. The introduction of enzyme digestion of tissue to give high yields of soluble collagen emerged in the early 1960's. These studies, and other similar ones, enabled the primary structure of collagen and its biosynthesis to be elucidated. Also, in the late 1960's it was realised that there was more than one collagen type! Now, some 28 different types have been identified.

Understanding the tertiary structure of collagen seemed elusive for several decades. Initial diffraction patterns for tissue were reported in 1919, but it was only when patterns for stretched tissue became available in the early 1950's that analysis became possible. Ramachandran, in Madras (as then), provided the innovative concept of the triple helix in 1954. This concept was refined leading to the accepted structure for collagen. Ramachandran's structure also provided key information to understanding the repeating 'triplet' sequence, (Gly-Xaa-Yaa)<sub>n</sub> found as a characteristic of collagens.

Diffraction changes during tanning were an area of study for Eckhart Heidemann and more recently by others, providing data on the structural changes to the corium and grain during processing. Another topic of collagen research where Heidemann provided leadership was in the use of peptides and polypeptides to study the stability



of the triple helix. This is also an area of research that has been studied by others subsequently, expanding on the initial concepts. Approaches have included the use of 'host-guest' peptides to study the effects of amino acid sequence changes in single and adjacent triplets. These data have now shown how individual amino acids can influence collagen stability and that significant stability can be provided through appropriate charged residues in adjacent triplets.

Synthetic peptide chemistry can have limitations. An alternative approach to study structure and function in collagens that has emerged more recently is the use of recombinant systems. Initially these were used to produce human collagens and to provide structural variations for study of selected functional sites. More recently, recombinant products have been used extensively to allow study of many minor collagen types that had been inferred from DNA data. A further recombinant system that is proving of interest is the production of non-animal, bacterial collagens. This recently discovered diversity in collagens provides structures that are typically stable around 35-39 °C, yet do not contain any hydroxyproline, an essential residue for the stability of almost all animal collagens. This lack of secondary modification, and the ready availability of synthetic genes, means that these collagens can be readily produced in large amounts by recombinant technology. Further, these new designed constructs have been used, for example, to further define biologically active sites in collagen chains.

Thus, a considerable understanding of the structure and function has now emerged which has proved of value in the leather industry as well as for other collagen based products. As the majority of these data relate to the properties of individual molecules, there are still many areas that are less well or poorly understood, for example in the processes involved in fibril and fibre bundle formation, the organisation of collagen in tissues and the relationships to other molecules in the extracellular matrix. Essentially, the smaller the scale, the more that is known, while as the scale and dimensions get larger, considerably less is known about the structures, interactions and processes involved.



## POPULAR LECTURE

### LEATHER AND ISTHMUS: IN TRIBUTE TO NAGAPPAN

Umayapuram K Sivaraman\*,  
T Ramasami, MD Naresh

Renowned Artiste in Mridangam, Former Secretary to Government of India, Ministry of Science and Technology, Scientist (Retd), Central Leather Research Institute, Adyar, Chennai 600 020, India

Nagappan remains an indelible name in the Indian leather sector. He was an industrial leader pas excellence. He remained a living and connecting bridge among various stake holders of the industry and with Government for the sector whether the subject pertained to trade or research for technology development. He was a statesman who looked beyond the short term material gains from investment. He invested into the establishment of Leather Museum and strived to connect tradition to modernity. He sought to protect and preserve art and tradition behind several percussion instruments of ancient origin. In tribute to the preserving and protecting spirit of Sri Nagappan, a public lecture cum demonstration on Musical Excellence of Mridangam is scheduled on 7<sup>th</sup> February 2017 as a part of congress of the International Union of Leather Chemist's and Technologists Society (IULCTS).





Dr Umayalpuram K Sivaraman is a renowned artiste for creative play of the ancient percussion instrument from South India, Mridangam. He along with some scientists have been engaged in scientific research on Mridangam for the last 5 years. Several new research findings have emerged based on the scientific research. Some original research findings on construction and design of user- and transport friendly devices have become available. Some of them pertain to the special roles played by parchments by virtue of their inherent properties. Lecture cum demonstration on the musical instrument Mridangam proposes to highlight the value and utility of science in contributing musical excellence.

The Maestro Dr Umayalpuram K Sivaraman would provide a thrilling musical experience on the South Indian instrument Mridangam along with his accompanying instrumentalists on Violin originating from Italy. He will bring to bear the musical quality of research based percussion instrument for an international audience from global leather fraternity. .

Dr T. Ramasami would outline the major research findings from modern science and highlight the roles and harmonics of the instrumental designs and tonal outcomes influenced by the use of parchments and application of black patch based on iron oxide based minerals in Mridangam.

It is planned as a fusion of art forms and with science. Isthmus means a small piece of land connecting two large land masses. The public lecture on the title “Leather and Isthmus” plans to present a synthesis of a seamlessly connected effort on standardization and construction of Mridangam through cross border learning in Art and Science of musical instruments and make a case for leather playing the role of a connector of the worlds of Art and Science.

The public lecture is in tribute to a true leader in global leather sector for his long lasting contributions to the Indian leather sector





# ABSTRACTS OF ORAL PRESENTATIONS



KN – FLS

## FUNDAMENTALS OF LEATHER SCIENCE

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Leather science provides the understanding of technology, to allow modification of current processes and progress to be made in creating new technologies.

Processing must be considered as interactions within a three-component system: substrate, reagent, solvent. The series of processes should be treated as a continuum, in which each step should relate chemically to the step before and the step after.

The mechanism of tanning is currently best described by the lock-lock theory; there is much supporting evidence, but direct confirmation would be useful.

Developments in leather science and consequently in leather technology can be defined in terms of increasing complexity and longer timelines: development, innovation, revolution. In each case, leather science must also monitor unintended consequences such as the alleged formation of chromium (VI) from chromium (III) tanning agents.

The future of leather science depends on the availability of leather scientists from a changing cohort of supporting researchers.

*Keywords:* Science; Technology; Development; Innovation; Revolution



## SITE-SPECIFIC INTERACTION OF POLYPHENOLS ON COLLAGEN USING MODEL COLLAGEN PEPTIDE

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Interaction of polyphenols with collagen has far reaching implications in biological and industrial processes especially in tanning process in leather making. Tanning is a process by which collagen matrix is stabilized to prevent putrefaction against heat, enzymatic biodegradation, and thermo mechanical stress. One of the tanning processes involves with vegetable tannage which consists of polyphenols. Hence the interaction of polyphenols with collagen may provide valuable information to understand the tanning process involved leather processing. Although several reports have been published on the interaction of collagen and polyphenol interactions, site-specific interaction of polyphenol with collagen is not completely understood. One of the possible reason could be the lack appreciate technique which explore the site specific interactions of polyphenols. Although NMR is a powerful technique to extract atomic level interaction between protein-polyphenol interactions, it is not an appropriate tool to investigate collagen-polyphenol interaction due to high molecular weight of collagen which precludes the use of NMR. However, in this study we have investigated the site-specific interaction of polyphenols such as Gallic acid, Catechin, Epigallocatechingallate and Tannin acid with model collagen peptide (MCP), which has molecular weight range of 10 kd, using spectroscopic techniques mainly 2D Nuclear Magnetic Resonance Spectroscopy. MCP mimics the triple helical nature of native collagen. The NMR results indicated that polyphenols interacts with MCP primarily in the vicinity of ionic (positive and negative) amino acid residues, which have proline or hydroxyproline in the vicinity, and hydrophobic amino acid residues. Further, NMR studied provided evidence that polyphenol interacts only with triple helix, not with monomer of MCP. CD analysis indicated that both triple helical structure and its thermal stability of MCP was not perturbed in the presence various polyphenols in the selected experimental conditions. The present study thus provide the knowledge about the site-specific interaction of polyphenol with triple helical structure which help in developing new molecules for tanning process as well as to find new molecules to stabilize collagen for biomaterial use.

*Keywords:* Collagen; Polyphenol; NMR; Site-specific; Circular Dichroism; Model peptide

FLS O-02

## MEASURING THE HERITABILITY OF TRAITS IN SHEEP AND DEERSKIN

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In this study the heritable traits imparted in sheep and deerskins were investigated using both traditional methods and the latest SNP (single nucleotide polymorphism) techniques.

305 progeny of Focus Genetics sheep-meat sires were slaughtered at  $173 \pm 3.3$  days, with an average carcass weight of 19.1 ( $\pm 2.5$ ) Kg. Pelt DNA was used to identify the skins. The animals had been genotyped with HD chips by FarmIQ.

Considerable phenotypic variation for pelt traits was observed with around 30% being identified as suitable for high value shoe leather production. Using two techniques for identification, several key pelt traits associated with high value leather production were found to be moderately to highly heritable. By linking skin traits to other traits for which markers already exist, and which farmers currently measure (facial eczema resistance or live weight, etc.), a route to an economic benefit to New Zealand from improved pelts was clearly identified.

A more traditional approach was applied to deerskins. Slaughtered eleven-month-old progeny ( $n=310$ ) from terminal (wapiti crossbred) and maternal (red) sire types were evaluated for 18 different quantitative and qualitative traits throughout processing to pearl-crust leather. For all traits except evenness grade of the pearl-crust leather, the relationship with pre-slaughter live weight covariate was significant ( $p<0.05$ ) and positive. Sire had a significant effect ( $p<0.01$ ) on eight traits including critical strength and finished-leather attributes ( $p<0.01$ ).

This study provides a first insight into improving the properties of skins on the back of the animal and has wide-ranging benefits for other animal types; including cattle, where SNP chip technology is in an advanced stage of development.

*Keywords:* Heritability; Traits; Phenotype



FLS O-03

## CHROME-TANNED LEATHER SHRINKAGE PROBED WITH MODULATED TEMPERATURE DIFFERENTIAL SCANNING CALORIMETRY

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In this work, the relatively new technique of modulated temperature differential scanning calorimetry (MTDSC) was used to investigate the shrinkage reaction of chrome-tanned leather. Differential scanning calorimetry (DSC) is in common use for the investigation of the leather shrinkage reaction. However, by modulating the temperature treatment of the sample rather than treating it to the flat temperature ramp normally applied in DSC, the transitions that occur can be separated into reversing and non-reversing transitions. In this work, the chrome shrinkage reaction is probed using MTDSC and the shrinkage reaction characterised as wholly non-reversing. This contrasts with glass transitions and melting transitions, which are characterised as reversing.

*Keywords: Modulated Temperature DSC; Shrinkage*

FLS O-04

## INFLUENCE OF NAPHTHALENESULFONIC ACID DERIVATIVES ON THE PROPERTIES OF THE HIDE. PART II

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The first part of this paper studied the influence of the composition of different types of naphthalenesulfonic acid derivatives, used in the neutralization phase, on certain characteristics of the hide.

In this second part, the influence of these products on the same hide characteristics when used as dye auxiliaries has been assessed.

The results confirm those obtained in part I, i.e. the greater the molecular weight of the naphthalenesulfonic derivative, the better the anionicity and the dye penetration with two different dyestuffs. Also, color intensity is observed to be slightly decreased with both dyestuffs. Dye levelness is improved by Acid Black 210 but not by Acid Brown 83.

Regarding physical and organoleptic properties, the greater the molecular weight of the naphthalenesulfonic derivative, the greater the degree of softness, the physical resistances and the grain tightness.

*Keywords:* Retanning; Naphthalenesulfonic; Neutralization; Dye



## SURFACE AREA GAIN OF LEATHERS DRIED UNDER DIFFERENT CONDITIONS

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Drying is one of the most important leather production process which is necessary to obtain usable leather form from skin and determines the basic structural, chemical and physical properties of the leather. Using different drying methods in the footwear upper production affect the change in surface area of the leathers as distinct from each other. Surface area gain has a great significance since the footwear upper leathers are sold depend their size of the surface area. In this research, it is determined that the surface area gain of the each footwear upper leathers which manufactured using the wet-toggle and vacuum drying methods that are different drying processes, and the area gain of the leathers are compared.

As a result, it is observed that the significance changes occurred statistically on the surface area gain of the same origin upper leathers as using the different drying methods and conditions. Especially, the wet-toggle for the drying of footwear upper leathers is a preferable drying method because of the better surface area gain provided by the method.

*Keywords:* Shoe upper leather; wet-toggle drying; vacuum drying; area gain



KN – ACSIL

## TANNING STRATEGIES FOR SUSTAINABLE LEATHER PRODUCTION

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Sustainable development, more and more, has become a major guideline concerning our life and industrial production. In manufacturing companies as e.g. in the leather sector, it is mainly cleaner production constituting a practical way for protecting human and environmental health, and for supporting the goal of sustainable development. This includes measures such as pollution prevention, source reduction, waste minimization and eco-efficiency, which involve e.g. substitution of toxic and hazardous materials, process modifications, and reuse of waste products.

In this spirit, in the field of leather production, the wet-green® tanning technology constitutes a really sustainable alternative to conventional tanning methods. The use of the patented wet-green® tanning system based on a purely aqueous olive leaf extract allows the production of high-quality leathers for the most different applications. At the same time, the use of environmentally and health relevant conventional chemical tanning agents like chromium(III) salts or organic synthetic reactive chemicals (i.e. glutaraldehyde and others, which are based on fossil resources) is waived. This sets new standards regarding sustainability.

As a tanning agent, the olive leaf extract combines the advantages of organic synthetic reactive agents by creating stable covalent chemical bonds with those of the usual vegetable tanning. The deposition of vegetable polyphenols (via hydrogen bonds) additionally generates a better fiber separation and filling effect as well as a pleasant round feel. As there is no traditional pickling process needed, application of the new tanning system also permits reduction of salt content in the effluent. Due to good fullness and the good dyeing behavior of the wet-green® based material, considerable savings of retanning products and dyes are possible compared to the usual chrome-free tanning process based on wet-white technology.

Production of the olive leaf tanning agent is not in any competition to food production. The olive leaves are obtained in great quantities in connection with the olive harvest and especially, the subsequent trimming of the trees (pruning) in the Mediterranean, where they accumulate as a residual material that is simply burned, in many places. The tanning extract is produced from the olive leaves, similar the tea production, and it is actually manufactured in plants, which comply with the high standards of the food industry. The special quality of the eco-effective tanning agent is not least reflected in the very good performance in the dermatological test, and in being awarded the Cradle to Cradle® certificate in Gold as well as Material Health certificate in Platinum.



In the production of Olivenleder® (the olive-leaf-tanned leather), sustainability and environmental compatibility are respected across the entire process chain by taking account of the most current findings. For the first time, by a vegetable tanning process, it became possible to produce leathers showing good shape retention but also exceptional softness, lightness and durability. Olive leaf tanned leather is suitable for applications in all kinds of areas like furniture for the residential and commercial/public sectors, automotive as well as shoes/leather goods, watch straps and clothing.

In contrast to conventional tanning technologies, the wet-green® system, additionally, opens up new possibilities of leather production via a novel type of universal intermediate by allowing drying and subsequently wetting-back without problems. This new type of dry leather intermediates (green crust®) will bring about more flexibility in processing and permit avoidance of fungicide application.

ACSIL O-06

## WASTE TO WEALTH APPROACH : ADHESIVE FROM THE UNUSED GOAT HEAD SKIN

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Slaughterhouse byproduct management is an important issue for the green environment. Byproduct from the slaughterhouse e.g. cow, buffalo, goat and sheep skin is the basic raw materials for the tanning industry. After slaughtering cow and buffalo head skin is used in small scale for leather processing. But in the case of goat and sheep, the head skins are disposed away without any proper management to the environment from where gaseous air pollutants are continuously merged to the atmosphere. Water body and soil are also being polluted by the waste. In Bangladesh, yearly 30 million goats are slaughtered (Aziz 2010) but all the goat head skins are disposed of without utilization for producing any commercial product. In this study, an investigation was carried out for the glue production for commercial use from the unused goat head skin by means of a cleaner environment. Goat head skin was collected from the local slaughterhouse: soaked and heat treated to extract the collagen in soluble phase. The extracted solution was dried and obtained glue was investigated for commercial application. The produced glue could be used in the packaging industry, furniture, plumbing, shoe making, book binding, etc. Glue was prepared from the goat head skin by using simple and easy technique with a few chemical. It was estimated that Bangladesh could produce 270 MT glue per year only from the unused goat head skin.

*Keywords: Goat head skin; Glue; Environment; Pollutant*



ACSIL O-07

## FABRICATION OF ANTIBACTERIAL CASEIN-BASED ZNONANOCOMPOSITE FOR LEATHER FINISHES THROUGH IN-SITU ROUTE

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Casein, a natural polymer extracted from raw skim milk, has superior film-forming properties including excellent adhesive force and strong heat resistance. Nevertheless casein film is easily spoiled by bacteria attack, which might restrict its practical applications. In this paper, casein-based ZnO nanocomposite leather finishing material was fabricated through in-situ polymerization aim at improving the antibacterial activity of casein films. The structure and size of nanocomposite were characterized while the tensile testing, water absorption and antibacterial activity of the films were detected. DLS measurement result showed that the size of nanocomposite latex particles was approximately 260nm. Moreover, the composite film displayed superior mechanical property, high water resistance and excellent antibacterial activity against *S. aureus* and *E. coli*. This work provided a feasible pathway for fabricating natural polymer-based nanocomposite antibacterial films which will has great potential use in some fields.

*Keywords:* casein; ZnO; in-situ polymerization; antibacterial; leather finishes

ACSIL O-08

## IONIC LIQUIDS: NEW AGE “DESIGNER” CHEMICALS FOR LEATHER PROCESSING

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Ionic liquids (ILs), the greener solvent media are regarded as preferential candidates for instigating desired effect on proteins due to the easy tunability of cation and anion. The use of these “designer” and “greener” solvents in leather processing has been explored in this study. Herein, we report the investigations carried out on collagen at different hierarchical level using various ILS. The conformational stability of collagen at the molecular level, thermal and dimensional stability at the inter-fibrillar level and fibre structure at skin matrix level using different types of ILs viz., imidazolium, choline, ammonium and phosphonium as cations with different anions have been studied in detail. Almost all ILs with the exception of choline destabilised collagen at fibrillar and skin matrix level. Imidazolium IL made no changes at molecular level whereas ammonium and phosphonium based ILs even altered the secondary structure of collagen. Imidazolium based ILs were explored as unhairing cum fibre opening agents thereby eliminating the use of lime and sodium sulphide during leather processing. Choline based ILs stabilised collagen and hence tanning using choline salts has been attempted. Thus, ionic liquids have been evidenced to have both stabilising and destabilising effects on collagen and the properties can be garnered and fine-tuned for various applications in leather processing. Future leather production will evince interest in the use of ionic liquids as advanced chemicals for making the leather processing cleaner and greener.

*Keywords:* Collagen; Ionic liquids; Thermal stability; Conformational Stability  
Unhairing; Fiber opening; Tanning



ACSIL O-09

## A NEW AGE CHROMIUM-MELAMINE SYNTAN: TOWARDS QUALITY UPGRADATION OF LOWER-END RAW MATERIALS

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One of the unavoidable steps in the transformation of wet-blue to finished leathers is the filling up of void spaces in the skin matrix. Drawback associated with chrome tanning, the lack of fullness is being addressed during the post-tanning process by employing synthetic tanning agents. In general, the syntans are manufactured by enhancing the molecular weight of aromatic compound such as phenol and its derivatives, melamine etc., through condensation reaction. Commercially available chromium syntan, which contains combination of chromium salt and phenol-formaldehyde condensate polymer, is employed during the rechroming process to ensure the uniform chromium content of wet-blue leather sourced from different places and also to impart fullness. However, in order to improve belly filling more amount of melamine-formaldehyde condensate is used in the subsequent re-tanning process. Liberation of free formaldehyde is one of the major limitations of the conventional synthetic tanning agent. Keeping in mind the strictures of free formaldehyde and selective filling, an attempt has been made to prepare a novel formaldehyde free chromium-melamine syntan. The prepared product has been used in the rechroming process. The product imparts selective filling/grain tightening effect on loose area/belly region and also increases the thickness without affecting the area yield. The product provides good dye levelling, excellent buffability with natural sheen, uniform milling pattern and apart from this upgradation of the lower selections with improved cutting value is also obtained.

*Keywords:* Chromium, Melamine, Syntan, Rechroming



ACSIL O-10

**NOVEL SURFACTANTS – IN LEATHER PROCESSING****V Vijayabaskar\* & J K Basu Jayant A Chaudhuri***Leather Chemicals, BalmerLawrie & Co Ltd., Manali, Chennai**\*Email: vijayabaskar.v@balmerlawrie.com*

This lecture addresses used mainly about surfmers – polymerisable surfactant and its copolymers used in processing of leather. There will be a discussion on novel concept of making polymerized fat using a surfmer based on renewable sources. A facile method was developed in-house containing a dispersion of a selected amphiphilic copolymer and substantially free from organic solvents. They impart light fastness characteristics, reduce fogging and minimize Cr(VI) a carcinogenic generation in leather.

Another part of this paper will cover the synthesis of novel polymer based on surfmer with carboxyl functionalities. This polymer binds the free chrome on to the collagen and Cr (VI) was below detectable limits on leather on ageing.



ACSIL O-11

## TANNING WITH A GALLIC EXTRACT IN COMBINATION WITH A CATIONIC ESTER FOR THE PRODUCTION OF HIGH PERFORMANCE LEATHERS

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A new metal free tanning system was developed by using a modified hybrid extract from Gall nuts and Tara in combination with a cationic fatty ester.

The hybrid extract obtained has self tanning properties with a shrinkage temperature of over 80°C ,a very light colour and strong light / heat fastness.

The tannage by itself with the gallic tanning agent is very anionic but by introducing a cationic ester during tannage is possible to modify the reactivity of the system and the final leather has amphoteric properties. The levels of exhaustion of retanning agents, dyes and fatliquors obtained are very high as well as low COD and high biodegradability of the final effluent.

The system can be associated to traditional vegetable tanning systems so recycling of the main tanning liquor can be made endlessly. A mass balance of the tanning material was carried out and tannins to tannins ratio monitored after several batches. The systems reaches equilibrium after two batches which guarantees consistency of quality.

By varying the retanning / fatliquoring all types of leathers can be obtained. The systems works well both on bovine and small skins.

A study on the effluent of the system was carried out and the biodegradability tested in a pilot tannery effluent plant.



KN - IVL

## STUDY OF THE VARIATION OF CHROMIUM VI CONTENT INSIDE THE LEATHER

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Trivalent chromium (CrIII) is the most widely used tanning agent. However, if the process is not perfectly mastered, some free CrIII radicals can be transformed into hexavalent chromium (CrVI). Since May 2015, CrVI's content of leather must not exceed 3 ppm in Europe. (Reach annex 17, §47). Anyhow, it has already been included in most specifications for many years.

Several hypotheses have been advanced to explain the CrVI appearance. Some studies assess the evolution within time of the CrVI content.

CTC has launched a research program.

Four different bovine leathers have been defined:

- Leather 1: tanned and finished with all the best practices known nowadays to avoid CrVI generation.
- Leather 2: treated with the same recipe, except the fat liquors used, which are unsaturated.
- Leather 3: tanned without applying the best practices.
- Leather 4: treated the same way than the third, but with a vegetal retanning.

For several months, we have been following their variation of the CrVI content, by studying particularly the influence of:

- The homogeneity of the CrVI content on the hide (mapping)
- The recipe applied to identify the best practices that are inescapable
- Assessment of the importance of the bad practices
- The storage, of the light effect



A new ageing methodology has been developed, which is representative of what is happening to the leather, during its use. This work was performed in connection with the standardization Committee CEN TC 289/ IUC.

The efficiency of reducing agents, used for prevention of CrVI generation, applied on bath or on the back side of finished leathers is also assessed.

These research works, started in July 2014, have already shown the impact of the application of best practices.

*Keywords:* Leather; Chromium VI; Ageing; Reducing Agent

IVL O-12

## INTELLIGENT REAL TIME LEATHER DEFECT DETECTION SYSTEM USING IMAGE PROCESSING TECHNIQUE

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The inspection of leather quality is very important in assessing the effective cutting value that can be obtained from the leather when used for making leather products. Leather being a natural material, quality of the leather varies due to the inherent variation in the raw material. The price of the skin or leather varies quite considerably with the selection and hence grading is done with diligent care by experienced assorters. However such a manual inspection is highly subjective and varies quite considerably from one assorter to another and often this subjectivity leads to dispute between the buyer and the seller of the leathers. Manual leather defect detection is tedious and subjective and repetitive inspection often results in missing the defects due to fatigue leading to inaccuracy and inconsistency.

To resolve the drawbacks of the manual method, an intelligent automatic leather defect detection using image processing technique is proposed in this paper. In the proposed method, the optimal texture features such as Entropy, Energy, Contrast, Correlation, Cluster Prominence Standard Deviation, Mean, and local homogeneity that discriminate between normal and defective leathers are extracted. The normal and defective leathers are classified using an artificial neural network features. Experimental results on the leather defect image library database suggest that the identification of leather defects can be automated with the application of image processing technique based on feature extraction technique using ANN as Classifier.

*Keywords:* Leather surface inspection; Leather defect; Image processing technique; Artificial neural network



## ANALYSIS OF CHARACTERISTIC ODOR COMPOUNDS IN LEATHER BY GC-MS AND GC-OLFACTOMETRY

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The leather odor component is a mixed various volatile compounds. The leather odor analysis has been performed mainly using a gas chromatography-mass spectrometry (GC-MS). Each of the peaks in the chromatogram represents an individual compound that was separated from a sample mixture. However, it is unknown whether each peak is odor-active. In odor analysis of foods and essence, gas chromatography olfactometry (GC-O) is used. GC-O refers to the use of human assessors as a sensitive detector for odor-active compounds. The sensitive detector “nose” enable the recognition of substances which other methods of analysis are unable to identify. In this study, the volatile compounds in leather were extracted using a solid-phase microextraction fiber. Then identification of the volatile compounds was achieved using GC-MS and GC-O. The result showed that major volatile compounds of more than 20 were identified by GC-MS. Among them, hexanal, heptanal, octanal, nonanal, heptanol, octanol, 2-ethoxyethanol, and 2-butoxyethanol were the main volatile compounds. Aldehyde such as octanal and alcohol such as octanol were characterized by GC-O. In contrast, solvent such as 2-ethoxyethanol was not characterized by GC-O.

*Keywords:* Solid-phase microextraction; Gas chromatography-mass spectrometry; Gas chromatography-olfactometry; Odor

IVL O-14

## METHOD FOR DETERMINING THE OPTIMIZED EXHAUSTION OF FATLIQUORS TO MINIMIZE THE ETP-INFLOW

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The proposed amendment of the German regulation for the treatment of tannery wastewaters (ATV-DVWK-M774) emphasizes the minimization of the pollution burden before treatment (inflow). Current regulations are directed towards setting limits to what may leave an ETP (outflow). The new provisions, on the other hand, demand that a verifiable reduction of the polluting load is realized before the water enters the treatment system. An absolute decrease at the level of individual components requires the measurement of these components for a starting point.

This paper discusses the ways of expressing the exhaustion of a selection of fatliquors on chrome and chrome-free leathers. Each product has a specific affinity to the tanned hide and an individual environmental imprint. This specificity can be used for targeted reduction of the inflowing pollution burden.

The findings of the study can act as a starting point for setting up an own methodology and a detailed level of reporting for all who need to understand a fatliquor's true affinity towards the leather and those who endeavor to minimize the environmental impact of their processing.

*Keywords:* Exhaustion; Environment; Fatliquor; Chrome; FOC; ETP



## ARTIFICIALLY INDUCED COLLAGEN FIBRIL ORIENTATION AFFECTS TEAR PROPAGATION IN LEATHER

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Ovine leather has around half the strength of bovine leather and is therefore not suitable for high value applications such as shoes. For leather from a variety of animals it has been found that the extent of collagen fibril alignment (orientation index) is closely correlated with the strength of the leather. We tested whether biaxial stretching for the duration of tanning or compressing pickled pelts prior to tanning the ovine skins could increase the orientation index of the collagen fibrils and the strength of the final product.

Control and test ovine skins were tanned using conventional chrome tanning methods. After the pickling and bating the test skins were compressed between rollers before tanning or stretched biaxially during the tanning process. The stretch was applied was between 2.3%, 10% and 15% of the pickled pelts original length; either uniformly (10% and 10%) in both directions or with 2.3% in one direction and 7.5% in the other. Tear strengths were measured by standard methods in two directions, normal to one another relative to the backbone of the skin. Collagen fibril orientation was measured using synchrotron based small angle X-ray scattering, both edge on to the leather and flat on to the leather.

The in-plane collagen fibril orientation index rose from ca. 0.45 to ca. 0.70 both with compression with rollers and biaxial stretching. With non-uniform biaxial stretching there was an increase in the flat-on orientation index. Tear strengths are affected by both the in-plane fibril orientation. Tear propagation is resisted by collagen fibrils arranged at right angles to the tear front but propagates more readily along the direction of fibril.

While it was possible to increase the collagen fibril orientation, this led to direction specific tear strength increase rather than an overall increase in the skins tear strength, which has a more complex but rational behaviour.

*Keywords:* Small Angle X-Ray Scattering; Collagen; Orientation; Biaxial Stretching; Leather; Tear Propagation

IVL O-16

## CHROME-FREE TANNAGE: SUEDE GARMENT LEATHERS FROM RURAL VEGETABLE SHEEP CRUST LEATHERS

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Worldwide research is being focused on chrome-free tanning systems. Many studies based on less chrome and chrome-less technologies have emerged in the recent past. The tannin molecules in vegetable tanned leathers form multiple hydrogen bonds with collagen and create a polyphenolic tanning matrix. The hydrothermal stability of vegetable tanned leather is in the range of 70-85°C. By retanning of vegetable tanned leather with metals the shrinkage temperature (Ts) can be elevated considerably in a process that is commonly known as semi-metal tanning. Semi-metal tanning systems have gained importance in recent times as an alternative for chrome tanning. In this study, an attempt has been made to manufacture of semi-alum garment leathers from sheep rural garad tanned crust leathers. Sheep rural garad tanned crust leathers carefully sorted for size, substance, and grain quality, so that the customers' requirements can be met accurately. The selected crust leathers followed the subsequent processing, viz, stripping, bleaching, retannage with aluminium sulphate prepared solution, neutralization, dyeing, fatliquoring, drying and finishing. Full chrome tanned garment leathers from sheep skins used as control leathers. The physical and chemical characteristics of experimental leathers are comparable to control leathers. The experimental trial resulted in very soft and flexible leathers with high tensile strength. However, the stripped rural garad tanned leather retanned with 2% Al<sub>2</sub>O<sub>3</sub>; resulted in shrinkage temperature of 102°C. The experimental trial resulted in leathers with good organoleptic and strength properties. The semi-alum tanning system provides significant reduction in the discharge of total dissolved solids in the wastewater. The work presented in this paper established the use of semi-alum tanning system as an effective alternative cleaner tanning methodology.

*Keywords:* Garad; Semi-alum; Stripping; Shrinkage temperature; Crust leather



IVL O-17

## EFFECT OF BINDER SELECTION ON TOPCOAT PROPERTY RETENTION AFTER ACCELERATED WEATHERING

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Within the new car purchasing process, the selection of leather seating is viewed as a premium upgrade over less-expensive cloth options. In keeping with this premium status, leather seating carries with it high expectations for comfort, appearance, and durability. To meet these expectations, Dow Leather Solutions has developed acrylic topcoat binders with an exceptional balance of performance properties when combined with conventional PUD binders. When considering state of the art topcoat systems, however, a continuing unmet need involves retention of properties after seating materials are subjected to a range of accelerated weathering conditions.

This paper compares the performance of fully finished automotive upholstery leathers after they are subjected to a range of accelerated weathering conditions including heat, hydrolysis, and several xenon-arc chamber conditions. A broad range of PUD chemistries and blends of chemistry types were tested, along with an examination of the effect of blending each of these with an acrylic topcoat binder in a standardized upholstery screening formulation. In order to assess performance, measurement of color, gloss, and Bally flexibility were conducted before and after exposure to each accelerated weathering condition.

An examination of the data showed that xenon arc methods using quartz filters resulted in the lowest performance with performance dropping proportionally to the length of the test. An analogous xenon-arc method involving use of an auxiliary lantern and filters was found to result in comparable sample damage, but only after much longer exposure duration. Exposure to hydrolysis and dry heat conditions produced the fewest changes in the samples. The data made evident that certain classes of PUD binders were preferred depending on the weathering specification being considered. Regardless of the various strengths and weaknesses of a particular class of PUD, a strong moderating effect was noted in many PUD-acrylic blend systems. This indicates that the two chemistries produce a measurable synergistic effect when used together in leather upholstery topcoats subjected to accelerated weathering conditions.



## ADVANCES IN BIO-BASED POLYURETHANES FOR LEATHER FINISHING

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Much of the current research into leather chemicals is focused on providing tanners with solutions that reduce their environmental footprint at each step in the leather manufacturing process. Less water consumption, effluent quality, the elimination of restricted substances and the introduction of naturally occurring ingredients are just some of the areas on which chemical companies like Stahl are working.

Coatings technology for the finishing step of the leather process has, until recently, been largely based on petroleum feedstock chemicals, like ethylene and propylene. Yet new product development has been driven more by compliance to specific substances, like NMP and NEP, than a desire for bio-content. However, as this paper summarizes, recent advances in biotechnology have allowed a new class of polymers to be developed. Made from renewable raw materials, these bio-based aqueous polyurethanes also demonstrate superior film performance to their fossil-fuel based predecessors.

### **From Nitrocellulose to Polyurethanes**

There are many polymer technologies, both solvent- and water-based, that can be used as binders in leather finish formulations: polyurethanes, acrylics, nitrocellulose and butadiene for example. Typically these polymers are combined with additives in a compound to provide the characteristic touch, surface appearance and durability of the final leather.

Nitrocellulose was widely used in the past for finishing leather but the elimination of solvents from tanneries and the need for more durable coatings, especially in the automotive industry, has meant that water-based polyurethanes have since become the standard for high performance leather finishing. Polyurethane films are both durable and flexible and they protect the leather from staining, abrasive damage and from the long term effects of weathering.

### **Polyurethane Dispersions**

Polyurethane dispersions (graph 1), also known as water-based polyurethanes, are produced by first reacting polyols with isocyanates, in the presence of an acid, to make a pre-polymer. This pre-polymer is neutralized, dispersed in water and this is followed by a chain extension step. The final product is an opaque white liquid. A polyurethane-based finish is typically applied by roller or by spraying onto the leather, then dried. As the water evaporates from the coating, the polymer coalesces and the cured polyurethane film is left on the surface.



### Graph 1: Polyurethane Dispersions Building Blocks

The main chemical building blocks for the manufacture of polyurethane dispersions are isocyanates and polyols (graph 2).

Ingredients	%
Polyol	60 - 80 (on solids)
Isocyanate	10 - 15 (on solids)
Solvent	5 - 10
Water	60 - 70
Others	0 - 5 (on solids)

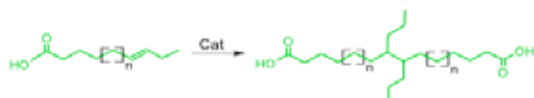
### Graph 2: building blocks Polyurethane Dispersions

The polyols used for polyurethane-based finishing are typically polyether (for basecoats), polyester or polycarbonate (for topcoats). The choice of polyol (and isocyanate) depends entirely on the final properties required for the end article.

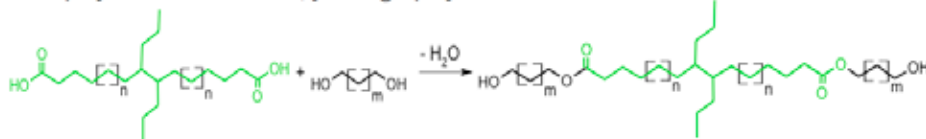
#### Bio-based Polyols

Certain polyols can be made using plant-based (renewable) resources instead of petroleum-based raw materials. In these cases, natural oils are extracted from the plant and transformed into polyols - the unsaturated fatty acid from the oil is dimerized then polymerized with a diol to produce the polyol, in this case a polyester diol (graph 3).

The unsaturated fatty acid from the (eg: rapeseed) oil is dimerized:



Then polymerized with a diol, yielding a polyester with renewable content:



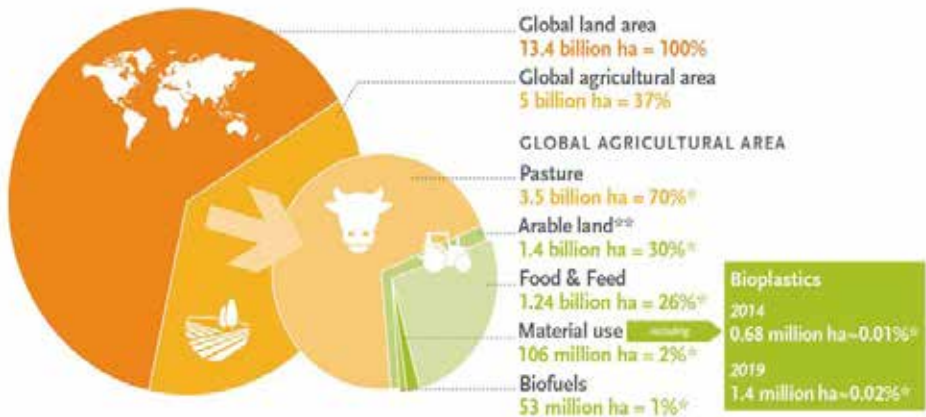
### Graph 3: bio-based Polyols

Many different plant oils can be used to make these bio-polyols, like canola (rapeseed), soy, palm or linseed. Some advantages of using renewable oils versus fossil fuel-based materials are:

- Plants can be re-grown, avoiding depletion of the earth's crust
- Wide availability of the plant resource in all regions
- Lower carbon footprint vs extraction and transport of fossil fuels
- Some plant oils already used in animal feedstuffs and biodiesel (eg: Rapeseed)

The overall land-use required for biopolyols is a small portion of the total land use for bioplastics, as illustrated in graph 4.

## Land use for bioplastics 2014 and 2019



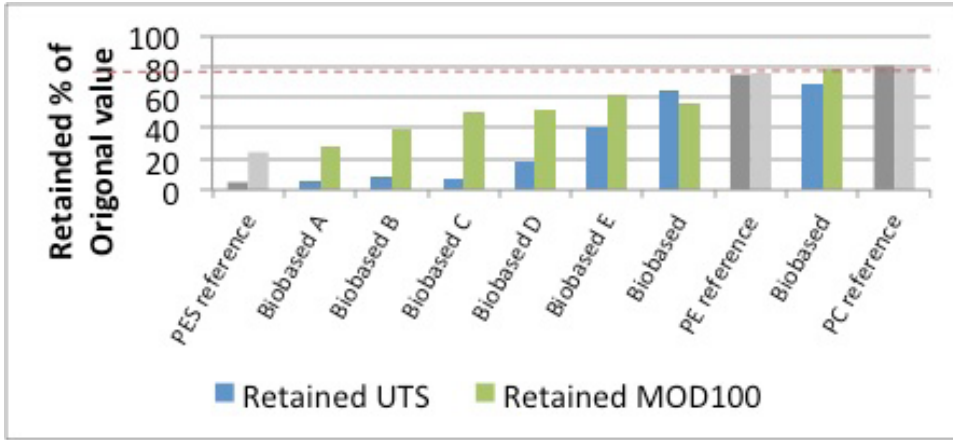
Source: European Bioplastics, Institute for Bioplastics and Biocomposites, nova-Institute (2015).  
 More information: [www.bio-based.eu/markets](http://www.bio-based.eu/markets) and [www.downloads.ifbb-hannover.de](http://www.downloads.ifbb-hannover.de)

\* In relation to global agricultural area  
 \*\* Also includes approx. 1% fallow land

**Graphic 4: Land use for bioplastics 2014 and 2019**

## Performance

Recent advances in biotechnology have made it possible to formulate high performance polyurethanes using polyols derived from plant-based oils. Although Stahl has been researching bio-based polyurethanes for several years, only recently have we observed the high performance characteristics illustrated in graph 5.



**Graph 5: Bio-Polyurethanes: Film Performance after Hydrolysis**

Test conditions: 50 C, 95% Humidity, 14 days

UTS : Ultimate Tesile Strength

MOD100 : Tensile strength at 100% modulus

PES: Polyester Polyurethane Dispersion

PE: Polyether Polyurethane Dispersion

PC: Polycarbonate Polyurethane Dispersion

**Explanation graph 5:**

Dried films of water-based polyurethanes were subject to the hydrolysis test and tested for tensile strength. Graph 5 is a comparison of the retention values of the films tested. Higher retention of tensile strength means that the polyurethane film in question is more resistant to the test. The conclusion of this data is that films made with the latest bio-polyurethane technology (Biobased EXP-1 and Biobased EXP-2) are more resilient than previously studied polyester and polyether-based alternatives. Indeed the properties come close to the level of polycarbonate-based polyurethanes, considered the gold standard for automotive finishing.

**The future: higher performance, more bio-content**

The described work is exciting and still developing. The biocontent level achieved so far can range from 10-35% depending on the final product design. Given that only a few years ago we were observing lower performance with a relatively small biocontent percentage in finishes for leather, we strongly believe that polyurethanes can be developed with higher biocontent and even higher performance in the future.

SFS O-18

## ENZYMATIC UNHAIRING: PERMEABILITY ASSAY OF BOVINE SKIN EPIDERMIS WITH FUNGAL ENZYME EXTRACTS

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The aim of enzymatic unhairing is allow the separation of the outer sheath of hair root from the dermal connective tissue. It's considered an ecofriendly process. It's not necessary more expensive since if it's applied on the epidermis surface enzymatic extracts could may be saved. The purpose of this work was to analyze the changes in pilosebaceous unit, basal laminous by unhairing action. Various keratinolytic fungi, previously isolated and selected from different soil samples were used: Neurosporacrassa, Verticilliumalbo-atrum, Trichophytonajelloi, Chrysosporiumsp, Aspergillussidowii, Paecilomyceslilacinus, Acremoniummurorum. Fungal isolated were cultivated in solid state conditions using hair waste obtained from the hair-saving unhairing process as substrate. Enzyme extracts were characterized according to their keratinolytic and proteolytic activity and protein content. Bovine skins were placed in a pressing-device, incubated at 25°C and 40 rpm in contact with different solutions on the epidermis side: fungal enzyme extracts with commercial tensioactives (0.1%, 0.5%), biocide 0.2% w/w (wet skin) for 4 h (soaking) and 24 h (unhairing). Samples of skin with and without enzymatic treatment were fixed in 4% formaldehyde, dried on increasing concentration of ethanol and analyzed with scanning electron microscopy. It was observed that the enzymes altered the epidermis, where detachment of corneocytes and empty hair follicles were observed. Characteristic patterns of hair cuticle and collagen fibres were preserved. The strongest depilatory effect was showed by Trichophytonajelloi. It was concluded that the enzyme penetration through epidermis could be beneficial for saving enzymatic reagents during its application in the handcrafted tanning of leather.

*Keywords:* Unhairing, Keratinolytic Fungal Enzymes, Permeability, Epidermis



## PREPARATION AND CHARACTERISTICS OF SURFACE MODIFIED PAN FIBER BY COLLAGEN PROTEIN

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PAN fiber for textile has similar mechanical properties to wool, such as good elasticity and intensity, but its moisture absorption and hand feeling are unsatisfied because its composition is different from wool. Collagen protein from leather has good moisture absorption and affinity to skin and the combination of collagen protein on PAN fiber surface can improve its properties difference from wool.

In our research work, the cyano-group on PAN fiber surface is hydrolyzed into carboxyl-group by NaOH, and acidylated into acyl chloride group, then reacted with collagen protein, to obtain surface modified PAN fiber. By this modifying method collagen protein is fixed on PAN fiber surface through covalent bond.

Infrared spectrum and SEM results show collagen protein has been combined on the surface of PAN fiber. Weight analysis shows the collagen protein content in the modified fiber is about 8%. The water absorption property of the modified fiber is 18.2%, which is improved by 93.6%. The moisture absorption is 5.74%, which is improved by 280.1%. Rate of dye-uptake is improved from 14% to 91%. The specific resistance is reduced by 99.2%. The performance of PAN fiber is improved to a great degree after surface modified by collagen protein.

*Keywords:* Collagen protein; PAN fiber; Surface modification; Property analysis

SFS O-20

## STUDY ON THE RECYCLING TECHNOLOGY OF UNHAIRING-LIMING AND TANNING WASTEWATER

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The recycling technology is one of the most important ways to realize the clean production in leather industry. In this study, a novel closed recycling technology of unhairing-liming and chrome tanning wastewater has been applied in mass production scale in a local tannery. In the recycling process, the content of various ions and TOC of the wastewater were measured. The collagen fiber dispersion and the distribution of ions in pelts were characterized. The shrinkage temperature and mechanical properties of leather obtained by the recycling technology were also tested.

All the trials showed that the novel closed recycling technology worked well without impairing the quality of the resultant leather and the zero emission of unhairing-liming and chrome tanning wastewater was realized. In the unhairing-liming step of the novel technology, the dosage of water, sulfide and lime were reduced by 80.8%, 33.3% and 23.4%, respectively. The collagen fiber bundles of limed pelts were split well. The distribution of calcium ion and sulfion in limed pelts was more uniform. 70% of salt and 20% of chrome tanning agent could be saved by recycling of chrome tanning wastewater. The shrinkage temperature of wet blue from different recycling times (from the first time to the 30 times) was all above 100°C. With the increase of the recycling times, the grain surface color of the wet blue tended to be similar. Furthermore, the mechanical properties and yield of the leather in the recycling technology were improved.

*Keywords:* Unhairing-Liming Wastewater; Tanning Wastewater; Recycling Technology; Zero Discharge; Mass Production





## DIFFERENT PRE-TREATMENTS OF CHROME TANNED LEATHER WASTE AND THEIR USE IN THE BIOGAS PRODUCTION

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Leather industry has undeniable economic and environmental importance worldwide converting a by-product of the meat industry in a value-added product. However the processing of leather generates a huge amount of new solid wastes. Usually, the tanning process is done with basified trivalent chromium salts, consequently a substantial part of the solids wastes are chromium tanned leather wastes (CTLW), which are normally disposed of through landfill, which may lead to water pollution or incineration, that is energetically disadvantageous. CTLW are crosslinked collagen residues produced in the leather industry which are very stable towards high temperatures and enzymatic degradation. This stability is due to natural cross-links in the collagen structure and chemical cross-links between collagen fibers formed in the tanning step in tanneries with chromium salts. As collagen is organic matter this waste can be considered for biogas production through its anaerobic digestion but to ease enzymatic degradation, necessary to produce biogas, a previous denaturation of the native structure has to be carried out.

The main goal of this study is to accelerate and improve the biogas production process with CTLW as a substrate in a way that it can be used industrially. With this purpose the following pre-treatments were performed on the wastes: autoclave, extrusion, and hydrothermal treatment. The pre-treated samples were analyzed regarding their degradation degree with various methods. Partial results show that the pre-treatments accomplish to degrade the collagenous structure of the samples. Those that underwent the autoclave treatment show a degradation degree by trypsin of 50% with only 24 min of treatment and it was possible to reach more than 90% after 192 minutes. Results for the extruded samples vary with operation conditions and it was possible to reach 35% of degradation by trypsin. The hydrothermally treated sample at 170°C reached a degradation degree by trypsin of 90%. The untreated CTLW was only 6% degraded after the same procedure. Comparing the untreated sample and two of the extruded samples for biogas production, the pre-treated samples were able to start production approximately five days before the untreated sample and they also presented a higher final biogas yield.

*Keywords: Leather wastes; Biogas; Collagen*



SFS O-22

## SUSTAINABLE LEATHER MANAGEMENT: A MASS BALANCE BENCH MARK OF DIFFERENT CHROMIUM TANNING TECHNOLOGIES

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The main “operating” step in leather manufacturing is the tannage, which stabilizes the collagen and chemically converts this protein into leather. Due to the ideal chemical characteristics of chromium in the valence state III this element can enter within the triple helical structure of collagen where it uses its special complexing and cross-linking behavior to stabilize the protein matrix. The geometric size of the resulting Cr(III)-complex after basification respectively and oleation respectively fits best in the surrounding 3D-protein-structure of the collagen. The macroscopically result is a significant increase of the denaturation point of the leather above 100°C.

It is known that some other metals such as titanium, iron or aluminum and some organic substance can provide a stabilization effect as well. The stabilization effect follows a different mechanism which is not so effective and consequently results in a lower denaturation point of the resulting substrate. Therefore, up to now no adequate alternative tanning process for leather exists that fulfills all the different properties resulting from unique chrome tanning salts (CTS). As a consequence a non-chrome system needs to compensate this lacking by adjusting the retanning recipe through the addition of significant amounts of conventional retanning chemicals resulting in a less sustainable process as well as in a different technical performance of the crust. This is the reason, why about 85% of the world’s leather demand is still based on Chrome tanned leather, and this has been the case for more than 100 years.

Decades of research were necessary to understand the complex chemistry of chrome tanning and several theories have been developed which explain the different phenomena’s of this process step. As a result today’s chrome tanning process is a stable and safe operation also with a resulting safe and high performing technical substrate. In order to further improve chrome tanning in general and especially from a sustainability point of view a closer look at two important aspects are needed. First: Process rules to avoid the formation of Cr VI in leather and generate a stable crust. Second: Process concepts to increase the utilization of CTS further in order to reduce the release of chromium into the effluent to an absolute minimum.



For the first topic clear process rules to follow are already established and well known as best available technology. This presentation will cover a closer look on the second topic: A simple mass balance is done to compare different process alternatives. It will be shown, that there are alternative process technologies available to the standard chrome tannage such as high exhaustion and hybrid technology (wet white pretanning in combination with rechroming), which significantly reduce the current discharge of chrome into waste, and which can be done with standard operating equipment in every wet blue tannery worldwide. These alternative technologies also mean that similar retanning recipes can be applied to that based on standard wet blue, and result in a leather with comparable crust performance.

*Keywords:* Chromium; Tanning; Mass Balance; Effluent; Waste; Exhaustion



SFS O-23

## FORMALDEHYDE AND ACETALDEHYDE ON LEATHER: SIMILARITIES AND DISCREPANCIES

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Formaldehyde and leather have a relation of over 100 years, since this aldehyde is a very common building block for the synthesis of syntans and resins and has even been used for tanning as such. While there is a lot of literature and best practice around how to minimize formaldehyde in leathers on the basis of extraction methods, the correlation with this data to the data deriving from emission tests leaves open questions, that will be addressed in the presentation.

Acetaldehyde is not used as a building block and rarely appears in extraction assays. However, it contributes to significant problems in emission test for automotive leathers, especially to meet the standards in the Chinese market.

This presentation will reveal new emission data assembled by new measurements. A new, facile method will be introduced, evaluated, and exemplified with data across the process of leather making, from beamhouse to finished leather and across various chemistries applied.



## REDEFINING CHROME TANNING: A WATERLESS APPROACH

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Leather is one of the most important commodities used globally for various applications with an annual trade of 120 billion USD. However, leather-processing industries are recognized as one of the major polluting sector. Conventional way of leather making is water intensive, in which 25-50 liters of water is employed for processing 1 kg of hides/skins. Although several technological options are available to reduce the water consumption, the volume of water used for leather manufacturing is still in higher order. It is projected that about 1.8 billion people will live in countries or regions with absolute water scarcity by 2025 AD. As water scarcity is emerging as a major threat for future generation, minimization of usage gains highest importance. Therefore, water usage and wastewater generation in industrial processes would be a sensitive issue in future and it is imperative to develop 'zero water use technologies'. Use of no water for chrome tanning does not only facilitate minimization of water but also provide a viable solution to the problem of chromium pollution. However, 'waterless chrome tanning' is highly challenging, as water is the best solvent for the transportation of chromium into hide network. The strategies adopted for waterless tanning include exploiting the matrix water for achieving the penetration of chromium into hide network. The developed technology has already been validated and commercialized and translated to many tanneries. The benefits are many folds, which include cost reduction, pollution reduction, avoidance of pickling and basification and finally improved quality of leather. In addition to the above benefits, the developed approach would provide a new paradigm in 'leather science', in particular, to the century old 'chrome tanning'.

SFS O-25

**CONCEPT OF SUSTAINABILITY: LOOKING FORWARD****Anne Lama***Institute for Creative Leather Technologies, The University of Northampton,  
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The concept of sustainability is not new and can be backdated to the late 19<sup>th</sup> Century. Within the leather industry evidence of growing concern regarding effluent issues was recorded in the late 1800s/early 1900s in various articles published during that period. Introduction of legislations to protect the environment were also seen around the same time. Simple effluent treatment procedures were practiced as well as various effluent treatment options were already investigated. Although hexavalent chromium was still in use, however, the negative impacts were noticed and solutions were proposed.

As the leather industry moved to the mid-1900, focus on effluent treatment increased. Many textbooks that published during that time contained chapters on effluent treatment. Single bath chromium tanning using trivalent chromium became popular and in the late 20<sup>th</sup> Century use of hexavalent chromium is completely abolished. IULTCS (International Union of Leather Technologists and Chemists Societies) effluent commission was formed. The Waste Framework Directive was introduced along with the concept of waste hierarchy. Effluent treatment started to be a standard procedure for many tanneries. The emergence of pressure groups such as 'environmentalist' and 'consumerist' was also observed during this period.

In the 21<sup>st</sup> Century, leather industry has moved beyond just treating effluent. Focus on certification and authentication has increased. Corporate Social Responsibility has become an integral part for many organisations. Community and economy are just as important as environment. For a sustainable business strategy it is important to measure the social and financial impact along with the environmental aspect. Therefore, it is becoming critical to adopt the concept of 'triple bottom line' and consider all three aspects that is social, environmental and economic sustainability, to ensure a sustainable leather industry.

*Keywords:* Sustainability; Triple Bottom Line



SFS O-26

## **THE ELIMINATION OF EFFLUENT FROM LIMING, ACID/SALT PICKLING, AND CHROMIUM TANNING, VERIFIED BY FIVE YEARS HIGH-VOLUME WET BLUE LEATHER MANUFACTURE**

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It is acknowledged that within the chemical processing of hides into leather that the liming, acid pickle and chromium tanning processes are the major contributors of pollutants. This is in terms of biological load, suspended solids, sulfide, nitrogen, chromium, salinity, and the resultant sludges for disposal.

This loading includes unused chemicals that are discharged from these processes due to their poor efficiencies. Many attempts have been made to lessen this waste at source, but technologies in common use have basically remained unchanged for decades.

Solutions to these problems are far reaching, and the details set down in this paper describe a technology that addresses and resolves these matters. This information was compiled through independent on-site studies within three major tanneries (identified), where approximately 60,000 wet salted US, European and Australian hides per week have been processed since 2013. Accordingly, this paper describes in detail this radical new approach to leather manufacture.

The investigations required slight changes within the building of a full scale wet blue manufacturing plant, and five years of developments before the technology was introduced to industry. The practicality and value of this technology - known as BIO-cycle - has been since been verified by continuous full scale manufacture that commenced in 2011.

The technology involves the complete retention and reuse of used floats from liming, pickle and tanning in self-contained loops. This ensures the complete uptake of processing chemicals, a significant reduction in water use, and zero effluent discharged from these critical manufacturing stages.

SFS O-27

**PROBIOTIC SOLUTIONS FOR SUSTAINABLE LEATHER****Juan-Carlos Castell\*, Claus Reineking***PROVIERA BIOTECH, LLC. 1710 Walnut St. Kansas City, MO 64108 (USA)**STAHL Leinfelden GmbH, Benzstrasse,  
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Since the introduction of industrial processing in the tanneries only little innovation has taken place. And certainly in the terms of sustainability. Yet, modern times ask for more natural alternatives to the traditional solutions.

Processing hides and skins to manufacture leather involves generating very high amounts of wastewater and solid residues, many of them valuable for other applications if they are not contaminated with chemicals. Nowadays, biotechnology is suitable to support tanners to improve the effluents and increase the value of by-products while reducing the need of synthetic chemicals.

Probiotics or beneficial microorganisms are used to obtain biochemicals through a controlled fermentation of natural ingredients resulting in a consortium of metabolites which properties outfit traditional leather auxiliaries extensively needed during the leather making process, such as wetting, dispersing and degreasing agents. Therefore, they have clear applications in the beamhouse operations, but also in wet-end and finishing.

Compared with traditional chemical synthesis products, probiotic biochemicals are totally made from renewable sources and its production process do not impact carbon footprint or generates emissions of greenhouse effect. There are not toxic, non-corrosive, safe for handling and free of concerning substances. They are fully biodegradable and have a positive influence in the efficiency of the biological reactors in the effluent treatment plants.

Probiotic metabolites are hydrotopes that help to cleave off from the collagen the non-leather making substances, including fats, and to disperse chemicals. Even more, they activate the ionic groups in the side of the protein chain, thus their affinity to the processing compounds. Consequently, biochemicals can eliminate, reduce or be combined with soaking and wetting agents, enzymes, degreasers, dispersing agents and dye auxiliaries. Also, they can improve leather quality by optimizing the up-taking of the tanning and processing substances. They are compatible with all chemicals used in the leather making process and do not require to adjust the conditions (pH, temperature,...) beyond those required in the manufacturing operations. Also, they can reduce bad odors or putrefaction and soaking of raw hides or skins can be carried out free of bactericides.

This presentation aims to demonstrate practical results in the tanneries on lowering effluent COD and improving leather quality.

*Keywords:* Biotechnology; probiotic; fermentation; metabolites; hydrotope; soaking; COD; renewable; sustainability



## CONTROLLING EMISSION IN LEATHER PRODUCTION: HOW CAN WE MAKE A DIFFERENCE?

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Leather production is a highly complex process which involves multiple process steps where different types of processing chemicals are involved. During this process, solid and liquid waste is generated but also volatile gaseous emissions. Over the past decades significant progress has been made developing technologies which help reduce emissions, be it chemicals with very good uptake and biodegradability or various biological and mechanical technologies to clean up waste water and exhaust air.

Designing the best process is often not easy for tanners particularly if it comes to comply with various local, national and international regulations or with eco labels. In the presentation an attempt is made to focus on the most efficient practices and technologies which will satisfy future regulatory needs while always having one goal in mind: production of sustainable leather, which is marketed as a premium product.



ECT O-28

## CLEAN SALT RECOVERY AND WATER RECYCLING USING NANOFILTRATION AND REVERSE OSMOSIS

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Tannery wastewater is a complex mixture of organic substances derived from the hide and inorganic substances such as salts and chemicals, which are added during the Beamhouse and Tanyard processing. In tannery effluent high concentration of Sodium Salts such as Sodium Chloride and Sodium Sulphates are found, which remain in the effluent after Primary and Biological treatment, resulting in high Total Dry Solids (TDS) levels after conventional treatment. Consequently many tanneries and leather business parks had to implement Zero Liquid Discharge systems to achieve strict TDS discharge limits, which comprise of a complex Tertiary treatment with Reverse Osmosis and Evaporators. The evaporation of the Reverse Osmosis concentrate shows difficulties, due to the nature and complex mix of residual salts causing scaling, which goes along with difficult disposal of the waste salts.

Nanofiltration membranes retain bi-valent ions and residual organics and leave salty water containing only Sodium Chloride, permeating the membrane. Nanofiltration is operated at a lower pressure of about 8-10 bars, thus consuming less energy than Reverse Osmosis and achieves higher recovery rates of up to 80%. This membrane technology is a suitable pre-treatment, due to the separation of scaling compounds and can improve the performance of Reverse Osmosis and the following Evaporators. The residual salt, after evaporation is pure Sodium Chloride, which can potentially be re-used for salting or pickling.

This combination of Nanofiltration with Reverse Osmosis and Evaporation can improve the overall performance of Tertiary tannery effluent treatment allowing for clean salt recovery and consistent high quality water re-use.

*Keywords:* Tannery effluent; Nanofiltration; Reverse Osmosis; salt recovery; water recycling



## BIODECOLORIZATION AND BIODETOXIFICATION OF LEATHER DYES FROM AQUEOUS SOLUTION AND DYE-CONTAINING EFFLUENTS BY NATIVE WHITE-ROT FUNGI STRAINS

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The discharge of dye-containing effluents in the leather production without adequate treatment is a matter of environmental concern. White-rot fungi have been reported by the ability in the treatment of synthetic dyes. This study aimed to investigate the biodecolorization potential, enzymatic activity and biomass production during the treatment of six leather dyes from aqueous solution by a native fungus collected and isolated in South-Brazil. The strain was identified as *Trametes villosa* PR-001 based on a molecular analysis of the internal transcribed spacer (ITS) region sequences. The results were compared with data obtained with other strain of *T. villosa*, previously isolated in a different local. The two strains of *T. villosa*, PR-001 and SC-10, achieved more than 85% of dye removal within 144 h of treatment under submerged fermentation conditions (30°C, 200 rpm and dye concentration of 200 mgL<sup>-1</sup> at pH 5.5). The increase in the extracellular enzymatic activity laccase (<350 UL<sup>-1</sup>) was directly linked to the biodecolorization. UV-Vis analyses showed reduction of the dye spectra peaks, indicating enzymatic biodegradation as the mechanism responsible for dye removal. Both strains were tested in different culture conditions to assess its real potential for treatment of dye-containing effluents produced in pilot scale and real tannery effluents from dyeing operations. The treatment was defined on the basis of biodecolorization, indicated by dye removal, and biodetoxification, based on the diminution of some parameters such as biochemical oxygen demand (BOD<sub>5</sub>), chemical oxygen demand (COD), total organic carbon (TOC), ammonia and total Kjeldahl nitrogen (TKN).

**Keywords:** White-rot fungi; *Trametes villosa*; leather dyes; real effluent; biodecolorization, biodetoxification

ECT O-30

## NOVEL FORMALDEHYDE SCAVENGER CONTAINING ACTIVE METHYLENE FOR EFFICIENT REMOVAL OF FORMALDEHYDE IN LEATHER

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As a kind of harmful substances, formaldehyde has some effect in induced carcinoma and promoted cancer process. Formaldehyde is a common chemical feedstock for numerous of industrial processes, it also used for the product of resin, rubber, coating, adhesive, etc. In leather manufacturing process, formaldehyde is used as preservative, biocide and it also is a raw material of amino resin and synthetic tanning agent. In order to meet the increasingly stringent formaldehyde evaluation standard, many approaches have been widely developed for eliminating formaldehyde. Chemical reaction is one of the most effective methods for scavenging formaldehyde in a certain short period. Formaldehyde elimination mainly is due to its high chemical reactivity, but most of the reactions belong to reversible reaction, so it is easy to cause secondary pollution. Methylene hydrogen of  $\alpha$ -hydrogen containing compound type which has high activity can react with formaldehyde at normal temperature. Above all, this reaction is irresistible. According to this mechanism, a hyperbranched polymer containing active methylene (HAMP) was prepared by transesterification reaction. The characteristics of hyperbranched polymer which has high functionality of terminal groups is its excellent reactivity, the unique structure of hyperbranched polymer can scavenge formaldehyde by physical adsorption via the molecular cavity.

The structure of HAMP was characterized by fourier transform infrared (FTIR), nuclear magnetic resonance (NMR), gel permeation chromatography (GPC) and dynamic light scattering (DLS). Formaldehyde-removal capacity of HAMP has been investigated in leather retanning process. The results indicated that the optimum amount of HAMP was 4wt% and the reaction time was 2h. Removal rate achieved 88.4%, formaldehyde content of leather treated by HAMP was lower than 180mg/kg. Meanwhile, scanning electron microscope (SEM) of the treated leather indicated that collagen fibers became looser. Physical-mechanical properties had slightly changes. Tensile strength changed from 8.31 N/mm<sup>2</sup> to 8.17N/mm<sup>2</sup> and tearing strength reduced to 22.57 N/mm from 29.54 N/mm, softness achieved 8.5.

*Keywords:* Formaldehyde Scavenger; Active Methylene; Leather



ECT O-31

## ANALYSIS OF FLOW AND ENERGY ASPECTS OF ZERO LIQUID DISCHARGE (ZLD) TECHNOLOGY IN TREATMENT OF TANNERY EFFLUENTS IN TAMIL NADU, INDIA

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High presence of electrolytes in irrigation water causes increase of osmotic pressure, which results in reduced water availability and retarded plant growth of crops; in particular, high concentrations of sodium can cause dispersion of clay and reduce water infiltration and drainage. Furthermore, in the course of conventional treatment the composition of TDS somewhat changes but its total level remains virtually constant and in the case of tannery effluents it considerably exceeds typical discharge norms

Mainly for this reason, the global trend of processing of fresh hides, i.e. salt-free raw material is continuously expanding; for a host of reasons this approach is non-existent in India.

Precarious situation with water and soil pollution in the area of tannery clusters along the Palarriver prompted the environmental authorities in the state of Tamil Nadu, India not only to press for adherence to TDS discharge limits but also to impose an approach not practiced in the tanning industry: a Zero Liquid Discharge (ZLD) concept.

Essentially, the ZLD concept attempts to eliminate the problem of high TDS waste streams by removing most of dissolved solids and reclaiming water. Designs differ, but the ZLD systems concentrate dissolved solids by Reverse Osmosis (RO) and some kind of Multi Effect Evaporation (MEE) until only damp solid waste remains. Solid waste is disposed and nearly all water is reclaimed and reused.

Accordingly, some of the existing Common Effluent Treatment Plants (CETPs) servicing tannery clusters and following the usual treatment technology (on-site pre-treatment, physico-chemical and biological stage/activated sludge) have been supplemented by advanced, energy intensive methods - RO and MEE, together with the necessary preparatory steps (tertiary treatment, water softening etc.).

The analysis investigates and relates raw and equalized effluent inflows, RO feed, permeate and reject, evaporator feed and condensate and the yield of recovered, reusable water. Water additions via chemicals dosing and steam and losses through evaporation, sludge and residual salt moisture are reviewed. Since the energy costs are critical for the viability of the entire concept, data about energy consumption (thermal, electrical main and Diesel) at key stages (RO, multistage evaporation) are consolidated, analysed and correlated. Additional energy needs and costs are compared with those for conventional (CETP) treatment and estimates made of the carbon footprint increase caused by the ZLD operations.

*Keywords:* TDS; ZLD; Effluent Flows; Evaporation Heat; Energy Consumption; Energy Costs; Carbon Footprint

ECT O-32

## STUDIES ON SIMULTANEOUS REMOVAL OF NITROGEN AND ORGANIC CARBON FROM TANNERY WASTEWATER USING AIRLIFT SEQUENCING BATCH REACTOR

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Tannery wastewater is characterized by having high organic carbon and nitrogenous compounds due to the raw hide/skin and chemicals used in making leather. As a result the removal of these pollutants along with others is mandatory to comply with discharge standards. The present study employed airlift sequencing batch reactor system to develop the simultaneous removal of nitrogen and organic carbon from synthetic tannery wastewater by seeding with conventional tannery CETP aerobic sludge taken from Ranipet CETP. The reactor (working volume of 5L) was run for 200d at different HRT's by automated control of the SBR cycles, pH, DO and temperature. The reactor was run at 18,15,12,10 and 8hrs total cycle times at constant 50% volume exchange ratio. The performance of the reactor was evaluated interms of TCOD, sCOD, BOD, TKN, NH<sub>4</sub>-N, NO<sub>3</sub>-N, NO<sub>2</sub>-N, DO and pH profiles. At the start of the operation, the reactor was run at constant MLSS of 3500mg/L, during these periods, the reactor shows no conversion or removal of the ammonical nitrogen, an indication that the nitrifiers population in the seed sludge was very less. Ammonical nitrogen conversion started after 30 days of operation and this operation was made for a total of 120.days. During this time, the reactor shows almost complete carbon removal and unstable partial nitrification to nitrite with very less conversion to nitrate. Later the reactor operation was changed to a constant SRT of 20d , DO,1mg/L and pH( 7.25-7.3) and different cycle times (18,12,10,8). The reactor was run for a minimum of two weeks for each cycle times. The result shows a 97% removal in terms of COD and a 94% removal in terms of ammonical nitrogen. The total nitrogen removal was observed to increase as the cycle time increases. The total nitrogen removal efficiencies for 18, 12, 10 and 8 hrs cycle times are, 69, 58, 53 and 43 % respectively. The COD, DO and nitrogen species profiles shows that the removal of nitrogen is happening during the initial phase of the cycle time after feeding due to denitrification. It was also observed that the remaining nitrogen in the effluent was more in the form of nitrate at higher cycle times and in the form of nitrite for lower cycle times. Kinetics study also shows complete removal of COD and ammonical nitrogen in 8hrs cycle time under controlled condition. In addition, cycle time control helps to change the characteristics of the effluent from complete nitrification to partial nitrification which is one of the important steps to link the reactor with anammox reactor system where in the presence of nitrite, ammonical nitrogen is anaerobically oxidized to nitrogen gas by anammox bacteria.

*Keywords:* SBR; Cycle time; Nitrification; Denitrification; Anammox



ECT O-33

## MICROBIAL FUEL CELL A NOVEL TECHNOLOGY FOR EFFLUENT TREATMENT AND ELECTRICAL ENERGY GENERATION

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MFC is one of the developing technologies to tap electrical energy from tannery effluent treatment plant without affecting its treatment efficiency. In the present study, a vertical MFC reactor has been used in order to simulate the real effluent treatment plant which is partitioned into two sections by proton exchange membrane. The upper portion acts as an air cathode and the bottom part contains anaerobic biomass which acts as an anode, where the effluent gets treated. During treatment the organics present in the effluent gets degraded by sludge biomass and as a consequence electrons and protons are generated along with by-products. Electrons move through external circuit whereas protons migrate towards proton exchange membrane thereby generating a potential difference which is used for current generation.

Experimental studies were conducted in order to enhance the effluent treatment process and current generation. Increasing the surface area of the electrode enhances only the current generation, whereas when the anaerobic biomass is subjected to diligent mechanical disintegration along with increased electrode surface area, enhancement of both effluent treatment and current generation were observed.

In control studies the maximum open circuit potential was 0.5 V with current generation of 0.1 mA (at 10 $\Omega$ ), Coulombic and COD removal efficiencies were 4 and 76% respectively. In the experimental reactors, where the surface area of the electrode alone was increased (3.5 times), an enhancement of 22% in potential difference, 13% in current and 3.5% in power were observed. The Coulombic and COD removal efficiencies were 5.2 and 86% respectively. In this study a new approach was adopted by introducing diligent mechanical disintegration, in order to enhance the current generation as well as coulombic and COD removal efficiencies. Thus enhancement, with potential difference of 53%, current of 28% and power of 15% was achieved, and as a consequence the Coulombic and COD removal efficiencies were significantly improved to 13 and 90% respectively. At this stage it can be concluded that, by increasing the surface area of the electrode and the microbial maintenance energy requirements (i.e., by diligent mechanical disintegration), enhancement in overall performances of the MFC could be achieved.

*Keywords:* Tannery effluent treatment; MFC; Current generation; COD removal; Coulombic efficiency; mechanical disintegration

ECT O-34

## TECHNOLOGICAL DEVELOPMENTS FOR TOTAL DISSOLVED SOLIDS (TDS) MANAGEMENT AND ENVIRONMENTAL SUSTAINABILITY IN ASIAN LEATHER SECTOR

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Environmental challenges due to the depletion of quality water resources in many leather industry clusters, it has become necessary to control Total Dissolved Solids (TDS) and salinity in the effluent discharged from the tanneries, development of technologies for TDS reduction in the treated effluent with water recovery. Adoption of special membrane system has been engineered in many individual and Common Effluent Treatment Plants (CETPs) in India, China and other leather producing countries. The sustainability of saline reject management is one of the major challenges for which viable technological solutions are being developed under pilot and commercial scale system.

Conventional tannery waste water treatment includes physiochemical and biological treatment systems to reduce hazardous chemicals such as Chromium, BOD, COD and Suspended Solids. To tackle treated effluent with TDS in the range of 10000 to 30000mg/l, multiple stage high pressure membrane system integrated with tertiary treatment units has been designed and implemented for recovery of water. To reduce the chemical usage and sludge generation in the tertiary treatment, Membrane Bio-Reactor (MBR) has been adopted to replace secondary clarifier and sophisticated tertiary treatment units such as Ultra-filtration (UF), Amiad filters, etc. Commercial scale high-tech membrane systems have been implemented in many locations for the capacities ranging from 500 to 10000m<sup>3</sup>/day with an investment of more than 300 million US dollars.

This paper deals with the recent developments on the environmental protection techniques in tannery wastewater treatment with focus on water-recovery for reuse, salt recovery, marine disposal of saline reject with proper bio-control system, etc. Details of applied innovative treatment technologies in India, China and other countries are provided in this novel technical paper. Sustainability of the Asian Leather Sector due to enforcement of new and stringent environmental regulations is also dealt in this paper.

*Keywords: Effluent Treatment System; Environment; Sustainability; Water Recovery*





## NEW DIMENSIONS IN CHILDREN'S SHOES

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### **Development Positioning:**

The high growth rate of children's feet necessitates the need for use of correct fitting 'lasts' to accommodate the growing feet. To gather reliable foot dimensions of children an Anthropometric survey is necessary to obtain accurate information on foot dimensions of children. This was carried out and the Foot Dimensions of 500 school children in the age group 5-10 years were "DIGITALLY CAPTURED" using "3D Foot Scanning" technique and Statistical Analysis of the data was done for "grouping" of the foot dimensions and five 'cluster groups' for children containing the 'Last' parameters for each of these groups were derived. The Modelling of the 'LAST' for 'COMFORT Footwear for Children' was also carried out. The Footwear was fabricated on the lasts derived by us and children's shoes with good fit and comfort properties were designed and produced. Testing of material which we are using for making shoes was also done. Gait analysis for new shoe with the children was carried out. With the results, improved products were fabricated the that would fit exactly and provide good comfort to the children's foot.

### **New features:**

The New Lasts developed are only 'five' in number and cover the entire spectrum of existing sizes of Children's Feet as spelt out in the conventional sizing systems available.

The above 'Last Proportions' derived for the Children's Shoes are unique and novel.

### **Inventiveness:**

The values of Length, Ball Width, Ball Girth and Instep Girth dimensions that are used to model the Children's Lasts for both Boys and Girls are significantly different from the existing values of the Children's Lasts.



**Significant outcome**

- Foot dimensions of the growing Children's feet captured through an Anthropometric survey using Digital Image Capture Technique
- Statistically analyzed the captured Data for 'Cluster Grouping' of foot sizes
- Modelled the derived Last parameters
- Incorporated Children's Footwear Trends in styling their shoes
- Enhanced the comfort of the shoes through an appropriate selection of components and accessories
- Fabricated special fitting lasts
- The styling was done to ensure the 'comfort' and 'safety' of the children.
- Colours incorporated in the styling of these shoes in harmony with the House to which these Children belong
- Shoes fabricated and the wear trials carried out for 'Fit' and 'Comfort' feedback
- Leather flag in House color printed with project name (STRAIT). Webbing tape in House color.
- Fabricated of 480 pairs of footwear for children
- Performance and Wear Evaluation of fabricated footwear carried out
- Gait Analysis assessment for comfort after wear trials
- Ready for commercialization

*Keywords:* Foot Growth; Children's Foot; Lasts; Foot Dimensions; Digital Foot Capture; Statistical Cluster Analysis; Grouping of Foot Sizing; optimization of Size range; Length; Ball Width; Ball Girth; Instep Girth; Indian Shoe Federation



## **DYNAMIC PLANTAR PRESSURE ANALYSIS OF PERSONS WITH DIABETES: AN APPROACH TO IMPROVE THE DESIGN OF THERAPEUTIC FOOTWEAR**

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Diabetic foot ulcers are one of the consequences of diabetes mellitus due to changes in foot shape. To achieve homogeneity of pressure distribution in foot, there should be a match between foot profile and footwear profile. Many of the studies to measure foot shapes are done with static foot data, dynamic foot data is still missing for better fitting footwear development. This study aims to improve the sole design of therapeutic footwear for persons with diabetes by analyzing dynamic plantar pressure profile of patients with diabetes. The study population involves diabetic patients without neuropathy (Group 1) and patients with diabetic neuropathy (Group 2). The data collected was compared with the data of control group without any ailments. The plantar pressure analysis was done using HR-Mat plantar pressure analyzer, BTS P-walk, at Gait analysis laboratory, CSIR-CLRI. The results indicate that there was no homogenous pressure distribution in group 1 patients and in case of group 2 patients the foot pressure has been increased and was not homogeneously distributed between the forefoot and heel area during walking. The step length, cadence and walking speed were found to be decreased and step width was found to be increased in group 1 and 2 patient's in comparison to the control subjects. These observations from the dynamic foot pressure profile will be helpful to design therapeutic footwear for persons with diabetes for enhanced pressure dissipation and increased comfort.

DIP O -37

## REDUCTION OF SKIN DISORDERS BY HCHO IN LEATHER PRODUCTS

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At JALT (Japan Association of Leather Tech'nology), we are trying to reduce skin disorders caused by leather products containing HCHO. Based on the experience of Japanese tanners, we are now paying closer attention to the effects of using natural and synthetic tanning agents in re-tanning processes.

At the time of manufacturing, many leather products have already been checked by makers for low levels of HCHO. In our previous report, we confirmed the general effects of natural or synthetic tanning agents on keeping HCHO levels low.

The subject of this report is on the possibilities of the long-term effects of these tanning agents on HCHO. In summary, regarding natural and synthetic tanning agents which were added to leather samples in the re-tanning process, HCHO content was measured at the beginning and end of major weathering tests. Also, we have done research on which combinations of tanning agents are suitable for keeping HCHO at low levels at every lifecycle stage. Our goal is to show the effectiveness of these tanning agents in keeping HCHO levels low at all times. Tanning agents are susceptible to color change, for example, when exposed to sunlight, so we are apprehensive of the reduced effectiveness of some tanning agents in reducing HCHO levels. We think it is important that not only leather tanning agents, but materials used at all stages of product manufacturing should strive to keep HCHO levels low at all times, from the time of manufacturing to consumption and use, until a product is finally disposed of.

On the other hand, we have another approach to this problem. Because we are the group company of a major Japanese department store, only we can survey our customer's opinions from department store databases. Our database has registers more than 400 opinions about leather products every year including various opinions about discoloration, sub-standard craftsmanship, and so on, totaling over 10,000 opinions from 1996. We must utilize this information to improve product quality and revenue. We will show that the survey of our database indicates the tendency of reducing the incidence of skin disorders as time passes from first-time consumer use.

*Keywords:* HCHO skin disorder natural tanning ag



DIP O-38

## COMPARISON OF VISUAL ASORTING PROCESS AND SPECTRAL PHOTOMETER USAGE IN LEATHER APPAREL PRODUCTION

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Leather apparel production consists of many steps following each other systematically. Each process step has its own importance and effect on quality. The properties of the material are important as well as design, pattern, well fitting, sewing and handiwork on the garment. Since each leather has its individual properties, leathers are assorted to constitute small homogeneous groups under standard light conditions considering their colours, handle, touch and surface appearance. Thus, assorting process plays an important role on quality of a leather garment. This process is carried out by assorting experts in a company depending on their experience and organoleptic controls. The aim of this study is to compare visual colour assessments of experts with the data obtained from a spectral photometer by using different CIE colour difference formulas and to determine the best formula matching to human assessments. The study was conducted in a leather apparel production company with 3 different colours (dark brown, whiskey brown and maroon) and 115 nappa goat leathers. Similar leathers were grouped as 5 or 6 to be manufactured as one leather jacket in assorting process by the experts. Then the colour differences of leathers in a group were measured by a spectrophotometer and evaluated with CIE76, CIE2000 and CIE94 colour difference formulas. Colour of each leather was measured from 7 different regions and the data were compared with the visual assessments statistically. As a conclusion CIE2000 colour formula matched best with the results of the human experts with 73% success.

*Keywords:* Leather Apparel; Assort; Spectral Photometer; Colour Measurement

**KN – EHC/GRAP**

**COOPETITION IN LEATHER ENGINEERING  
EDUCATION - A STRATEGY FOR A WIN-WIN  
SITUATION FOR CONCERNED STAKEHOLDERS**

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Leather continues and will continue to play a decisive role in the growth of many countries over the next few decades. Engineering education in leather in countries/continents across the globe caters to the demand for the technical talent to run and manage the leather and allied industries. Globalization is now reckoned a big factor in education as it is in an eminent position in business, finance etc., throwing open fresh challenges mostly in higher education administration and management. Partnership and twinning seems to be the answer at national and international levels. Co-opetition (short for “ Cooperative Competition ) in which different leather engineering institutions spread across the globe work towards a common goal of sustainable leather industry but at the same time seek to achieve and maintain individual objectives and “ vision and mission” accomplishments seem to be in perfect order. A mechanism to sustain healthy cooperation and simultaneous competition, in which the academic and research and other strengths of the individual institutions will be maintained will be highlighted.



## ELEARNING AND BLENDED TRAINING IN THE LEATHER PROFESSIONAL EDUCATION

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Being human resources so crucial for the sector's competitiveness, UNIDO understand the importance of training. For competing in the market on quality, product consistency and performance, fashion and service to customers, skilled personnel are essential. The combination of experience and youth, i.e. skilled workers and young applicants, represents the key asset on which the competitiveness of the sector is based. This can be enhanced at sector level by developing continuing vocational training and life-long learning.

While UNIDO is not an educational institution, and main aim is technology transfer, supplementary training and capacity building tailored to specific needs of local counterparts of different backgrounds is an essential part of technology transfer.

Conventional training/teaching/learning methods and routinely suggested course durations, forms and arrangements suit neither today's (to be) employees and industrial operations. Especially as manufacturing units are shifting from one region to other very fast. Similarly also training/retraining of workers and staff needs to be fast and efficient. Main concept of the new training is to use available technology to improve and increase learning efficiency by using and adopting appropriate tools.

### **What are features of modern training/learning system?**

*Flexible:*

*modular*

*complementary*

*efficiency*

Rapid development and especially information and communication technology (ICT) during recent years more and more also for development of training/learning material. With further development and especially new software various new training material, concepts and trainers aid have been developed, starting with knowledge bank up to more sophisticated animated and interactive training/learning courses and eLearning courses.

In short **e-Learning** is a computer and electronic network enabled transfer of knowledge and skills:

- a) availability of computers (terminals, work stations, lap tops or notebooks)

- b) Internet or Intranet connection with acceptable data transfer speed (for graphics) and access right to electronic learning resources;
- c) learner’s basic knowledge and skill soft handling hardware and using computer (programs),
- d) availability of electronic learning materials such as courses, lessons, tests etc.

On one hand e-Learning offers flexibility (in terms of time, place and pace), on the other hand it requires all above conditions.

More and more e-Learning contents are offered by training providers—including prestigious universities—for free to the wide audience, however, within the leather value chain there are only few such training tools available. Mainly due to size of the sector and subsectors and costs associated with the Learning Content Development (LCD).

UNIDO has started to build range of courses and learning content (LCD) for the leather value chain :

- i. Introduction to treatment of tannery effluents (5 modules)
- ii. How to deal with hydrogen sulphide gas (module & test & certificate)
- iii. First Aid (9 modules)
- iv. Sustainable leather processing (course planned)



Figure 1: Example of the Learning Content for the Module: How to deal with hydrogen sulphide gas – publication – animated visual training – test - certificate

Main objectives of learning content development are :

- ✓ to provide access to up-date training programmes for training institutions especially in developing countries with limited resources;
- ✓ access to all students and trainees as access to education and training should be accessible to all and consequently it should lead to the development of the leather sector;
- ✓ same time with access to some region is not possible due to security issues and UNIDO is providing also assistance to such countries, on-line training and assistance is an opportunity to assist such regions;
- ✓ last but not least also it reduces costs of training.

The e-Learning environment (Fig.2) is fairly different from that of conventional face-to-face and self-training. Learning content (objects) and the training community (composed of teachers and learners, as well as other resourceful persons accessible through the WWW) come to the parser engine—in reality a computer server-based electronic system—that personalizes the set of knowledge according to the recipient profile (including actual needs, abilities and availability). The learner invokes content at her/his liking—of course, within the planned and organized frame work ensuring logic and information logistics required for achieving the intended results (e.g. competence, certificate) and may also be forced to provide appropriate feedback (e.g. forgetting access to the next stage of learning, surveys or exams). The personal front end is the ICT gateway connected to the learning network, where as learning resources are available to the incumbent from depositories, by interacting with the supporting and/or participating community. All activities, achievements, feedbacks and rewards are monitored and registered (stored) by the computer network system. As most of courses implemented by UNIDO are blended courses, also face-to-face training is part of courses implemented.

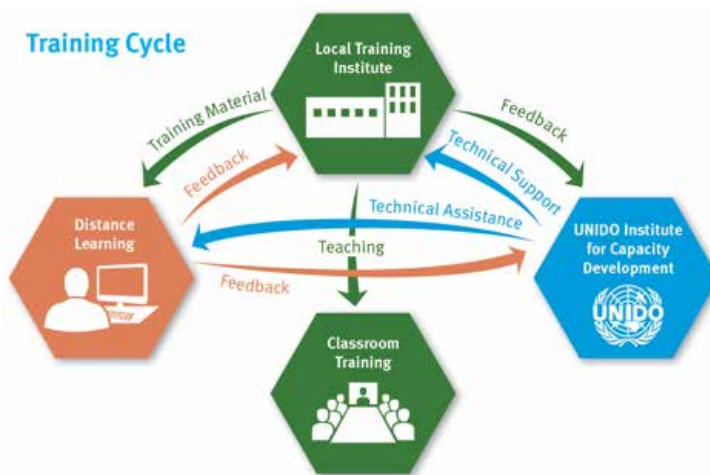


Figure 2: eLearning environment & training cycle





Blended and eLearning courses are accessible within [www.leatherpanel.org](http://www.leatherpanel.org) portal and it is already used and tested in Tanzania by Dar as Salaam Institute of Technology (DIT), Mwanza campus.

To a date, participants from more than 60 countries use training material individually.

Coordination among various organizations and institutions in development of training programmes, is one option how to maintain required level of training reflecting requirements from industry for more effective and flexible training programmes. Cooperation and joint preparation of training material will lead to an efficient use of resources.

*Keywords:* e-Learning; Skills Development; Training; Training In The Leather Value Chain; UNIDO



## **ROLE OF CSIR-CLRI IN SKILL INDIA INITIATIVE: ENRICHING PRIMARY LEVEL HUMAN RESOURCE THROUGH ARTISANAL SKILL DEVELOPMENT**

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CSIR-Central Leather Research Institute (CLRI) has catered to the artisanal training needs of the Indian leather sector since its inception through various avenues including the Leather Technology Mission. Today CSIR-CLRI, as a societal empowerment initiative, is hosting skill training programmes for the needy artisans below poverty line in different leather trades pan India with financial support from various institutions. The Institute has an outlay to train more than 10000 candidates in the next two years nurturing them to take up wage/self-employment. The paper focuses on the case study of skill development initiative taken up by CSIR-CLRI in association with several social organizations. CSIR-CLRI has successfully empowered 650 candidates in different leather trades during 2015-16 as part of the societal initiative. The study will cover a detailed analysis of the project including the skill training needs analysis, background of participants, eligibility criteria, implementation mechanism, project flow and critical phases. The trainees' perceptions on elements such as course material, infrastructure facilities and post-training assistance have been captured through feedback mechanism. Several statistical analysis tools will be employed to evaluate the results of training feedback. The primary objectives of the project include tapping the talent potential of Indian youth, improving productivity and improving quality of life of the needy. The outcomes of the training as against the objectives will be analyzed to come out with a model of success points and key areas for improvement. Thus a role model for skill development initiatives from CSIR-CLRI will be proposed for many such programmes to be taken up in future.

*Keywords: Skill Development; Societal Empowerment; Training Needs*

## GRAP O-41 INDO-ETHIOPIAN ALLIANCE FOR TRANSFORMATION OF ETHIOPIAN LEATHER SECTOR

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Leather has played an important role in the development of civilizations. Today leather products are considered to be one of the most important consumer products. Leather and leather products industry is one of the strategic sectors of Ethiopia in view of economic growth, foreign exchange and employment generation. The raw material resource is one of the strength points of Ethiopia and the Ethiopian High Land sheep skins are known for their quality to produce all kinds of leather products, particularly their suitability for making niche products such as glove leathers. Ethiopia has been consistently figuring in the list of top 30 countries contributing to the raw material base for the global leather industry. Ethiopian government has been taking proactive measures to facilitate forward integration and value addition in leather sector. The Federal Democratic Republic of Ethiopia is aiming for a giant leap in leather and leather products by providing favourable policy environment and strategic incentives for the sectors.

### **CAPACITY BUILDING ETHIOPIAN LEATHER SECTOR :**

Every development needs capacity power house from all participants of the sector. For the leather sector the capacity building program was mainly focused in two areas. These are Institutional Capacity Building Program, which was planned to build the institutional capacity of Ethiopian Leather Industry Development in order to enhance the support capacity for the sector. The other capacity building program was to enhance the capacity of the sector main players, Tanneries and Shoe manufacturers. These two capacity building programs are addressed by Twinning and Benchmarking Programs.

### **BENCHMARKING PROGRAMME**

The Ethiopian government considers that the leather industry, being the largest manufacturing industry has the potential to contribute significantly to the export earnings of the country on one hand and employment opportunities on the other. Hence, it is trying to catalyze the growth of the industry through policy interventions and intensive technology up gradation programmes through benchmarking projects for tanning and footwear industries. CSIR-Central Leather Research Institute (CSIR-CLRI) did Benchmarking - Technology up gradation of tanning sector and the programme for footwear sector was carried out by Footwear Design and Development Institute (FDDI) of India. Phase I of Benchmarking programme was undertaken between March and September 2010. CSIR-CLRI deputed project team to undertake technology up gradation programme at selected tanneries in Ethiopia. After the successful completion of first phase Benchmarking programme, second phase programme was carried out in selected eleven tanneries for the period



between January and August 2011. The benchmarking programmes were leading to self-sustainability of the Ethiopian tanneries in terms of new products development, competence building in the areas of research & development, technical up gradation, Product & Quality standardization and productivity enhancement with system formulation and implementation for production of finished leathers for export. Subsequent to the successful implementation in capacity building of Ethiopian tanneries, Govt of Ethiopia banned the export of intermediate processed leathers, exports of finished leather and leather products only were permitted.

The various action modules covered under the benchmarking programme are as follows:

- Selection of new products/Development or standardization of process technology/ Market linkage / Production
- Up gradation of lower ends and full exploitation of splits

*Strengthening of technological capabilities for the production of glove and suede leathers*

- Strengthening of tannery machinery system
- Training of Machine operators (buffing and polishing)
- Ensuring implementation of an integrated system for efficiency & profitability enhancement in tanneries
- Capacity building in the finished leather production
- Article specific quality control, machine operation, planning

## **Capacity Building Ethiopian Leather Industry Development Institute : Twinning Programme**

Leather Industry Development Institute (LIDI) has been established by the Govt. of Ethiopia primarily to serve the leather and products sectors. Through LIDI, Ethiopian Government had executed Benchmarking - Technology Upgradation of Ethiopian Leather and Leather Products sector. In view of the new national policy on leather and leather product sectors, the support systems in terms of technology supply, manpower development in Ethiopia are needed to be in place. The role to be played by LIDI in this context are much crucial. In order to realize the national goals and vision, LIDI's capability and capacity need to be enhanced significantly. The transformation of LIDI to be capable of serving the industry and ultimately to bring about the envisaged growth of the leather and leather products sectors, a project to Twin the capabilities of CSIR-CLRI by LIDI was envisioned. The TWINNING project had been structured, planned and executed taking into account the principal objective of transforming LIDI. The ultimate transformation would enhance LIDI's capability to offer all the needed services and support for the whole leather value chain. The major objectives of the Twinning project are as follows.

- Creating and providing intellectual and skilled manpower to cater to the requirements of the industry



- Providing technical support in all the spheres of leather and leather product sectors
- Providing services to the industry such as testing, certification and establishing norms or standards
- Forecasting the global market dynamics and preparing the Ethiopian leather and leather products sectors to meet the changing requirements
- Creating functional tripartite linkage among the University, R&D/laboratories and industry to start real time activities in research and training during the twinning period for strengthening B.Sc programme and commencing M.Sc. and PhD programmes in leather.
- To act as a nodal centre for training the trainers who in turn will serve the TVET centres
- To promote and support the growth of SME in leather and leather products sector through various entrepreneurship development programmes

CSIR-CLRI had given a comprehensive proposal for enabling LIDI to become a globally competent centre. The twinning programme was carried out for a period of three years between 2011 and 2014. The major areas covered under twinning are strengthening academic programmes of LIDI, providing industrial consultancy in the areas of leather and products through applied research, establishing testing services and human resource development for the product sector through vocational programmes.

Footwear Design and Development Institute (FDDI) had been a partner to carry out activities related to the areas of footwear and leather goods. A total of about 600 man-month interventions had taken place for carrying out the activities under twinning project.

## **Summary on Accomplishments of Twinning Programme Phase I**

### **To capacitate LIDI to undertake and carry out research and development activities in leather, leather products and allied areas**

#### **Accomplishments**

- A state-of-the-art laboratory established
- Two product development centres are established both for the footwear and articles.
- Joint R&D programs in leather and products undertaken
- Academic projects carried out under M Sc programs
- Research works are carried out through Ph D programmes



**Outputs:**

- One paper presented in Turkey IULTCS (2013)
- Two papers presented in Asia congress held in Japan (2014)
- About 10 publications made in peer reviewed scientific journals
- Two patents filed
- Spin off projects (a. Study of histology of Ethiopian hides and skins: ETB 2 million; b. Multifunctional Fatliquor from indigenous source: ETB 0.8 million from MoS&T) secured

**To capacitate LIDI to undertake industrial consultancy activities in leather, leather products and allied areas**

**Accomplishments**

- Consultancy projects in leather (M/s Sheba Tannery), in products (M/s Anbesa, M/s ELICO, M/s Sheba) have been taken up and completed
- Training of manpower for M/s Pittards completed

**Outputs:**

- As many as five industrial units benefitted
- About 15 personnel (of LIDI) were trained on consultancy in leather and leather products areas
- One consultancy service (post-twinning) has been taken up in ELICO by Leather Technology Directorate
- Consultancy services have been taken up in product units too

**To capacitate LIDI to establish/strengthen academic (B Sc) and skill development program (TVET)**

**Accomplishments**

- Academy - Research linkage established between LIDI on one part and Addis Ababa institute of Technology, College of Veterinary medicine & agriculture and Addis Ababa Science and Technology University on the other
- B Sc program curriculum reviewed and B Sc program conducted for three years
- First degree program for footwear and leather products was started with Addis Ababa Science and Technology University.
- TVET (leather and goods & garments) curriculum reviewed, syllabus prepared and teaching and learning materials prepared

**Outputs:**

- LIDI capacitated in conducting the B Sc program in Leather and Footwear Technology
- LIDI also capacitated in conducting TVET programs

**To capacitate LIDI to provide testing and analytical services with excellence of international position****Accomplishments:**

- CLRI facilitated the modernization of testing and analytical laboratory
- Series of advanced training programs conducted at LIDI and at CLRI

**Outputs:**

- Physical testing and chemical analysis laboratory capacitated to perform to meet international requirements

**To capacitate LIDI to develop built-in mechanism for continual improvement****Accomplishments:**

- A quality management system in accordance to ISO 9001 has been designed and implemented
- Organization restructured
- Training provided to enhance administrative capability of LIDI

**Outputs :**

- New structure of organization is in place
- This led to the basis for organization restructuring many similar organizations
- LIDI - world's first leather institute certified with ISO 9001
- Biometric system introduced in LIDI

**To improve the overall management and functional capability of LIDI****Accomplishments:**

- Training in internet and intranet provided
- Video-conference facility established
- LIDI website modified
- Intranet established in LIDI
- Software for purchase developed



## Personnel trained on leadership skills and soft skills

### Outputs:

- LIDI is internet and intranet capable
- Video-conference facility will enhance the long distance communication and discussion
- The overall soft skills ability of LIDI top management personnel enhanced

### Twinning Programme Phase II

After the successful completion of Phase I Twinning project, second phase of twinning project between CSIR-CLRI and LIDI commenced from June 2015. The focus on the Phase II twinning project had been to strengthen Environment Engineering, consultancy and technology development & transfer activities.

### Alliance: Way Forward

CSIR-CLRI and LIDI Twinning is a great partnership that proves to be a fitting model of win-win, which built not only the collaboration between two institutes but also two countries. The alliance established between LIDI and CSIR-CLRI is a role model for capacity building of institution and industry. The ties between LIDI and CSIR-CLRI are expected to grow from strength to strength for the sustainable development of global leather sector.



**GRAP O-42****DEVELOPMENT OF AN INTERNATIONAL  
PROFICIENCY TESTING BY INTERLABORATORY  
COMPARISON APPLIED TO PHYSICAL AND CHEMICAL  
TEST METHODS FOR MINERAL TANNED LEATHER****Carlos Amador Meza Moya**

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Given the environment of global competition for markets, the leather industry and footwear must be able to demonstrate the confidence that it has on the quality of the marketed materials and products, so that it must be supported by third-party laboratories using quality assurance mechanisms that provide customers with great confidence, objectivity, transparency, compliance with the international system of units, and especially to achieve greater accuracy and traceability to the available reference materials.

In this context, one of the problems experienced by a leather testing laboratories in the world has to do with the inability to demonstrate expertise in international testing methods determined by third-party organizations (proficiency testing providers to the industry leather), because the business opportunities are limited because they cannot prove competitive advantages (technical expertise for carrying out mechanical tests materials leather-footwear) over other testing laboratories.

Through the United Nations Development Program, supported by the governments of Mexico (AMEXID) and Uruguay (AUCI) and the participation of more than ten countries in America and Europe was developed a project for two international rounds of proficiency testing by interlaboratory comparison according to the guidelines of the ISO / IEC 17043:2010, in order to demonstrate competence in carrying out the test methods for mineral-tanned leathers and increase the competitiveness of the leather-footwear industry sector, with some of the following objectives: 1) demonstrate consistency of results between laboratories, 2) determine the performance of individual laboratories for specific tests or measurements, 3) help identify problems in laboratories and initiate actions to remedy these problems, 4) establish the effectiveness and compatibility tests or new measurement methods and similarly, 5) to monitor established methods. 6) Identify differences between laboratories, 7) to determine the performance characteristics of a method, 8) Assign values to the MRC and assess whether they are suitable for use in specific procedures or specific tests.

It is concluded by means of this study that was possible to consider the repeatability and reproducibility obtained from this proficiency testing by interlaboratory, to improve the trustability in the emission of the testing results.

It is recommended that participants promote normalization method to improve the satisfaction rate method.

*Keywords: Proficiency Testing; Quality; Leather*





# ABSTRACTS OF POSTER PRESENTATIONS



FLS P-01

## COMBINATION TANNING BASED ON TARA AND SODIUM METASILICATE - A NEW CHROME FREE TANNING SYSTEM

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Chrome is the well-established tanning system adopted globally. Consumer awareness and short coming of chrome tanning system calls for a need for the development of chrome free tanning, Hence, this research work is focused on, the development of silica-Tara combination tanning system as an alternative to chrome tanning. This tanning system eliminates the use of chromium in tanning process to avoid environmental impact. The combination tanning based on masked (citrate and tartrate) silica and tara were optimised for the amount of tara, order of addition and masking salt used for the preparation of silica tanning agent. The order of addition of silica and tara, amount of tara and also the type of masking agent had a significant influence on the shrinkage temperature, physical strength and organoleptic properties of the leathers produced. Tanning system with tara followed by masked silica resulted in wet white leathers with shrinkage temperature of 80°C. Among the combination system evaluated, leathers obtained by Tara tannage followed by masked sodium metasilicate were observed to be stronger, fuller and better general appearance with the durable characteristics. In contrast, pretannage with masked sodium metasilicate resulted poor organoleptic properties and less hydrothermal stability. In general the characteristics of the leathers obtained by tara- silica combination system provides leathers with good organoleptic properties and comparable physical strength for upper leathers tanned with chrome. Skins stabilized with tara - silica combination tanning could be adapted to shaving readily; most important is that it would not produce wastes containing chromium which is zero chrome discharge. The tara-silica combination tanning system also resulted in leathers with good buffeability and hence the leather made from this tanning system is also suitable for the manufacture of suede leathers especially for upper. The cost of the new system is higher but can be compensated with the environmental benefits.

*Keywords:* Tara; Silica; Chrome Free; Vegetable Tanning; Combination Tanning



## PHYSICOCHEMICAL PROPERTIES OF COLLAGEN ISOLATED FROM LUMPFISH SKIN IN COMPARISON WITH PIGSKIN COLLAGEN

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The outer skin of mammal is the main raw material of leather industry, such as, bovine hide, pig skin, sheep skin, etc. Furthermore, a variety of fish skins is also used to produce leather because of its structural characters of layer. Main fish skin products are belts, accessories and art crafts welcomed by the consumers. However, since the area of fish skin is small, fish skin leather only accounts for less than 0.1% of the total leather. As the main component of leather, collagen has been extensively utilized in food and cosmetic industries due to its excellent biocompatibility and safety. In this paper, lumpfish skin was used as raw material to extract acid soluble collagen (ASC) and pepsin soluble collagen (PSC) with triple helical structure by two different extraction approaches. For comparison, collagen (PPSC) was extracted from pig skin using a pepsin digestion method. Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) pattern revealed that ASC and PSC were typical type I collagen, consisting of  $\alpha_1$ ,  $\alpha_2$  and  $\beta$ -chains. Fourier transform infrared (FTIR) spectra of ASC and PSC were observed and suggesting that pepsin hydrolysis did not affect the secondary structure of collagen, especially triple-helical structure. For ASC and PSC from lumpfish skin, the isoelectric points (pIs) were recorded at pH 5.33 and 4.71 respectively, which supposed to be correlated with acidic and basic amino acids residues. the pIs of PSC and PPSC were lower than that of ASC, this might be attributed to pepsin cleaved the telopeptide region, resulting to difference in amino acid composition in  $\alpha$ -chains. The denaturation temperatures ( $T_d$ ) from the thermal denaturation curve were calculated to be 17.9 °C and 17.5 °C respectively. The  $T_d$  of ASC, PSC from lumpfish skin were significantly lower than that of PPSC (37.9 °C). The results further support that the thermal stability of collagen is correlated with the environmental and body temperature of fish. This research suggests that the outer skin of lumpfish could serve as an alternative raw material of collagen.

*Keywords:* Physicochemical properties, Lumpfish skin collagen, Pigskin collagen

FLS P-03

## THE AGGREGATION BEHAVIOR OF COLLAGEN MOLECULES IN DIFFERENT CONCENTRATIONS OF ACETIC ACID SOLUTION

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A large amounts of bovine split wastes were discharged in the leather industry, which contained high-value native collagen. Collagen-based materials were often used in the form of solution or involved in processing of collagen solution. However, collagen molecules have tendency to entangle and aggregate in solution. The physicochemical properties of collagen were correlated to its aggregation behavior in solution. Systematic studies on the aggregation behavior of collagen molecules in different concentrations of acetic acid (AA) was performed to provide information on their utilization. For this purpose, collagen solutions in the presence of 0.1-2.0 M acetic acid (AA) were investigated. Fluorescence measurement of pyrene showed that the critical aggregation concentration (CAC) of collagen increased from 0.518 to 1.581 within the AA concentration ranging from 0.1 to 2.0 M, indicating that aggregated state of collagen molecules was associated with AA concentration. A distinct decrease (from 2027.1 to 846.5 nm) in the average size of collagen aggregates across the whole AA concentration range was detected by dynamic light scattering, which demonstrated that the disaggregation of collagen aggregates was enhanced with the increase in electrostatic repulsion between collagen chains. Meanwhile, the value of intrinsic viscosity decreased from 14.16 to 9.60 g/dL and the Huggins coefficient increased from 0.786 to 1.635 were obtained in the intrinsic viscosity measurement, suggesting that the molecular interaction among collagen molecules was depended on the AA concentration. Furthermore, the increased fluorescence anisotropy (from 0.1289 to 0.1997) demonstrated that the rotation of collagen molecules became restricted with the increase of AA concentration, indicating that the rigidity of collagen molecules in solution was strengthened through the greater ionization of AA solution. As observed by automatic force microscopy, collagen fibers were overlapped with each other and displayed a disordered morphology above CAC, while the collagen fibers were separated from each other and displayed an oriented morphology below CAC. This observation was manifested by the changes in the aggregation behavior of collagen molecules aforementioned fluorescence polarization analysis.

*Keywords:* Collagen Molecules; Acetic Acid; Aggregation Behavior



## THERMAL AND ANTIMICROBIAL CHARACTERIZATION OF OLEA EUROPAEA LEAF REINFORCED TPU-BASED BIO-COMPOSITES

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In this study, the use of plant leaf obtained after the harvest as a potential reinforcement material in polymer composites was investigated for the production of footwear sole material. For this purpose, olive (*Olea europaea*) leaf was used as the reinforcement material for thermoplastic polyurethane (TPU) based composites. Alkali and silane treatments were applied for modifying the surface of olive leaf to increase the compatibility between the filler and polymer matrix. The preparation of the composites with different filler loadings (10, 20 and 30 wt%) was performed via hot melt extrusion. The bio-composites were characterized using Fourier Transform Infrared (FT-IR) Spectroscopy, Differential Scanning Calorimeter (DSC), Thermogravimetric Analysis (TGA) and Scanning Electron Microscopy (SEM) analyses and antimicrobial studies. The antimicrobial activity was tested with Gram-positive and Gram-negative bacterial strains for the prepared bio-composites. The FT-IR results showed that the olive leaf was incorporated into the polyurethane matrix successfully and partial structural modifications were occurred as a result of the alkali treatments. Although the thermal resistance of composite materials at low temperatures was found slightly lower than the TPU, higher thermal resistance values were obtained at higher temperatures. The obtained bio-composite materials were found to be a good candidate to use as bio based antimicrobial footwear sole material.

*Keywords:* Bio-composites, olive leaf, TPU, DSC, FT-IR, SEM, antimicrobial activity



FLS P-05

## ENCAPSULATED CHLORHEXIDINE DIGLUCONATE USAGE ON THE DIABETIC FOOTWEAR UPPER LEATHERS

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It is important for a therapeutic shoe to have a wearable quality and its comfortable use is also prominent in terms of providing an increase in user's quality of life. In long-term treatment of diseases, medical products which are to be manufactured with medical leather materials might be a prominent alternative via local effect application as an adjuvant to the treatment.

It is aimed in this study to produce micro-particles which contain the active agent chlorhexidine digluconate and application of these micro-particles on vamp leather for manufacturing diabetic shoes while providing them a functional quality. Within the scope of the project, micro-particles loaded with drugs were obtained via spraying chlorhexidine digluconate active agent and through spraying with ethyl cellulose polymere and ustulation. In vitro characterisation studies were performed on the acquired microparticles. Additionally, active agent quantitation and in vitro drug delivery studies were also performed. Following the studies, the determined optimum microparticle formulations were applied on the leather, then existence and efficiency of microparticles within the leather was shown in the subsequent studies.

*Keywords:* Chlorhexidine Digluconate, Encapsulation, Diabetic Shoes, Leather



## AN INVESTIGATION ON FUNGICIDAL MECHANISM OF BIOCIDES ON NEW ASPERGILLUS VERSICOLOR STRAIN-TANCK-1 ISOLATED FROM LEATHER WATCH STRAP

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A new fungal species growing on leather watch strap has been isolated and characterized by 18s rRNA sequencing and found to be *Aspergillus versicolor* (GenBank accession number KX814964). Three fungicidal formulations used in leather industry were evaluated for their efficacy in controlling the growth of this fungal isolate. Among the three biocide formulations, 2-(Thiocyanomethylthio) benzothiazole was found to effectively inhibit the fungal growth with minimum dosage (MIC of 31.2µg/ml) when compared to potassium dimethyldithiocarbamate (MIC- 1250µg/ml) and 2,2,dibromo-3-nitrilo propionamide (MIC- 625µg/ml). The mode of action of the fungicides at 2-fold MIC dosage on 3-5days old fungal mycelium was also studied. There is an increase in the membrane permeability in the biocide treated samples, which is evident from cellular release and decrease in cellular ergosterol content. The effect of biocide on cell wall seems to be very negligible as evidenced from little change in the chitin content. Scanning electron microscopy study reveals that there is a considerable change in the mycelium with the collapse of hyphae structure and the effect was observed to be very pronounced in the case of dimethyldithiocarbamate and 2,2,dibromo-3-nitrilo propionamide, where the hyphae seem to have totally collapsed with considerable reduction in thickness. The spores also seem to have shrunk in size with biocide treatment. It appears from the results that all three biocides bring about fungal inhibition through membrane damage with almost negligible effect on the cell wall.

*Keywords:* *Aspergillus versicolor, Chitin, Ergosterol, Fungicides, Leather Watch Strap, SEM, 18S rRNA.*

FLS P-07

## INFLUENCE OF THE STATUS OF LEATHER COLLAGEN ON THE PENETRATION AND FILLING OF MIMOSA EXTRACT

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Gelatin solution, gelatin gel and pickled skin were chosen to represent the three kinds of status of leather collagen. The penetration, filling and combination between leather collagen and vegetable tannin extract were investigated by measuring the ultraviolet absorbance of mimosa extract solution, thickness, area and bursting strength of skin at different stages when adjusting the concentration and pH value of gelatin solution and the charge status of skin. Although the experimental phenomena when adding mimosa extract into three kinds of leather collagen system were different, the results were the same. When pH value was higher than 5, mimosa extract did not combine gelatin in solution state. When pH value was lower than 4.5, mimosa extract combined with gelatin immediately and precipitation appeared. When pH value was 5, mimosa extract combined with gelatin also. The penetration rate of mimosa extract in gelatin gel was larger when pH value ranged from 4.5 to 5.1. When pH value was 3.5, the penetration rate was smaller. Moreover with the increase of the ratio between mimosa extract and gelatin (M/G), the penetration rate of mimosa extract became bigger. As to pickled skin, when the pH value before vegetable tanning was 5.0 and after tanning was 3.5~4.5, the absorption rate, filling and combination of mimosa extract were good.

*Keywords:* Mimosa Extract; Penetration; Filling; Gelatin Solution; Gelatin Gel; Pickled Skin



## STUDIES ON EFFECT OF DIFFERNT PIGMENT AND BINDER COMBINATIONS ON SURFACE PROPERTY OF FINISHED LEATHER

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The present work attempts to analyze the surface and physical properties of leathers finished with various combinations of binders and pigments by keeping other auxiliaries constant. The contact angles of liquid drops resting on the leather surface have been used to evaluate surface energy, acidity, basicity components of the surface energy, polarity and work of adhesion. Contact angle values have been measured for chrome tanned and conventionally re-tanned crust and finished leather made by varying pigment and binder combinations. The wettability of finished leather has been correlated with the contact angle values: the higher the contact angle value the less wetting is observed. Complete wetting can be obtained when the contact angle value is zero i.e. the drop of liquid spread spontaneously on the surface and partial wetting is obtained when the contact angle value is in between 00 and 90o. Acrylic binders with different film forming properties, protein, polyurethane and butadiene binders have been combined to prepare different finish formulations. Pigment to binder ratio for acrylic system and acrylic with polyurethane binder system have been optimized from the information obtained from contact angle values which have direct relation to degree of wetting. And the results have been correlated with wet and dry rub fastness, finish adhesion, vamp flexing value, water vapour permeability and water proofness. It has been observed that when the surface of leather is coated with acrylic binder the contact angle value due to polar solvents(water) , non polar solvents(hexadecane) and moderately polar( DMSO) and methyl iodide show that as the thickness of coating increases, the contact angle value decreases for the base coat and sharply increases when top coat is applied. Top coats have the ability to increase the contact angle and they improve the performance properties of leather such as water resistance, fastness, finish adhesion etc. Cationic and anionic finishing formulations have been compared to study their effect in modifying the surface of finished leather based on contact angle values, wet and dry fastness to circular rubbing and water resistance. It has been observed that leathers finished using anionic finishing technique shows better wet rub fastness and water resistance effect compared to cationic finishing technique.

*Keywords:* Contact Angle, Surface Energy, Cationic Finishing, Anionic Finishing, Work Of Adhesion, Acidity, Basicity

FLS P-09

## DEVELOPMENT OF BIO-ACCEPTABLE LEATHER USING BAGASSE

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Leather is extensively used in the manufacture of various life style accessories such as shoes, bags, garments, and upholstery (automobile and furniture). The leather waste generated from leather products manufacturing industries, and the products after the intended life, results in the generation of huge amount of solid wastes. The compilation of leather waste generated by leather and leather products sector alone accounts to more than 2500 tons/year. Hence, studies on making leather amenable for easy disposal after its intended use is a priority research. Tanning would be a critical process, which would have significant impact on the degradability of the leather.

A unique process is proposed for the development of tanning system and leather, which would be amenable for easy disposal (degradation under specific environmental conditions) after the life cycle of intended product usage. In this present work, bagasse a byproduct of sugarcane industry, which is rich in cellulose content is proposed for use as tanning agent after converting them into dialdehyde cellulose (DAC) by oxidation method. The conventional delimed pelt is proposed to be tanned using DAC, followed by post tanning and finishing process using greener chemicals. The processed crust leather showed significant resistance to collagenase degradation, which clearly establishes the tanning efficiency of the prepared DAC. The tanned leather resulted in good mechanical strength. Fungal strains, which were isolated from hydrolyzed bagasse solution, were tested for the degradation of the crust leather tanned with DAC. Delimed pelt, chrome tanned, and vegetable tanned crust leathers were used as control for degradation assay. It had been observed that the leather from the newly developed tanning system showed significant resistance to degradation in comparison to delimed pelt. However with reference to chrome and vegetable tanned leather, DAC tanned leather showed better biodegradation.

*Keywords:* Bagasse, Dialdehyde cellulose, Tanning, Bio-degradation



## SOLID STATE NMR STUDIES ON COLLAGEN FIBRE MATRIX

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Nuclear Magnetic Resonance (NMR) is a non-destructive technique plays a very crucial role, providing details at the atomistic level. The uniqueness of NMR arises from the fact that it can be utilized for the study of hard as well as soft solids and also crystalline and amorphous materials. The initial aim of this work was to assess the feasibility of using solid state NMR for the characterization of leather samples. Chrome tanned leather samples were treated with and without dye (in dry and wet conditions). Solid state  $^{13}\text{C}$  CPMAS NMR measurements were intended for the evaluation of the structure and dynamics of collagen, which is a basic constituent of leather. In addition, wideline  $^1\text{H}$  NMR studies with a view to evaluate the role of water environments in collagen will be presented.

*Keywords:* Solid state NMR, Collagen, CPMAS, wideline  $^1\text{H}$  NMR

FLS P-11

## INTERLABORATORY COMPARISON FOR PHYSICAL AND CHEMICAL TEST ON LEATHER IN AMERICA AND EUROPE FOLLOWING CRITERIA OF ISO/IEC 17043

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Interlaboratory comparison for leather has been a challenge. The heterogeneity of the material and the variability of the test itself, shows that many variables affects the final result. LATU and CIATEC participated in a project supported by the International Cooperation Agencies of Uruguay and Mexico and developed a technique for processing cow leather capable to be used as a material for interlaboratory comparison. The program was organized by CIATEC in collaboration with LATU, following the criteria in ISO/IEC 17043:2010.

The performed standards by the laboratories were: determination of tensile strength and extension percentage (IULTCS/IUP 6: 2011), determination of tear load (IULTCS/IUP 8-1:2002), determination of pH (IULTCS/IUC 11:2008) and determination of chromic oxide content (IULTCS/IUC 8-1:2007).

Two rounds of two different samples of leather each have been executed and 20 laboratories from America and Europe have participated on each round. The evaluation of results was performed using Z-score according to Annex B of ISO/IEC 17043:2010. The criteria to establish the assigned value for the different parameters was Annex C of ISO 13528. In both rounds, satisfaction percentage was above 70% for the interlaboratory participation. The performance of laboratories between rounds shows an improvement of the determination for physical tests (in average).

Finally it can be affirmed that the design and methodology used of the interlaboratory comparison is fitted for the purpose to evaluate the participants performance for all the tests executed.

*Keywords:* Interlaboratory Comparison, Leather, Tensile Strength, Tear Load, Physical Tests, Chemical Tests, Total Chromium, Ph, Quality Control



## A COMBINATION OF ANALYTICAL METHODS TO COMPARE THE THERMAL STABILITY AND EVOLUTION PRODUCTS OF LEATHER TANNED BY DIFFERENT AGENTS

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Tanning is the most important process of treating skins and hides of animals to produce leather, which is more durable and less susceptible to decomposition. Tanning hide powder into leather involves a process which permanently alters the protein structure of skin. In this paper, much progress has been made in elucidating relationship between tanning solution concentrations and thermal stability. We study the thermal stability by TG-DSC. We compare the thermal stability of hide powder tanned by 2.5g/L, 5g/L, 7.5g/L, 10g/L and 12.5g/L chromium solutions and hide powder tanned by 1.8g/L, 2.7g/L and 3.6g/L glutaric dialdehyde solutions. Thermogravimetric analysis simultaneously coupled with mass spectrometry and Fourier transform infrared spectrometry (FTIR) was employed to study the thermal modification and degradation of leather through in depth analysis of the evolved gas. The information on the evolution of gaseous compounds during pyrolysis under the conditions revolved in this work can be provided by TG-MS-FTIR method and their evolution are different. The evolution products were similar while the distribution is not same, and the thermal stability is different for the different concentrations. Thermal stability of pure collagen is lower than 2.5g/L chrome tanning solution tanned hide powder, and all the samples tanned by chrome solutions are almost same in thermal stability. It demonstrated that the concentration affect less in thermal stability. In DSC curves, we found the peaks in hide powder tanned by 12.5g/L chrome solution are lowest, it demonstrated that high concentration is not the optical tanning process.

*Keywords:* Thermal Stability, Leather, Decomposition, Tanning



FLS P-13

## NMR APPROACHES ON BINDING AND DYNAMICS OF POLYPHENOLS WITH COLLAGEN

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Interaction of small molecules with collagen has far reaching consequences in biological and industrial processes. The binding and dynamics of polyphenols viz., gallic acid (GA), pyrogallol (PG), catechin (CA) and epigallocatechin gallate (EGCG) with collagen (type-I), were monitored by various solution NMR parameters such as  $^1\text{H}$  and  $^{13}\text{C}$  chemical shifts ( $\delta\text{H}$  and  $\delta\text{C}$ ),  $^1\text{H}$  nonselective spin-lattice relaxation times ( $T_{1\text{NS}}$ ) and selective spin-lattice relaxation times ( $T_{1\text{SEL}}$ ) as well as spin-spin relaxation times ( $T_2$ ). In addition, saturation transfer difference (STD) NMR was employed to probe the site of GA, CA, PG, and EGCG which are in close proximity to collagen, which is further validated by Water-Ligand Observed via Gradient Spectroscopy (WaterLOGSY) experiments. The selective  $T_1$  data enabled to determine the global binding affinities of polyphenols with collagen. EGCG exhibits high binding affinity with collagen followed by CA, GA, and PG. The details of NMR results with a view to appreciate molecular insights on collagen-polyphenols interactions will be presented.

*Keywords:* Collagen, Polyphenols, NMR, spin-relaxation times, STD NMR, WaterLOGSY and global binding affinity.



## RHEOLOGY OF POLYURETHANE COPOLYMERS FOR LEATHER FINISHING

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Rheological properties of polymer coated leather and formulation for leather finishing's were examined. The flow properties of finishing agents were analyzed using Brookfield viscometer and rheometer. The effect of different formulation additives on viscosity behavior and hydrogen bonding interactions in hard segments of polyurethane (PU) copolymers have been analyzed through rheometer. The rheometric data shows the shear-thinning behavior of all the formulations. The PU copolymer formulations containing acrylic segments show the elastic behavior. The viscosity of the PU copolymer formulations does not change significantly in the Brookfield viscometer, however, could provide more reliable viscosity data. At higher concentration, the viscosity profile indicates, the dilatant behavior, due to the entanglement or physical crosslink of polyurethanes. The formulated polyurethanes show shear-thinning behavior and exhibit non-Newtonian flow properties of all the copolymers.

*Keywords:* Rheology, viscosity, leather, polyurethane, flow properties

## CHEMICAL CHARACTERIZATION OF VEGETABLE TANNINS

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During the leather making process, tanning is the most important operation, which improves the durability and practicability of leather products and prevents putrefaction, induced by the tanning agents that react with the collagen molecule, stabilizing the triple helical structure of collagen matrix; thereby the leather acquires resistance towards chemical, thermal and microbiological degradation. Natural products like vegetable tannins widely used for leather tanning. In this work, the percentage of total tannin polyphenols from Acacia, Chestnut, Tara and Quebracho extracts/preparations for tannins were quantified by the hide-powder method and the UV colorimetric method identified the total phenols percentage. Condensed tannins showed higher total tannin polyphenols : total polyphenols ratio, indicating that they may have greater interaction with collagen protein than hydrolysable tannins. The spectra of the tannin samples were recorded by Fourier-Transform Infrared Spectroscopy (FTIR) and Attenuated Total Reflectance cell (ATR), showing a clear separation between the two tannin groups. Finally, GPC (gel permeation chromatography) technic was useful to compare relative molar mass and polydispersity among the tannins. Acacia showed the lowest result of molar mass, indicating that it may penetrate more easily in the hide than the other tannins. These characterization methods are applicable for identifying properties that may explain tannins properties and their performance in leather tanning.

*Keywords:* Tanning, Vegetable Tannin, FTIR, Hide Powder, Biodegradation.



## LIME AND SULFIDE FREE UNHAIRING OF SKINS USING PROTEASE ENZYME AND SODIUM HYDROXIDE

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The leather industry boasts many accolades such as contributing to the growing economy, generating employment and uplifting the image of the industry amongst the other industries. Although, the industry is notorious for the huge amounts of pollution load that it generates during the course of leather making. Liming, a prime pre-tanning operation that shapes the leather, is also the main cause of pollution. Lime and sulfide had been reported to be incontrovertibly malevolent, since past few years. Replacing the sulfide with enzyme for eco-friendly unhairing had been the most sought after option but the characteristic feature given by lime needed to be met. Sodium hydroxide, a strong alkali, when given in minimum quantities could plump the skin for necessary fibre opening. The current work dealt with the unhairing of skins with an actinomycete *Brevibacterium luteolum* (MTCC 5982) based protease enzyme produced through SSF. The extracted enzyme from bran was applied as a paste to the flesh side of skin at a concentration of 5% w/w (300-400 U/ml) and unhaird after 6 hours. The pelt was then put for fibre opening in sodium hydroxide solution of varying concentration ranging from 0.1-0.5% w/w. The pollution load parameters and physical characteristics of leather were determined and compared with the conventional lime-sulfide system based pre-tanned leather. The properties of the leather obtained from sodium hydroxide based system were found to be better than the conventional lime-sulfide system based leather. Lower quantities of sodium hydroxide were required to achieve the similar plumping effect as with the case of lime. Furthermore, fibre opening using sodium hydroxide was achieved over a night whereas lime based fibre-opening took around 48 hours. Protease resulted in intact hair removal and was found to be an eco-friendlier option. The process was less time-consuming too.

*Keywords:* Protease, Unhairing, Solid-state Fermentation, Sodium hydroxide, Lime-sulfide free

FLS P-17

## A NON-CONVENTIONAL VIEW ON LEATHER SCIENCE: STRATEGY AND DESIGN OF SOLVENT SELECTION GUIDE FOR WATERLESS LEATHER MANUFACTURING

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### ***Need of Solvent Selection Guide:***

The existing knowledge on the leather science is mainly based on “Aqueous System”. In future, the industrial revolution may redefine the aqueous medium into non-aqueous. Therefore, the development solvent selection tool would provide the basic platform for the redefinition of convention leather processing.

### ***Designed Solvent Selection Guide:***

For the first time, the solvent selection guide (SSG) has been developed for leather world with a view of sustainable manufacturing. A novel “Solvent Selection Tool” has been developed to identify sustainable non-aqueous media for leather making from the solvents listed in GSK’s SSG. The developed solvent selection tool has been structured into four segments and each one has a particular screening criteria. Preliminary screening –I, based on the cumulative score of GSK’s SSG, enabled the shortlisting of 41 solvents from 110. Screening-II, based on toxicity (LD50 value > 5000 mg/kg of rat), has filtered the number of solvents down to 16 from 41. The effect of selected 16 solvents on the hydrothermal stability of skin matrix (screening- III) shows that 9 solvents namely propylene carbonate, 1,2 propane diol, 2-butanol, ethyl lactate, tetraethylene glycol, ethyl acetate, ethanol and dimethyl carbonate have no negative impact, whereas other 7 such as glycerol, DMGMBE, Diethylene glycol, propyl acetate, 1, 3 propane diol, 1,4 butane diol and 2 propanol has negative impact on thermal stability. Propylene carbonate, dimethyl carbonate, ethanol and 2-butanol show superior tanning performance (screening-IV) in terms of mass transfer efficiency (>99% w/w), hydrothermal resistance (104 °C) and leather quality than other selected solvents. The internal comparison results show that propylene carbonate is an ideal medium for sustainable tanning process. The propylene carbonate based tanning process enjoys zero discharge of water/chromium(III), avoids the usage of fungicides in tanning process and is ecologically acceptable.

*Keywords:* GSK, Solvent, Non-aqueous, Tanning



## EVALUATION OF SPECIFICITY OF PROTEASE FOR DEHAIRING

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Global concerns about environmental impact of leather industry have been forcing the tanneries to adopt cleaner leather processing technologies. Enzyme based leather processing methods have the potential to substantially reduce the pollution, toxicity and also improve leather quality. One such greener process option is in use of proteases in dehairing of skins and hides. But the important criterion in choosing enzymes for dehairing is the specificity towards the targeted biomolecules on skins. As the skin itself is a proteinous substance, use of non-specific proteases might degrade other skin proteins and cause damage to resultant leather. The present work deals with the comparative study on the specificity of a dehairing and non-dehairing protease isolated in our laboratory. Two proteases producing bacteria, *Bacillus cereus* VITSN04 and *Bacillus megaterium* VITSN02 were used in this study. Studies on the efficacy of enzymes to dehair goat skins revealed *B.cereus* protease exhibited potent dehairing efficacy whereas protease from *B.megaterium* did not. Dehairing and non-dehairing enzyme was identified as serine and metalloprotease respectively and optimal pH and temperature for activity were also determined. The study on catalytic specificity of dehairing enzyme using serine specific peptide based synthetic substrates showed that cleavage preference was for basic amino acid at P1 position and had hydrolysed trypsin specific substrate efficiently. The activity of *B.cereus* enzyme to unhair was evaluated at its specificity level using protein substrates such as keratin, collagen and proteoglycan and compared with *B.megaterium* protease. The results showed that the dehairing enzyme was non-keratinolytic, non collagenolytic but digested the proteoglycan with release of core protein in reaction solution evidenced by HPLC studies. The non dehairing protease had degraded keratin substrate but not collagen and proteoglycan. This study conclusively signifies the importance of enzyme specificity for an enzyme based dehairing process.

*Keywords:* Protease, dehairing, *Bacillus*, proteoglycan

FLS P-19

## ROLE OF COLLAGEN PEPTIDE ON CELL ADHESION AND PROLIFERATION

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Collagen type I, which is the main component of the skin is found to have several biological roles in addition to structural role. Collagen is now well known to function by interaction with specific cell receptors like integrins and promote cell adhesion and proliferation. Hence use of collagen peptides and hydrolysates in therapeutics has increased tremendously. The aim of the present study was to determine the cell adhesion and proliferative property of short amino acid sequences in type I collagen. In earlier study, a larger peptide was isolated from bovine Achilles tendon collagen which showed better cell adhesion in HeLa (epithelial) cells. From the larger peptide, smaller sequence that had role in cell interaction was identified using bioinformatics tool to focus on a shorter peptide and the activity was confirmed in HeLa cell lines. The peptides were coated onto sterile cell culture dishes at different concentrations and incubated for 6 h for adhesion and 48 h for proliferation assay and bovine tendon collagen coated dishes were used as positive control. The cell count increased with increasing concentration of peptide when compared with uncoated dish. MTT assay also showed similar results. Proliferation assay was recorded as images, which showed effective proliferation of the cells in peptide coated dishes when compared to uncoated dish. The cell adhesion and proliferation assay was performed with fibroblast (3T3-L1 cells), keratinocytes (HaCat) and compared with epithelial (HeLa) cell lines. The concentration of peptides with highest cell adhesive and proliferative activity was determined. Fluorescent staining of the cell nucleus with Hoechst 53328 exhibited no visible DNA fragmentation and active dividing cells were also observed. The results showed the effectiveness of the peptide in cell adhesion and proliferation of the cells. The peptide cell membrane interactions are to be studied in detail to completely understand the mechanism underlying the adhesion property of the peptide. This basic study on bioactive collagen peptides would provide information for development of biocompatible biomaterials and scaffolds.

*Keywords:* Collagen, Peptide, Cell adhesion, Cancer cell lines



**USE OF TERNARY SOLVENT (WATER – ETHANOL – ETHYL ACETATE) MEDIUM FOR LEATHER PROCESSING :  
A POSSIBLE PARADIGM CHANGE**

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An attempt to replace water (7-10 m<sup>3</sup>/ton) in leather processing with a ternary mixture of solvents that would have a lower boiling point than water (for easy recovery through evaporation) and also bring about maximum solubility of conventional dyes, syntans and fatliquors is reported. The ternary mixture (Water– ethanol – ethyl acetate) reported in this study provided for good solubility/dispersion of leather chemicals. Average particle size of the syntan/dye in solvent / water remaining the same, particle size distribution of dyes and syntans was advantageous in the solvent medium, leading to better diffusion. Amongst various trials, neutralization of the leathers after tanning in solvent medium followed by use of neutralization syntans was found to be more advantageous to obtain leather properties comparable to conventional controls. The adsorption studies of dye used in the present study followed Freundlich model in both solvent and water medium indicates multilayer adsorption. Physical properties of the leathers were similar to that of control, indicating clearly that the solvent had no adversary effect on collagen and also provided for good diffusion and fixation of chemicals. The method thus reported in this study could provide for a minimum change approach to leather processing with ample contribution to water saving.

Keyword: Ternary solvent, Freundlich model, diffusion



FLS P-21

## NUCLEAR MAGNETIC RESONANCE METABOLITE PROFILING OF PLASMA TREATED WITH RUMEN SUBMUCOSA COLLAGEN OR ITS CHITOSAN-TREATED FILM AS WOUND HEALANT IN RAT MODEL

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Developing an ideal wound dressing material for skin defects is a clinical emergence as it endures to be a global burden. Decellularized extracellular matrix (ECM) derivatives from various xenogeneic origins have been successfully used as dermal substitute, as it contains perpetuated bioactive molecules which serve as a regenerative template for faster dermal reconstruction. The major objective of this study is to evaluate the in-vivo biocompatibility of an un-tapped type I collagen film (COL-F) derived from bovine rumen submucosa in comparison with the same COL-F treated with 1% (w/v) chitosan solution to produce another biofilm (COL/CS-F). The comparative study includes the evaluation of physical and biological properties of the biofilms in treating open excision wounds in rats. The physical properties of the both COL-F and COL/CS-F were observed to possess excellent fluid uptake ability, good water retention and controlled degradation kinetics. The topical application of the biofilms resulted in exquisite wound healing on day 16 with wound contraction rate of  $92.83 \pm 0.95\%$  and  $94.83 \pm 0.46\%$  for COL-F and COL/CS-F respectively. The estimation of biochemical parameters (collagen, hexosamine and uronic acid) was correlated with histological observations which elucidates the evidence of effective collagen synthesis and tissue vascularisation as a result of better wound prognosis. The metabolomics of the wound healing phase was acquired by Nuclear Magnetic Resonance (NMR) spectrometer, which demonstrates time-dependent up and down regulation of metabolites in response to injury. Overall, the presence of chitosan in the COL-F accelerated wound healing by exerting relevant biomimetic and chemotactic effects at the wound surface. The ability of COL-F and COL/CS-F to treat open wounds with favourable tissue re-epithelisation and remodelling at a shorter duration demonstrates its potential feasibility in the field of skin tissue engineering.

*Keywords:* Collagen, Chitosan, Proton NMR, Wound healing, Metabolomics



**THE EFFECT OF MINERAL TANNAGES  
ON THE STRUCTURAL PROPERTIES OF LEATHER :  
INSIGHTS FROM SMALL ANGLE SCATTERING  
(SAXS) STUDIES**

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The fundamental aspects of the interaction of collagen with mineral tannages such as chromium (III), zirconium (iv) and aluminium (iii) and, their effect on structure and molecular level changes has been studied using small angle scattering (SAXS) and Differential Scanning Calorimetry (DSC). The role of bound and unbound water interactions in the collagen structure were found to be dependent on the chemistries of the tanning agent and their cross-linking ability. Also for the first time using in-situ SAXS we have studied the kinetics of the tanning reactions and the changes in collagen structure during processing. The effect of mineral tannages on the structure and properties of leather will be discussed based on results from DSC, AFM, SEM and SAXS.

*Keywords: SAXS, Structure, Mechanism, Bound and Unbound water, AFM, DSC*

FLS P-23

## INTERACTIONS OF SODIUM SILICATE WITH COLLAGEN DURING TANNING

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Although chrome is used commonly and very effective as a tanning agent, its low uptake and potential toxicity has created a growing demand for environmental friendly alternatives. A fundamental mechanism and structure study was carried on using combined tannages of sodium silicate and chrome. The effects of sodium silicate and chrome on ovine skin were investigated by using small angle X-ray scattering (SAXS), atomic force microscopy (AFM), scanning electron microscopy (SEM), and differential scanning calorimetry (DSC). The overall results showed that silicate plays an independent role in tanning process from what chrome does. The effect on D-spacing and fibril diameter will be discussed based on SAXS and AFM results.

*Keywords:* Leather; Sodium Silicate; Sol-Gel; SAXS; AFM



## THE REDUCTION ABILITY OF THE ORGANIC ACID FOR HEXAVALENT CHROMIUM

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The chromium (Cr) included in the leather derived from a tanning agent often changes to harmful Cr (VI). It is evident that Cr (VI) is formed by the oxidation of the unsaturated fatty acid included in fat-liquoring agents or residual fat of chrome leather. Formed Cr (VI) is usually reduced to Cr (III) under the acid condition in the presence of adsorbed water and organic substance.

In this study, we focus on the ability of organic acid to reduction for Cr (VI). Formic acid, lactic acid, citric acid, and oxalic acid are used as organic acids which can apply to tanning processes. Propyl gallate and quercetin was adopted as reductants to compare with the reduction ability of those organic acids. In order to obtain reliable experimental findings, we have adopted the simple solution system. That is, Cr (VI) and gelatin solution system was prepared. The constant concentration of Cr (VI) and gelatin were adjusted to 50 mg/ml and 1g/100ml, respectively. By use of mineral acid, pH of the solution was adjusted to 3.5-3.8. In the presence of the organic acid, the concentration of Cr (VI) was determined at regular time intervals. The experimental results indicate that the reduction ability of organic acids is follows;

Propyl gallate = Quercetin > Lactic acid > Oxalic acid  $\cong$  Citric acid  $\cong$  Formic acid

The lactic acid which is a mild acid practically applied to the tannage. We also studied a part of the reduction mechanism of Cr (VI).

*Keywords:* Hexavalent Chromium, Reduction, Organic Acid, Lactic Acid

FLS P-25

## BIOMIMETIC FABRICATION AND CHARACTERIZATION OF COLLAGEN/PS/NBAG SCAFFOLD FOR BONE TISSUE ENGINEERING

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The bone tissue engineering scaffold was developed by compounded the type I collagen with the porous scaffold of the sol-gel derived nano-bioactive glass in the system  $\text{CaO-P}_2\text{O}_5\text{-SiO}_2\text{-Na}_2\text{O}$ . In the present study, novel biomimetic composite scaffolds, with similar properties to natural bone, were prepared, blended and cross-linked with bioactive glass, type I collagen and phosphatidylserine (PS). Several phospholipids, especially phosphatidylserine (PS) with high affinity for calcium ions have been shown to be an important component of them. Previous work had shown that PS is able to form complexes with both  $\text{Ca}^{2+}$  and  $\text{P}_i$ , nucleate hydroxyapatite formation. We choose different collagen content to confirm the maximum degree of collagen holding the collagen structure of the triple helix content;. The molecular weight of collagen characterized by electrophoresis profiles which effect on biocompatibility.

The collagen/PS/NBaG scaffold use genipin (GNP) or 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) and N-hydroxysuccinimide (NHS) as the crosslinker. The collagen/PS/NBaG scaffold was prepared by using a freeze-drying technique and characterized by scanning electron microscopy (SEM) and Transmission electron microscope (TEM). The cross-section morphology shows that the collagen/PS/NBaG scaffold possessed a three-dimensional (3D) interconnected homogenous porous structure. The porosity of the collagen/PS/NBaG scaffold sample was tested according to the Archimedes principle. The mechanical properties of the scaffolds were analyzed using a texture analyzer. XRD analysis demonstrate crystallographic properties of the scaffolds which immersing them in simulated body fluids (SBF). The functional groups of composite samples and nano-bioactive glass (NBaG) were examined by FTIR. All results demonstrate the Sol-Gel bioactive glass-type I collagen-PS scaffold with good biocompatibility and osteogenesis is a new ideal scaffold for bone tissue repair and regeneration.

*Keywords:* Collagen, Bioactive Glass, Phosphatidylserine , Freeze-Drying Technique, Scaffold



## MOLECULARLY ENGINEERED DUAL-CROSSLINKED HYDROGEL WITH GOOD ELASTICITY AND TOUGHNESS

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Articular cartilage, covering the end of long bones in bodies with almost no friction, bears the great pressure from our gravity, and withstands high impulse or shear in a large range of movement. Therefore, it is essential to develop hydrogel with good elasticity and toughness in the field of artificial cartilage. Herein, a composite hydrogel with good elasticity and toughness was prepared, using gelatin (Gel), oxide cellulose, and acrylamide. Firstly, Gel and oxidized cellulose were used to form network structure though Schiff base reaction, and then, acrylamide was allowed to penetrate into the network structure of Gel/oxidized cellulose for radical polymerization. The interweaving of two networks provides the hydrogel with good elasticity and strength. And then the ionic coordination ( $\text{CO}_2\text{LFe}^{\text{III}}$ ) was chosen as the third crosslinking to further strengthen the Gelatin/oxidized cellulose/pAAm hydrogel. The hydrogel has an advantage over each individual gels and could simulate partly the structure of native extracellular matrix of cartilage tissue. Besides, the influence of different forms of cellulose (microcrystalline cellulose, microfibrillated cellulose, cellulose nanowhisker, oxidized microcrystalline cellulose, oxidized microfibrillated cellulose, and oxidized cellulose nanowhisker) on the performance of hydrogel was investigated. The compression strength showed that the toughness of hydrogel gradually increased with increasing the content of cellulose. The loading-unloading test on the hydrogel showed the hydrogels are good in elasticity and able to recover quickly soon after removing the pressure. The results suggested that the hydrogel with good elasticity and toughness might serve as promising scaffolds for cartilage tissue engineering.

*Keywords:* Cartilage; Hydrogel; Gelatin; Cellulose; Acrylamide

FLS P-27

## BIOMATERIAL WITH TUNABLE PROPERTIES OF GELATIN AND CARBOXYMETHYL CELLULOSE VIA TEMPLATE PRECIPITATION

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A previously unreported gelatin/carboxymethyl cellulose(GEL/CMC) hybrid system was prepared by in situ precipitation method. Hydroxyapatite was precipitated in GEL and CMC bi-template and crosslinking sites were formed between the amino groups of GEL and the aldehyde groups of CMC through crosslink reaction using ethyl-3-(3-dimethylaminopropyl) carbodiimide iodide salt/N-hydroxysuccinimide (EDC/NHS). The gelatin/carboxymethyl cellulose/hydroxyapatite (GEL/CMC/HA) material was successfully prepared with different template ratios in biomimetic environment. The structure and morphology of the composite were investigated by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy(SEM). Then this novel composite material was characterized, including water absorption, water permeability and mechanical properties. Moreover, biocompatibility was evaluated by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) test.

The results revealed that HA was well assembled on the surface and inside both GEL and CMC molecular templates. GEL and CMC bi-template lead to more nucleation sites and active centers in comparison with a single GEL template system, and affect the orientation, size, and shape of the HA. SEM images showed that GEL/CMC/HA material had loose inner structure with irregular macro-pores, and HA crystals are almost completely cover the wall. The interconnected pores were in range from 100 to 300  $\mu\text{m}$  in diameter. The high permeability of composite permitted the exchange of oxygen, nutrients, and soluble metabolites. It also possessed good mechanical properties and excellent biocompatibility. Based on the experimental results above, it was suitable for various clinical applications, such as cell scaffolds and tissue regeneration. This high-performance composite material was expected to be applied in fields of biomedicine as tissue guided regeneration material.

*Keywords:* Collagen, Carboxymethyl Cellulose, Hydroxyapatite



## SYNTHESIS AND CHARACTERIZATION OF LOW MOLECULAR WEIGHT DIALDEHYDE GUAR GUM FOR COLLAGEN STABILIZATION

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Polysaccharides are sought to be alternative eco-friendly and biodegradable for collagen stabilization. Modified polysaccharides are promising alternative for conventional aldehydes in leather manufacture. Oxidation is one of the most common methods for modifying polysaccharides for collagen stabilization. However, high molecular weight of these oxidized polysaccharides decreases the water solubility. In the present work, low molecular weight dialdehyde is prepared and used as a stabilizing agent. Guar gum is a neutral polysaccharide formed by the repeating units of galactose and mannose. Periodate oxidation of guar gum with modified reaction condition yields low molecular weight dialdehyde guar gum. The formation of aldehyde group is confirmed by FT-IR analysis and the low molecular weight of the compound is determined by mass spectrometry. Collagen stabilization is carried out with low molecular weight dialdehyde guar gum. Stabilized collagen shows good thermal and enzymatic stability and the results in par with conventional aldehyde stabilizing agent. The enzymatic degradation of native collagen and crosslinked collagen films are studied against bacterial collagenase by measuring the hydroxyproline release. The DAG crosslinked collagen shows 20.68% degradation of collagen as compared to 98.63% of degradation in native collagen at 48 h period of incubation. The low molecular weight of dialdehyde mimics the effect of conventional aldehydes without any toxicity.

*Keywords:* Dialdehyde Guargum, Stabilization, Polysaccharide, Thermal Stability and Enzymatic Stability



FLS P-29

## VISCOELASTICITY OF COLLAGEN AS AN INDEX TO STUDY EFFICACY OF CROSS LINKING AGENTS

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Leather being a strategic material with its characteristic properties of porosity, moisture management and visco-elasticity, still requires a proper understanding in terms of the correlations of interface to its surface properties. Experimental tools presently available for studying surfaces and interfaces of materials cannot be used directly on leather and its composites. Hence new custom built tools are required that can analyse the cross sectional properties with the surface characteristics of leather. In this context, studies on visco-elastic behaviour of collagen have been carried out in the absence and presence of small molecules with different degrees of hydrogen bonding as well as covalent crosslinking. Among the small molecules, Cr(III) complexes, oxazolidine(Ox) and tetrakis(hydroxymethyl)phosphine sulfate (THPS), etc. have been tested for their efficacy of cross linking of collagen. The mechanical strength and visco-elastic properties of collagen with these additives have been characterized using a custom-built Quartz crystal microbalance (QCM). Plots of frequency change vs. energy dissipation ( $\Delta F$  vs.  $\Delta D$ ), various intermediate steps involved in the fibril formation have been determined. From the slope of these plots, an empirical degree of rigidity has been evaluated. These have been correlated with the visco-elasticity data and compared with microscopic as well as calorimetric data. The results will be discussed in the poster in detail.

*Keywords:* Viscoelasticity, Collagen, Polyphenols, QCM



## ISOELECTRIC POINT AND CHARGE STATE OF CHROME-FREE LEATHER DURING TANNING AND POST-TANNING PROCESSES

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Application of chrome-free tannage, aiming at eliminating chrome pollution from the source, is an inevitable trend for the sustainable development of leather industry. However, the mechanism of charge regulation of chrome-free tanning and post-tanning system remains unclear due to the lack of information on the isoelectric point (IEP) and the charge state of chrome-free leather, leading to the restriction on the development of chrome-free tannage. In this study, a novel technique based on a Zeta potential analyzer was used to measure the Zeta potential of solid leather sample, and thus the IEP of chrome-free tanned leather was obtained quickly and accurately. Several types of leather including vegetable tannin-aluminum combination tanned leathers, vegetable tannin-aldehyde combination tanned leathers and chrome-free mineral tanned leathers were used for the measurement. Under optimal tanning conditions, the IEP of chestnut tannin-aluminium combination tanned leather (5.17) was slightly higher than that of chestnut tanned leather (4.84). This suggested that the electropositivity of the veg tanned leather could be increased when Al tanning agent was involved. The IEP of mimosa-modified glutaraldehyde combination tanned leather (4.06) was significantly lower than that of mimosa tanned leather (4.61), which was in accordance with their tanning mechanisms. The IEP of a kind of zirconium-polysaccharide based ligand tanned leather was the highest (approx. 7) among the chrome-free mineral tanned leathers, which is similar with that of chrome tanned leather. During post-tanning processes, the IEP of leather decreased step by step due to the gradual binding of anionic retanning, dyeing and fatliquoring agents to leather. Compared with Cr tanned leather, the novel Zr tanned leather achieved even higher absorption rate of post-tanning chemicals as a result of its stronger electropositivity at lower pH range. As a result, a leather charge regulation theory could be established using this method to balance the post-tanning process of chrome-free tannage.

*Keywords:* Chrome-free tannage, Isoelectric point, Leather charge, Post-tanning

FLS P-31

## PHYSICO-CHEMICAL CHARACTERISTICS OF POLYALDEHYDE NANOPARTICLES AND ITS LEATHER APPLICATIONS

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Development of new tanning agent is one of the focused researches among leather research fraternity. Nanoparticle based tanning systems are developed with metal oxides have the major disadvantage of metal recovery from effluent. Modified biopolymers are reported as a stabilizing agent in leather manufacture. The present work explores the possibility of making leathers using modified biopolymer nanoparticles. Starch, a polysaccharide with high functionalization is converted into dialdehyde starch nanoparticles (DASNP). The periodate oxidation of starch is carried out in water-in-oil microemulsion to form DASNP. The size of the particles in suspension has been measured by dynamic light scattering technique. The synthesized DASNP is used for collagen stabilization. The crosslinking study of DASNP is carried out with collagen extracted from bovine tendon. The increased thermal and enzymatic stability is observed in crosslinked collagen compared to native collagen. The enzymatic degradation of collagen is greatly reduced by DASNP crosslinking and thermal stability is increased by 40°C for the crosslinked collagen. The tensile strength and elongation of the crosslinked collagen is found to be 7 Mpa and 20% respectively. DASNP crosslinking increases the load bearing capacity of collagen is evident from tensile strength. Dialdehyde starch nanoparticle crosslinking of collagen improves stability and strength of collagen.

*Keywords:* Dialdehyde Starch, Nanoparticles, Thermal Stability, Enzymatic Stability, Biopolymer.



## MOLECULAR LEVEL UNDERSTANDING OF THE STABILITY DIFFERENCE OF COLLAGEN INDUCED BY CHROMIUM SULFATE AND ALUMINIUM SULFATE

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Though the tanning process of both chromium(III) and aluminum(III) are mainly the reactions of coordination with the collagen sidechain carboxyl groups, however, the shrinkage temperature of chromium tanned leather can be up to 100°C, while aluminum tanned leather is not washable and the shrinkage temperature is only 70~75°C. It is of great significance to investigate the differences of chromium and aluminum tanning mechanism to improve aluminum tanning process. In this paper, the differences are explored from two aspects, i.e. the species distribution of tanning liquors and the thermodynamics of coordination reaction. Visual Minteq was used to study the species distribution of chromium and aluminum tanning liquors respectively. It is concluded that there are more multinuclear metal species in Cr tanning liquor than in Al tanning liquor, e.g.  $\text{Cr}_3(\text{OH})_4(\text{H}_2\text{O})_{10}^{5+}$  accounts for 66% in 0.05mol/L  $\text{Cr}_2(\text{SO}_4)_3$  and  $\text{Al}_3(\text{OH})_4(\text{H}_2\text{O})_5^{10+}$  12% in 0.05mol/L  $\text{Al}_2(\text{SO}_4)_3$ . In addition, there are large amount of negative specie  $\text{Al}(\text{SO}_4)_2(\text{H}_2\text{O})_2^-$  (up to 60% in  $\text{Al}_2(\text{SO}_4)_3$ ) of which the coordinating effect is low because of electrostatic repulsion with the ionized collagen sidechain carboxyl groups. The density functional method (DFT) was used to study the kinetics and thermodynamics of tanning reaction with Lanl2dz for chromium and aluminum atoms and 6-31g(d) for non-metal atoms, and the theoretical parameters such as the electrophilic indexes  $\omega$  and the Gibbs energy change  $\Delta_r G$  were calculated. It is indicated that the reactivity of multinuclear species is higher and the complexes of multinuclear species are more stable, and It's interesting to notice that the differences of  $\Delta_r G$  between corresponding chromium and aluminum tanning reactions are minor. Then the main reason for the lower shrinkage temperature of  $\text{Al}_2(\text{SO}_4)_3$  maybe the lower contents of multinuclear Al species and the higher content of the negative specie  $\text{Al}(\text{SO}_4)_2(\text{H}_2\text{O})_2^-$  in Al tanning liquor. These results suggested that appropriate masking agents which increase the multinuclear Al species content and decrease the negative specie content should improve aluminum tanning process.

*Keywords:* Collagen, Stability; Chromium Sulfate, Aluminium Sulfate.

FLS P-33

## THE STRUCTURE AND RHEOLOGICAL BEHAVIOR OF TYPE I COLLAGEN IN N-METHYLMORPHOLINE-N-OXIDE (NMMO)/H<sub>2</sub>O SOLUTION

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Collagen is widely used in many ways due to biocompatibility, biodegradability and low immunogenicity properties<sup>[1]</sup>. Type I collagen was extracted from pig skin with pepsin in this study, and exists as a triple helical configuration. Collagen hardly dissolves in the water, but the additions of NMMO make the process of dissolving easy. The pig skin collagen displayed two  $\alpha$  chains ( $\alpha 1$  and  $\alpha 2$ ) and one  $\beta$  chain. However, we dissolved collagen in the NMMO solution and used ethanol as a precipitating agent to obtain the regeneration collagen. The results of Sodium dodecyl sulfate-polyacrylamide gel electrophoretic (SDS-PAGE) show the structure of regeneration collagen only has  $\alpha$ -chains. Rheological measurement<sup>[2]</sup> is an effective method to evaluate the structural properties of collagen. The storage modulus ( $G'$ ), loss modulus ( $G''$ ), steady viscosity ( $\eta$ ) and complex viscosity ( $\eta^*$ ) change were measured in rheological measurement, the results showed the predominance of viscosity in NMMO solution at low concentrations of collagen and the predominance of elasticity at high concentrations of collagen. The steady viscosity of all the samples were decreased with increasing the temperature, and the  $\eta$  values were increasing with increasing the collagen concentration. The shear-thickening and shear-thinning behaviors could be observed when increasing shear rate. The viscosities is higher when the concentration increases and temperature decreases.

*Keywords:* Collagen; NMMO; SDS-PAGE; Rheology.



ACSIL P-01

## THE EFFECT OF DIFFERENT PARAFFIN EMULSIONS ON THE THERMAL STABILITY OF COLLAGEN

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Paraffin emulsions are an important lubricating agent in meeting needs for present-day leather properties. The fatliquoring process with paraffins penetrates deeply between fiber bundles and bonds physically or chemically with the reactive groups of collagen. In our study, paraffin emulsions containing ZnO nanoparticles were used to develop the stability of modified collagen. Zinc oxide paraffin emulsions were applied to the leather in the fatliquoring process. Shrinkage temperatures of leathers ( $T_s$ ) were determined with a special test apparatus according to the IUP 16 standard method. Differential scanning calorimetry (DSC) measurements carried out on the fatliquored leather at a constant heating rate were used to determine denaturation temperatures ( $T_d$ ) and melting temperatures ( $T_m$ ) of the fatliquored leather. The results of the research show that the thermal stability of leathers was improved remarkably by fatliquoring with all paraffin emulsions.

*Keywords: Paraffin emulsion, Leather, Fatliquoring, DSC, Shrinkage Temperature, Denaturation Temperature*

## ACSIL P-02

## INK DYES FOR LEATHER INDUSTRY

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Dyes and pigments offer significant potential for functional and aesthetic design of leather materials. Search for viable alternative leather colorants, which have the potential to develop new creative designs and provide functionality are presently in focus. In this context application of alternative textile dye substances that can offer special effects to leather have increasingly gained importance. In this study, the potential application of ink dyes in leather industry was investigated as an alternative to conventional dyes for the production of leathers with high fastness properties. For this purpose, leather dyeing recipes were developed by using two different ink dyes including latex and sublimation based ink dyes and applied at dyeing process of metis type crust leathers in order to produce high performance leathers. The quality performance of dyed leathers were investigated in terms of colour measurements, to-and-fro rubbing fastness, crockmeter rubbing fastness, and light fastness characteristics before and after washing leathers in a washing machine under specified conditions according to TS EN ISO 15702 standard. The colour measurements prior and subsequent to washing process were determined with Minolta CM-3600A spectrophotometer. To-and-fro rubbing, crockmeter and light fastness properties were examined in accordance with TS EN ISO 11640, ASTM D5053 and ISO 105-B02 standards respectively. The results of the study showed that latex and sublimation based ink dyes could be used as a newly adapted dye group and applied successfully in leather dyeing process for the production of leather goods with high fastness properties.

*Keywords:* Ink Dyes, Colour Fastness, Leather Dyeing, Washing Fastness, Light Fastness



ACSIL P-03

## SYNTHESIS AND APPLICATION OF WATERBORNE EPOXY RESIN TANNING AGENT

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Epoxy group has good reaction activity and can combine with the active groups of collagen. In this research, waterborne epoxy resin tanning agent was prepared by free radical copolymerization using the allyl glycidyl ether, acrylic acid and acrylamide as raw materials, then it was used in leather process for decreasing chrome pollution. The structure of epoxy resin tanning agent was characterized by fourier transform infrared spectroscopy and nuclear magnetic resonance spectroscopy. The results showed that the epoxy resin tanning agent contained carboxyl group and epoxy group. The application results showed that the shrinkage temperature of leather treated with epoxy resin associated with 2% chromium powder was 101.9°C and the thickening rate was 55.5%, which was better than those of leather tanned with 6% chromium powder. Besides, the  $\text{Cr}_2\text{O}_3$  content in effluent was reduced by 80.1% after tanning process and can reduce the pollution of the environment.

*Keywords: Waterborne Epoxy Resin; Tanning Agent; Free Radical Copolymerization*



ACSIL P-04

## POLYACRYLATE/HOLLOW ZINC OXIDE COMPOSITE EMULSION AND ITS APPLICATION IN LEATHER FINISHING

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Polyacrylate/hollow ZnO composite emulsion were prepared by physical blending of polyacrylate emulsion and hollow ZnO. The appearance, dilution stability, centrifugal stability and chemistry stability of as-obtained polyacrylate/hollow ZnO composite emulsion were measured. At last, the composite emulsion was applied in leather finishing. The results showed that polyacrylate/hollow ZnO composite emulsion has a clear bluish tinge and exhibits excellent dilution, centrifugal and chemistry stability. The comprehensive performance of the leather samples sprayed with polyacrylate/hollow ZnO composite emulsion is superior to that with pure polyacrylate emulsion. Among them, the tensile strength, water vapor permeability and air permeability are increased by 103.33%, 27.17% and 50.46%, respectively. It is mainly interpreted by the fact that the introduction of hollow ZnO into polyacrylate matrix would significantly increase the free volume in the polyacrylate film and generate interfacial pores between ZnO microstructures and polymer chains, which provide many channels for transmission of water vapor and air.

Keyword: Polyacrylate; Hollow ZnO; Leather finishing; water vapor permeability; air permeability



## UNCERTAINTY AND SENSITIVITY IN THE CARBON FOOTPRINT OF LEATHER PRODUCTS

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Carbon Footprint (CF) was used to evaluate potential environmental impacts of leather products must be taken into account considering its whole life cycle. In this paper, the bag made of leather was take as case study, uncertainty and sensitivity in the carbon footprint of leather products was given the major concern on to analyze. There were many kinds of materials used in the whole life cycle of leather products, such as leather, polyester and rubber materials, metal products, chemical materials (glue and leather, etc.) and packing materials (copy and tissue paper, etc.). It was concluded that the key of leather product CF is the amount of main material (leather), but packaging materials could not be ignored. Energy consumption scenario may be the second ranked supplier of the final value of CF, because that the CO<sub>2</sub> equivalent (kgCO<sub>2</sub>e) varied with energy material. At the meantime, the choice of waste treatment scenario had a greater effect on the ranking of leather product than parameters uncertainty in all stages. Therefore, in the early stages of ecological design of leather products and ecological control of industrial clusters, the impacts of various materials and stages on the environment should be considered and balanced to accomplish a fairest evaluation.

ACSIL P-06

## THE CHARACTERISTIC AND APPLICATION OF HIGH BASICITY CHROME TANNING AGENT

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Basicity, representing the molecular shape of Cr-complexes, is an important indicator of chrome tanning agent. The chrome tanning agent mainly produced by traditional reduction methods such as sulfur dioxide reduction method and glucose reduction method. The sulfur dioxide method produces chrome tanning agent with 33.3% basicity and the agent can have different basicity by glucose method

In this paper, the difference and specificity of the two methods were discussed. Moreover, the effect of high basicity chrome tanning agent is analyzed and the preparation process is optimized by adjusting the adding quantity of sulfuric acid. The influence factors in the process of reduction were studied, The factors affecting the reduction of dichromate in sulfuric acid dosage, carbohydrate reductant and water consumption were summarized. The reducing content of hydroxyl groups in the basic chromium lead to decreasing of the basicity, Meantime, increasing alkalinity will result in poor reducibility. Besides, Carbohydrate as the reducing agent will lead to the masking characteristic of chrome agent. Especially for high basicity chrome tanning agent, the masking effect is obvious. The structure of the chrome complexes in the high basicity chrome agent was analyzed in this paper, and the application in chromium hydroxide sludge disposal and the utilization of the Cr-sludge were explored. The application of high basicity chromitan has the important significance in Cr-wastewater recycle process.

*Keywords:* High Basicity Chrome Tanning Agents; Carbohydrate Reductant; Chrome Sludge; Resource Utilization



ACSIL P-07

## SYNTHESIS AND PROPERTIES OF GRAPHENE OXIDE / HYPERBRANCHED WATERBORNE POLYURETHANE

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Hyperbranched waterborne polyurethane (HWPU) dispersion was synthesized by using acetone base on isophorone diisocyanate(IPDI), polyether polyols(GE-220), dimethylol propionic acid(DMPA) and terminal hydroxyl hyperbranched polymers as raw materials. A series of GO/HWPU composites were prepared by adding various amounts of graphene oxide (GO) by situ polymerization process. The structure of the product was characterized by FT-IR, SEM, XRD, TG and AFM. And the mechanical properties of film formation, water absorption, hydrolysis resistance and conductivity were detected. The results were as followed: GO were grafted onto HWPU molecule. Crystalline resin was increased after GO added. When the mount of GO added is 0.6%, the thermal decomposition temperature of the pure HWPU film increased 48.67 °C and tensile strength and elongation at break increased 79.31 and 28.7% respectively. When the mount of GO added is 1.0%, the volume resistivity of the composite film reached  $4.75 \times 10^{\Omega} \cdot \text{cm}$ . Compared with the pure HWPU film, the four orders of magnitude reduced. It showed that the addition of Go can improve the polyurethane electrical insulation and good antistatic effect of composite materials.

*Keywords:* Graphene oxide, hyperbranched waetrborne polyurethane, in-situ grafting

ACSIL P-08

## MODIFIED SOYBEAN PHOSPHOLIPIDS/TITANIUM DIOXIDE NANOCOMPOSITE: PREPARATION AND APPLICATION AS FATLIQUORING AGENTS

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Lots of leather chemicals were added to obtain leather products in leather process. But some chemicals, especially natural oil or fat added in fatliquoring process, can offer a good medium for mold. It affects the appearance and properties of leather seriously. In leather factories, the makers often avoid mildew of leather by adding anti-mold agent. However, the anti-mold material used in leather has weakly binding abilities with leather fibers, poor long-times, harmful to the environment. In this research, an environmental friendly nanocomposite fatliquoring agent based on nano  $\text{TiO}_2$  was synthesized with good ability for anti-mold. Soybean phospholipid reacted with 1-allyloxy-2, 3-epoxy propane firstly. Then modified soybean phospholipid was obtained by oxidized-sulphited reaction. The modified soybean phospholipids/titanium dioxide nanocomposite (MSP/ $\text{TiO}_2$ ) was obtained by adding anatase  $\text{TiO}_2$  into modified soybean phospholipids via blending method. The results of stability showed that MSP/ $\text{TiO}_2$  had superior dilution stability and emulsion stability. The FT-IR results showed that the nanocomposite was obtained. The XRD results showed that the crystal type of  $\text{TiO}_2$  was not changed in MSP/ $\text{TiO}_2$ . DLS test showed that the average particle size of MSP/ $\text{TiO}_2$  was about 200-250 nm. Nanocomposite prepared was applied as fatliquoring agent in the leather fatliquoring process of sheepskin garment. The application results showed that the elongation at break and tear strength of leather treated with MSP/ $\text{TiO}_2$  were better than commercial fatliquoring agent. The tensile strength of leather treated with MSP/ $\text{TiO}_2$  was almost with commercial fatliquoring agent. The highest fat content reached 17.09% when leather treated with MSP/8%  $\text{TiO}_2$ . The anti-mold results showed that the leather samples treated with MSP/ $\text{TiO}_2$  had great anti-mold properties for against *Aspergillus flavus*.

*Keywords: Soybean Phospholipids; Titanium Dioxide; Blending Method; Fatliquoring Agent Of Leather*



ACSIL P-09

## CARDANOL FUNCTIONALIZED ZINC OXIDE NANOPARTICLES: ENHANCING VALUE OF LOW GRADE RAW MATERIALS

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Indian leather is known for its quality. The industry foresees an opportunity to take its present annual turnover of around 12 billion USD to 24 billion USD by 2020. This increase in turnover is only possible through better value realization from existing raw material as demographic changes and population growth in the country has resulted in stagnation in terms of raw material availability. For enhancing the raw material base, India may have to rely upon hitherto unexplored sources of raw material (conventional being – cow, buffalo, goat and sheep) or cheaper imported raw materials. Thin substance, low strength etc. are characteristic features of the unexplored material and they result in leathers which do not fetch higher value. Using vegetable tannins have not been feasible as the growth period of tannin bearing plants vis-à-vis requirement of commonly employed tannins do not match. Recent advancements in nanoscience and technology indicate that functionalized metal oxides can be employed for stabilizing collagen – providing enhanced thermal and mechanical strength to collagen tissues.

This paper presents an approach through which both these challenges, viz., that on raw material and on need alternatives to chrome tanning. Here we propose to utilize the cardanol (polyphenol, extracted from cashewnut shell) functionalized Zinc Oxide Nanoparticles (ZnO) as post tanning materials. ZnO nanoparticles were synthesized by wet chemical methods, and functionalized with cardanol. Size and morphological studies of the bare and functionalized ZnO Nps were studied by techniques like TEM, XRD and FTIR. Physical strength and organoleptic studies on post tanning using cardanol functionalized ZnO and cardanol itself have been evaluated and functionalized nanoparticles are found to be promising candidates for substance enhancement. This study thus provides a newer insight for a cleaner, economical leather processing and add value to currently less utilized leather resources.

*Keywords: Cardanols, Metal oxide nanoparticles, Functionalization, Post tanning.*

ACSIL P-10

## EFFECT OF THE POSITION OF SULFATE ON THE AGGREGATION STRUCTURE OF TYPE I COLLAGEN IN COLLAGEN/CHONDROITIN SULFATE BLENDS

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Nowadays a promising approach for the development of functional biomaterials is the combination of native extracellular matrix (ECM) components. Collagen/chondroitin sulfate (Col/CS) biomaterials have been well investigated and show many advantages. Since the sulfate group position influences the biological functions of collagen-based biomaterials which can be correlated with the aggregation state of collagen, the effects of the position of sulfate group of chondroitin sulfate (CS) on the aggregation of collagen molecules with collagen concentrations of 1.0 mg/mL under physiological conditions was studied mainly by fluorescence techniques. In this paper 4-chondroitin sulfate (CSA) and 6-chondroitin sulfate (CSC) were chosen to evaluate the effect of sulfate group position.

Both the synchronous fluorescence spectra and fluorescence emission spectra showed that the fluorescence intensity of collagen intrinsic fluorescence varied greatly with the additions of CSA and CSC. As for Col/CSA blends with ionic strength of 0.10 mol/Kg, when 9% CSA was added, the fluorescence efficiency of tyrosine residues reached the maximum which was bigger than that in pure collagen solution and with the further addition the fluorescence intensity continued to decrease. The fluorescence intensity of tyrosine residues in Col/CSA blends was similar to that in pure collagen solution when CSA content was 50% and it became the lowest when CSA content was 80%. As for Col/CSC blends with ionic strength of 0.10 mol/Kg, the fluorescence efficiency of tyrosine residues increased with the addition of CSC and reached the maximum when CSC content was 80%. The fluorescence efficiencies of tyrosine residues in Col/CSA blends were lower than those in Col/CSC blends under the same conditions. Since the fluorescence intensity was the balance result between the positive effects, such as the strengthened stability of tyrosine residues, the enhanced  $p-\pi$  conjugated effect and the increased aggregation degree of collagen, and the negative collision among molecules, it was speculated that the effect of CSC on the promotion of collagen aggregation was stronger than that of CSA and moreover the void spaces of Col/CSC network were bigger than those of Col/CSA network. The environment scanning electron microscopy images further confirmed the effect of sulfate group on the collagen aggregation structure.

*Keywords:* Type I Collagen; 4-Chondroitin Sulfate; 6-Chondroitin Sulfate; Aggregation Structure; Fluorescence Spectra Analysis



## THERMAL SENSITIVE SYNTANS FOR LEATHER MAKING

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A stimulus is the ability to detect or react to internal or external environmental change. Skin of a live animal can be termed as smart as it can respond to temperature, pressure and pain. After flaying, its ability to sense such changes is lost. In order to regain some of those smart functions, leather needs to be treated with special chemicals. Thermoresponse is one of the smart functionality which can be incorporated to leather. Leather can be made to respond to heat or cold by incorporating thermoresponsive syntans. Thermoresponsive syntans can be made by encapsulating Phase Changing Materials (PCM) into condensate polymers. PCMs are long chain hydrocarbons that are non-toxic, inexpensive and easily available for making thermoresponsive syntans. PCMs take advantage of latent heat that can be stored or released from a material. It possesses the ability to change their state with a certain temperature range, which in turn slows down the raise in temperature by absorbing heat. Phase transitions of these materials depend on the number of carbon atoms presents in their backbone. The hydrophobicity of PCMs necessitates their encapsulation into polymeric substances as core materials using melamine formaldehyde, urea formaldehyde and phenol formaldehyde condensate polymers.



ACSIL P-12

## PREPARATION, CHARACTERIZATION OF POLYMER/ LAYERED DOUBLE HYDROXIDES NANOCOMPOSITE AND ITS APPLICATION PROPERTIES IN LEATHER MAKING PROCESS

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Layered double hydroxides (LDH) are a class of ionic lamellar compounds made up of positively charged brucite-like with an interlayer region containing charge compensating anions, it can be used as precursor for the synthesis of nanocomposite. Meanwhile, it can enhance the color intensity and consistency to leather due to the positively charged layer structure of LDH. To solve the "colour-losing" effect of polyacrylic, novel LDH/ P(DMDAAC-AA-SAS) nanocomposites with LDH loading of 0.5, 1.0, 1.5, 2.%, 2.5, and 3.0% have been prepared using the polymer dimethyl diallyl ammonium chloride-acrylic acid-sodium allyl sulfonate [P(DMDAAC-AA-SAS)] and LDH through self-assembly process. Fourier transform infrared spectrometer (FTIR) analysis indicates that the nanocomposites are prepared successfully. X-ray diffraction (XRD) and transmission electron microscope (TEM) of the nanocomposites show that the LDHs are partly exfoliated, and the solubility of the LDH/P(DMDAAC-AA-SAS) is affected by the LDH loading amount. Different LDH loading amount LDH/ P(DMDAAC-AA-SAS) nanocomposites have been applied in leather process. The results show that, the leather treated by 1wt% LDH loading LDH/P(DMDAAC-AA-SAS) nanocomposite expresses better thickening rate and physical characteristics than those of P(DMDAAC-AA-SAS) treated leathers. In addition, the dyeing properties of leather treated by nanocomposite can be improved obviously.

*Keywords:* Layered Double Hydroxides, Nanocomposite, Leather Dyeing, Self-Assembly



ACSIL P-13

## THE DEVELOPMENT OF GRAPHENE FOR POLYURETHANE COMPOSITE FUNCTIONAL MATERIALS

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Graphene has a unique two-dimensional structure and excellent thermal conductivity and electrical conductivity. It can be used to modify the performance of other materials for broader application. Synthesis of composite material with polyurethane is a kind of new functional polymer material research direction and the composite material has wide application prospect. This paper reviews the preparation methods of graphene and polyurethane composite materials, as well as the application of the self-healing, UV curing, Shape memory, conductive, electromagnetic shielding, and biocompatibility properties of the composite material. Finally, we made certain outlook of the application of graphene in polyurethane.

*Keywords:* Polyurethane; Graphene; Functional Materials; Review

ACSIL P-14

## p-CONJUGATED MOLECULAR MATERIALS FOR POSSIBLE LEATHER APPLICATIONS

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Molecular materials with  $\pi$ -conjugated moieties have gained greater significance for their application in optoelectronics. Molecules with thermotropic liquid crystallinity with semiconducting property are categorized as advanced functional materials. Among the structural motifs employed for constructing such materials, functionalized thiophenes, triphenylamine, alkoxy biphenyls and phenyls cores are most popular. Further, molecules generated from triphenylamine core results in three-dimensional propeller structure which directly influences the molecular packing in solid state. In this work, we explore the utility of triphenylamine and 3-cyanothiophene based molecular materials where phenyl as well as biphenyl units are appended as side chains. These molecules are synthesized from thiophenes by direct arylation of respective brominated precursors using palladium acetate as catalyst. The mesogenic molecular materials are investigated with a hot-stage polarising microscope and differential scanning calorimetry. Accordingly, for those based on 3-cyano thiophene, nematic, smectic A and smectic C phases with excellent mesophase range are noticed depending on the length of terminal alkoxy chains. The layer ordering in smectic A and smectic C phase is established by powder X-ray diffraction, while the orientational order of all the rings of core unit is accomplished by  $^{13}\text{C}$  NMR spectroscopy. Triphenylamine based non-mesogenic molecules are analyzed for photoluminescence properties. The appearance of optical emission in solution as well as solid phase encouraged us to explore application of some of these materials in leather as surface emissive materials.

*Keywords:* p-Conjugation, 3-Cyano Thiophene, Triphenylamine, Mesogens, Optical Emission And Direct Arylation



ACSIL P-15

## FACILE SYNTHESIS OF CHITOSAN-BASED SILICA NANOCAPSULES FOR FRAGRANCE-CONTROLLED RELEASE LEATHER FINISHES

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Nowadays consumers' concern towards hygiene and active lifestyle is creating new challenges for leather industry. As is known, the intimate contact of garment leather with human body often generates unpleasant smells, which are unbearable for consumers. To better resolve this problem, fragrance-encapsulated chitosan-based silica nanocapsules for leather finishes were successfully fabricated via interfacial polymerization. The capsule structure was confirmed by transmission electron microscope (TEM), atomic force microscope (AFM) and X-ray diffractometer (XRD). Significantly, chitosan in the outer shell may endow the nanocapsule with intrinsic antimicrobial activity and film-forming capacity, while silica in the inner shell could give a sustained fragrance release. Release results indicated that these nanocapsules could ensure a lasting release for nearly 96h. Notably, the as-obtained nanocapsules exhibited obvious temperature-controlled fragrance release behaviors. The release of fragrance decreased with the increase of temperature from 20°C to 40°C, which confer the coatings with expected temperature responsiveness. More importantly, it was noted that these nanocapsules showed a good compatibility with the common used film binders during leather finishing process. Compared with those finished with pure fragrance, leather samples finished with fragrance-released chitosan-based SiO<sub>2</sub> nanocapsules demonstrated superior sustained release property, improved hygienic properties, as well as better antibacterial properties, which hold much promise in obtaining functional coatings on leather surface.

*Keywords:* Chitosan, Nanocapsule, Temperature-controlled fragrance release, Leather finishing

ACSIL P-16

**CAN NANO CHANGE THE LEATHER DYEING WORLD?****Ramalingam Sathya\*, Kalarical Janardhanan Sreeram,  
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The emerging field of nanotechnology aims at revolutionizing the industrial world via introducing nano-based material for colouring. In particular, silica based colourant nanoparticles for colouring was developed, which shows extraordinary performance in colouring world dually with self-fixing property. In this regard, the use of nano based pre-functionalised colourant, which possess perfect framed structure is unexplored in colouring world especially in leather colouring along with stabilisation. Herein, we report the inclusion of organic cationic colourant into the silica matrices by simple emulsion technique in aqueous condition. Unique photophysical properties displayed by the colourant enable the development of newer colouring method, and excellent resistance to high optical and thermal conditions. In addition, the newer system does not require any pre-treatment like acidification for fixing the colourant with minimum amount of water usage. Excellent stability from the new method of silica functionalised colouring system will not only reduce the environmental burden but also make the colouring process to be sustainable. It will also highlight some noteworthy recent avenues in using nanometre sized materials as a colouring agent for processing fibrous matrix. Finally, the developed nanoparticles containing silica based colourant with superior colouring properties forms an important area of research with significant prospects for colouring application.

*Keywords:* Polymeric Infusion, Fibrous Matrix, Dyeing, Nano Dyes, Stable Colourants.



ACSIL P-17

## EFFECT OF WATER BASED POLYURETHANE-GRAFT-ACRYLIC ACID COPOLYMERS AS TOPCOAT ON CRUST LEATHER SURFACES

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Water borne ionomer urethane/acrylic acid (WBUAA) copolymers were synthesized using controlled polymerization technique. The ionomeric WBUAA were prepared by quaternizing the copolymer of acrylic acid with different percentage of base solution and dispersed in water. The polymer structure of the copolymers was confirmed by FT-IR and FT-NMR analysis and their molecular weight was determined by GPC using waters standards. The thermal stability of the WBUAA was determined by thermogravimetric analysis, the thermogram shows that the improved thermal stability with the increasing the amount of ionic content in the acrylic acid. Differential scanning calorimetric demonstrate that the microphase separated materials as temperature increased. The WBUAA copolymer dispersions were used to apply as topcoats for skin. The performance of the copolymer dispersions as coating materials was assessed by different standard testing procedures and compared with other industrial products.

*Keywords:* Ionomer, Urethane, Leather, Acrylic Acid, Graft Copolymers

ACSIL P-18

## NANO ZNO INCORPORATED HIGH PERFORMANCE ACRYLIC BINDER FOR LEATHER COATING

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Poly acrylate /nano ZnO composite leather finishing agent was prepared by emulsion polymerization with Methyl Metha Acrylate, 2 Ethyl Hexcyl Acrylate, Lauryl Acrylate and Acrylic Acid monomers. The synthesized ZnO was incorporated during emulsion polymerization process. The ZnO incorporated acrylic binder shows better UV resistance, mechanical properties in applied leather against the control.

*Keywords:* Leather, ZnO, UV Resistance, SEM, EDAX, FT-IR, TGA, and AFM



ACSIL P-19

## HIGH PERFORMANCE PHOSPHATED ACRYLIC BINDER FOR FLAME RETARDANCE OF LEATHER COATING

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Phosphorous based flame retardant was synthesized by using dichloro ethyl phosphate in the laboratory. The synthesized Phosphorous based flame retardants were incorporated in acrylic tetra polymer binder during emulsion polymerization process. The high performance phosphated amino resin was used in leather finishing in base coat application. The flammability of the coated leather was tested by vertical flame test. The results indicate that the above flame retardants incorporated acrylic binder can enhance the flame resistance of coated leather against the control sample.

*Keywords:* Leather, Flame Retardant, SEM, EDAX, FT-IR, and TGA



ACSIL P-20

**GUARGUM INCORPORATED HIGH PERFORMANCE  
ACRYLIC RESIN BINDER FOR LEATHER FINISHING****Sudhahar Sivaraj \*, Uma Gunasekar, Swarna V Kanth,  
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Acrylic polymers used as coating binders in leather finishing. Bio polymer Guar gum was synthesized in laboratory and the same was incorporated in acrylic resin binder during emulsion polymerization process. The high performance guar gum incorporated acrylic resin was used in leather finishing in base coat application. The above guar gum incorporated acrylic binder can enhance the covering, adhesion, flow properties, against the control sample. Usage of this guar gum incorporated acrylic binder gives remarkable enhancement of covering property especially in low grade leathers against the control.

*Keywords:* Leather, Guar gum, SEM, EDAX, FT-IR, TGA, and AFM



ACSIL P-21

## GRAPHENE REINFORCED ACRYLIC POLYMER NANO COMPOSITE FOR LEATHER COATING APPLICATION

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Poly acrylate / graphene composite leather finishing agent was prepared by emulsion polymerization with Methyl Metha Acrylate, 2 Ethyl Hexcyl Acrylate, Lauryl Acrylate and Acrylic Acid monomers. The commercially available graphene was incorporated during emulsion polymerization process. The graphene incorporated acrylic binder showed the improved dielectric properties, thermal resistance, in applied leather. SEM studies showed the even distribution of graphene nanoparticles in the acrylic binder matrix. Improved thermal stability was observed by Thermo Gravimetric Analysis for the graphene nanoparicles reinforced acrylic binder.

*Keywords: Leather, Acrylic binder, SEM, Thermo Gravimetric Analysis, dielectric properties*

ACSIL P-22

**TETRAHYDRODIBENZO[A,I] PHENANTHRIDINES BASED  
CHROMOPHORES AS BIOMARKERS****Udayadasan Sathiskumar\*, Balijapalli Umamahesh, George Augustine,  
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The application of luminescent molecules is of great interest due to its high sensitivity and selectivity to its surroundings such as pH, polarity, hydrophobic or hydrophilic environment. Though ethidium bromide is used as a well-known fluorescent marker to probe the biological systems, different molecules based on its skeleton has been developed with enhanced sensitivity, fluorescence in the near IR region and different functional groups. Synthesis of 5-aryl-7,8,13,14-tetrahydrodibenzo[a,i] phenanthridines (THDPs), a structural analogous of ethidium bromide were synthesized by simple condensation followed by six membered cyclic aromatization and cyanation of arylbromide using Rosenmund-von Braun reaction in two steps to yield highly luminescent materials. All the phenyl rings were found to be in near-coplanar configuration due to the presence of ethylene bridges. As a result, efficient  $\pi$ -conjugation was maintained throughout the molecules. UV-Visible absorption and fluorescence spectra of THDP became shifted to longer wavelength upon substitution of different moieties at 5-aryl position. A maximum of 200 nm red shifted fluorescence with respect to parent compound was observed for the nitro substituent. However, tradeoffs in spectral shifts were noticed when two strongly electron withdrawing groups such as nitro and cyano groups were present simultaneously. Presence of one or more acceptors induced the intramolecular electron transfer processes, and the photophysical properties of THDP core was tuned by different substituents. Application of this fluorophore has also been demonstrated by means of DNA interaction studies.

Keywords: DNA intercalation, Phenanthridines, Photophysical studies, Fluorescence spectra, UV spectra



## TREATMENT OF DYEING AND FINISHING WATERS USING INNOVATIVE PHOTOCATALYSTS

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Waters coming from dyeing and finishing processes by leather industries produce serious problems because they contain dyes and other pollutants. Toxic and recalcitrant for the environmental, these pollutants are difficult to remove by conventional treatments. For this reason, the heterogeneous photocatalysis is a promising and efficient method to remove them.

ZnO is an excellent and promising photocatalytic material to oxidize organic pollutants into CO<sup>2</sup> and H<sup>2</sup>O. In order to enhance the photocatalytic activity of ZnO, in this work, the doping of ZnO with praseodymium (Pr) has been realized and studied in the photocatalytic treatment of dyeing and finishing waters with a total organic carbon (TOC) values in the range 540-1200 mg/L.

ZnO particles doped with Pr were prepared by a modified precipitation method and characterized by different techniques (XRD, Raman, UV-Vis DRS).

The photocatalytic activities of the synthesized samples were investigated under UV light with a specifically photocatalytic apparatus designed for the experimental tests.

In the case of dyeing waters, photocatalytic results showed a discoloration of 64% and a TOC removal of 40% after 7 hours of UV irradiation. Interesting results are obtained also for the finishing waters; reaching a discoloration of 76% and a TOC removal of 48% after 3 hours of reaction time.

The obtained results evidenced the efficiency of the synthesized photocatalyst in the treatment of real dyeing and finishing water coming from leather industries.

ACSIL P-24

## PREPARATION AND PROPERTIES OF COLLAGEN-BASED FOAMING AGENT

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Leather tanning is the process of the animal skins being processed into leather, but most of the collagen-based materials become a solid waste or solid contaminants due to the process of splitting, cutting, grinding and trimming operations. Our country produces about 140 million tons of leather solid wastes per year, of which about 80% is composed of collagen protein or rich in protein resources, therefore, those leather solid wastes can be recycled to some other useful substances. As a raw material of protein-based foaming agent, it has the significant value of theoretical research and practical use. On basis of the public literatures, gelatin possess foamability and foam stability but its foam height is not high enough that leading to the poor surface activity. Thus, collagen-based foaming agent was synthesized by the amidation reaction between collagen powder and lauroyl chloride to improve surface activity of the protein-based foaming agent. Structure and properties of the collagen-based foaming agent were studied by gel permeation chromatography, infrared spectroscopy, X-ray diffraction, thermal analysis and surface tension instruments, etc. It can be seen from GPC result that the relative molecular mass of collagen-based foaming agent was increased after modification compared to that of lauroyl chloride, indicating that lauroyl chloride was grafted onto the collagen molecules. Through the comparison of the IR absorption peaks, It was further demonstrated that lauric acid segments were grafted onto collagen polypeptide through reaction of acyl chloride and amino groups, FT-IR analysis also confirmed that the synthesis reaction accorded well with Schotten - Baumann mechanism. GPC and IR results confirmed that collagen-based foaming agent had the due structure. XRD results illustrated that the incorporation of lauroyl can increase the tacticity and crystallinity of the collagen molecular chain segments. Collagen foaming agent can be dissolved in water and ethanol, is slightly soluble in methanol, acetone and not in common organic solvents. And its CMC and surface tension are 1.5g/L and 39.5 mN/m.

*Keywords:* Collagen; Lauroyl Chloride; Foaming Agent; Structure and Performance



ACSIL P-25

## PREPARATION OF AN ANTIBACTERIAL CATIONIC PROTEIN BASED ON GELATIN AND ITS APPLICATION IN LEATHER RE-TANNING

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An antibacterial cationic protein (ACP) with tunable chemical and physical properties was prepared from the reaction of gelatin with 2, 3-epoxypropyl trimethyl ammonium chloride (EPTAC). It was indicated that the grafting density of quaternary ammonium salts was influenced greatly by the molar ratio of EPTAC/amine group ( $\text{NH}_2$ ). FTIR and  $^{13}\text{C}$  NMR results showed the  $-\text{NH}_2$  groups of gelatin reacted predominantly with epoxy groups when molar ratio of EPTAC/ $\text{NH}_2$  was less than 2.5:1. Hydroxyl groups ( $-\text{OH}$ ) of gelatin would also participate with epoxy groups if the molar ratio of EPTAC/ $\text{NH}_2$  was higher than 2.5:1. The antibacterial activity and thermal property of the cationic protein changed with the content of quaternary ammonium salts. Furthermore, the antibacterial cationic protein as re-tanning agent was used in the re-tanning process of cattle wet-blue leather. Compared with the leather re-tanned without ACP, the thickening rate and the tensile strength of leather re-tanned using 2% ACP increased greatly. Additionally the color saturation of leather samples improved, which was proved by the higher  $\Delta E$  (color difference) value of leather sample investigated by X-rite 8200.

*Keywords:* Cationic protein; Antibacterial; Gelatin; Quaternary Ammonium Salt; Re-tanning

ACSIL P-26

## SYNTHESIS OF END-CAPPED FLUOROALKYL HYPERBRANCHED POLYMER LATEX AND ITS HYDROPHOBIC PROPERTIES IN LEATHER

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Fluoroalkyl-terminated hyperbranched polymers have attracted much attention due to their novel structures, unique properties, and potential application prospects. Especially, this structure will facilitate the fluorine enrichment on the material surface, thus, it is anticipated that higher application cost of the fluorine-contained polymers could be solved in the near future. In this work, polyurethane prepolymer (PU) with NCO terminal groups was manufactured by the stepwise polymerization of isophorone diisocyanate (IPDI), polyethylene glycol (PEG800) and dimethylolpropionic acid (DMPA). Then, fluorine-containing polyurethane prepolymer (FPU) with fluoroalkyl and NCO terminal groups was synthesized by reaction of perfluorohexyl ethyl alcohol and PU. Next, novel fluoroalkyl terminated hyperbranched polyurethane (FHBPU) was fabricated via the grafting reaction of FPU and hydroxy terminated hyperbranched polymer (HPAE). Finally, FHBPU latex was obtained by neutralization, adding water, and high-speed stirring operations and applied in the wet-blue goat waterproofing treatment. Infrared spectrum (IR), proton nuclear magnetic resonance ( $^1\text{H}$  NMR), Transmission Electron Microscope (TEM), nano particle size, and static contact angle analyzer were utilized to characterize structure of the resultants, particle morphology and average size, as well as hydrophobicity such as water contact angle on grain side of the treated crust leather. Results showed that final product had due structure. FHBPU latex particles presented irregular sphere with a polydispersity index of 0.261 and an average diameter of 238.8 nm. The treated crust leather by 1.6% FHBPU active ingredients based on the weight of wet-blue goat had favorable hydrophobicity and water contact angle on its grain side attained  $142.9^\circ$ .

*Keywords:* Hyperbranched polymer; Leather waterproofing; Polyurethane; Latex particle morphology



## LINEAR-HYPERBRANCHED AMPHIPHILIC POLYPHOSPHATE ESTERS– A NOVEL FATLIQUOR ON THE LEATHER

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Leather-making process is a way of preserving skins to stop decomposition and to provide a strong and flexible material. From now, the environmental pollution caused by leather making is the primary concern in the development of leather industry. Fatliquoring is one of the key operations in the manufacturing of leather which can protect the leather against cracking, and the traditional fatliquor is also the cause of environmental pollution. So it is necessary to develop the eco-friendly materials to replace the traditional fatliquor. In recent study, the dendritic molecular has three-dimensional molecular structure, making certain filling possible. Meanwhile, the structures of hyperbranched polyphosphate esters are similar to phospholipid in structure, and phospholipids can form adsorption films or chemical adsorption films on the leather. So we thought of synthesizing linear-hyperbranched polyphosphate esters to research the effect of flexibility on leather.

The fatliquor of the linear-hyperbranched polyphosphate esters (PAMAM<sub>n</sub>-3-Ps) have been constructed through random multibranching esterification of lauroyl chloride and phosphate ester as a branching agent. Subsequently, a series of surfactants products were obtained. Benefiting from the amphiphilic structure with the hydrophilic core and many hydrophobic tails, PAMAM<sub>G<sub>n</sub></sub>-3s and PAMAM<sub>G<sub>n</sub></sub>-3-Ps were able to self-assemble into nanomicelles in aqueous media. Importantly, the polymers show the low critical micelle concentration (CMCs) and small particle sizes. Here, the PAMAM<sub>G<sub>1</sub></sub>-3 and PAMAM<sub>G<sub>1</sub></sub>-3-P were applied in the collagen fibers of leather to improve the fibers distance and mechanical property of collagen fibers, and the addition of polymer certainly effect on the thermal properties of leather. From XRD, SEM, TG, DSC and XPS the analysis elucidates that the polymer can enhance the distance of collagen fibers with crosslinking the collagen fibers, but does not destroy collagen fibers. Additionally these polymers display significant flexibility, which could replace ordinary fatliquor in future. The result provides a new application of using linear-hyperbranched amphiphilic polyphosphate esters into traditional leather materials to enhance the performances of collagen fibers.

*Keywords:* PAMAM; Phosphorylation; Amphiphilic; Fatliquor; Cross-linking



ACSIL P-28

## THE RELATIONSHIP BETWEEN MICROSTRUCTURE AND PROPERTIES OF POLYACRYLATE/NANO-ZNO COMPOSITE LEATHER FINISHING AGENT

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To solve the blindness of performance regulation and control during the research of polyacrylate/ZnO nanocomposites leather finishing agent, a series of polyacrylate/ZnO nanocomposites for leather finishing are prepared through a facile physical blending process. Thus, in this paper, detailed discussions on the effects of reaction time, temperature, and agitation rate on the mechanical properties, water vapor permeability and water uptake of polyacrylate/ZnO nanocomposites are reviewed. The structure change rules of ZnO nanorods and polyacrylate latex particles, the distribution of ZnO nanorods during the preparing and film-forming process of polyacrylate/ZnO nanocomposites leather finishing agent are studied systematically. The relationship between the structure of ZnO nanorods and the properties of polyacrylate/ZnO leather finishing agent are built by analyzing and summarizing the influence of the distribution of ZnO nanorods on properties of films.

*Keywords:* Coating; Polyacrylate; ZnO Nanorod; Properties



ACSIL P-29

## THE ANTIBACTERIAL PROPERTIES AND ABRASION RESISTENCE OF POLYACRYLATE/GRAPHENE COMPOSITE IN FINISHED LEATHER

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Graphene has high specific surface area, good mechanical properties and electrontransfer ability and has been widely used in polymer in order to improve the relevant performances. Reduced graphene oxide (rGO) was prepared by graphene oxide (GO). GO and rGO were introduced into polyacrylate emulsion (PBA-MMA-GMA) respectively to prepare PBA-MMA-GMA/GO and PBA-MMA-GMA/rGO composites. The composites were applied in leather finishing. The influences of GO and rGO on antibacterial property of composites and abrasion resistance of finished leather were investigated. The result of XRD showed that the interlayer spacing of GO was increased compared with graphite. The result of FT-IR showed that GO was reduced. The particle sizes of GO and rGO were 225 nm and 155.7 nm, respectively. The results of antibacterial test showed that PBA-MMA-GMA/GO composite had no antibacterial property. The antibacterial rates of PBA-MMA-GMA/rGO composite and the leather finished by PBA-MMA-GMA/rGO to *Escherichia coli* were 77.5% and 68.0%, respectively. PBA-MMA-GMA/GO and PBA-MMA-GMA/rGO composites could improve the abrasion resistance of finished leather and rGO had a better performance than GO.

*Keywords:* Polyacrylate, GO, Composite, Antibacterial, Abrasion resistance.

IVL P-01

## VALUE ADDITION OF LEATHERS FROM ETHIOPIAN CATTLE HIDES: STRATEGY FOR QUALITY IMPROVEMENT

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Although the raw cow hide supplies for tanners are not small, producing quality leather is difficult, which can compete in international market. From the total export of finished leather in the year 2011/2012 only 10.7% is the share for finished cow leathers. Main types of problem that alter production of quality cow leather are both anti- mortem defects (scratches, rub mark, or horn rake pox, brand mark, wound etc) and post-mortem defects (fly cuts, fleshing cuts and putrification) that degrade the value. Surface defects mainly scratches and fly cuts largely and wound in certain extent are major drawbacks for not having quality product. To have an insight about Ethiopian cow hide raw material and to standardize a process technology both chemical characterization such as hydroxyproline content, fat content, nitrogen content, moisture content and chromic oxide content and physical characterization such as tensile strength, tear strength, % elongation, grain crackiness and rub fastness were carried out. Also histology of the raw material, Scanning Electron Microscope (SEM) analysis at crust stage, hair pore count using stereo-microscope of the crust and organoleptic properties at crust stage and after finishing were carried out in comparison with Indian cow leather.

A newer approach of drum up-gradation using pigment and protein filler and modern type of finishing i.e. cationic compact finish were used to achieve the overall goal of producing quality leather. The results from the physical tests reveals that grain crackiness of the experimental leathers is not affected by the use of pigment and filler in drum. The experimental leather showed better defect coverage and had better organoleptic properties. In the present study, promising results were found that can be used to add value to Ethiopian cow upper leathers to be salable in the world market.

*Keywords:* Hide, leather, Organoleptic properties, Histology, Scanning Electron Microscope



**LUMINESCENT TETRAHYDRODIBENZO[A,I]  
PHENANTHRIDIN-5-YL) PHENOL-BORON COMPLEXES  
(BOROPHENANTHRIDINES) AS FLUORESCENT PROBES**

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A series of weakly emissive, excited state intramolecular proton transfer active tetrahydrodibenzo[a,i] phenanthridin-5-yl)phenols were efficiently synthesized using 2-tetralone and substituted salicylaldehydes. These dyes were smoothly coordinated with boron trifluoride diethyletherate resulting in  $\pi$ -conjugated and rigid tetracoordinated boron-phenanthridine complexes. The complexes were highly emissive in solution and solid states with large Stokes shift values ranging from 6190 to 10410  $\text{cm}^{-1}$  and moderate fluorescence quantum yields. A systematic photophysical and solvatochromism studies revealed that the intramolecular charge transfer process was more effective in borophenanthridines than with others, which was supported by DFT study. Further, the electrochemical studies testified the high electron-accepting ability of these boron complexes. Since, these borophenanthridine complexes was found to be sensitive to its surrounding environment, this molecule can be used to understand the collagen-ligand interactions and other biological applications based on fluorescence techniques.

*Keywords: Luminescent Complexes, Florescent Probes, Protein-Ligand Interactions*

IVL P-03

## ECO-FRIENDLY DYEING OF LEATHER THROUGH RECOMBINANT TECHNOLOGY

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Synthetic dyes are commonly used in leather, paper and textile industries. Certain dyes cause health hazards and environmental constraints when those removed as an effluent. Hence, development of efficient and cost-effective eco-friendly dyes play a vital role in dyeing industries which motivate researchers to focus on less toxic and biodegradable dyes from natural resources like plants, animals and microbes. The objective of this work is to develop a novel natural dye for dyeing leather using a fluorescent protein by recombinant technology as a greener approach. We select two different fluorescent variants, among them positively charged fluorescent variant was selected for the leather dyeing process in this study. This fluorescent protein encoding gene cloned in pET30b vector was successfully transformed and over expressed in *Escherichia coli* and was purified using affinity chromatography. Dyeing conditions such as concentration of purified protein and duration of dyeing were optimized as 5  $\mu$ M and 4 h respectively. From the results obtained, it is suggested that fluorescent protein could serve as an eco-friendly dye for leather that might reduce pollution loads generated by the leather industry during dyeing process.

*Keywords:* Green fluorescent protein, *Escherichia coli*, dye, recombinant technology



## DETRITUS TO FUNCTIONAL AUXILIARY: TWIN PROPERTIES POLYMER FROM WOODY BIOMASS FOR CLEANER POST TANNING PROCESS

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The emerging field of nanotechnology aims at revolutionizing the industrial world via introducing nano-based material for colouring. By-product utilisation has been recognised as a promising cleaner technology has attracted intense attention from both academic and industrial fields in the last decade. Waste and by-product streams from existing industrial sector (e.g. paper and pulp industry) could be used as renewable resources for production of useful artefacts. In this regard, the option explored in this work is appropriate modification of black liquor through simple process and the modified polymer has been evaluated thoroughly for suitable application as retanning agent. The multi functionality of the polymer provided opportunity to utilize this twin functional polymer as a retanning agent in leather processing. The separated acid soluble polymer would be employed not only for filling and also for crosslinking with the collagen, leading to improved dyeing, and physical property of protein based substrate. Effect of filling nature of modified polymer on strength property, softness nature, related morphological changes, and the dyeing property of the leather samples were thoroughly investigated. The polymer treated leather shows good softness, improved belly filling, and high strength, with uniform dyeing. The polymer also exhibited enhanced functional properties as well as improved dyeing thus making it as a better retanning agent. The polymer retanning agent will act as an auxiliary for intense dye shade with minimum dye percentage. Hence, the potential use of multifunctional polymer has gained more importance in economic processing.

*Keywords: Black liquor, Lignin polymer, Post tanning process, Clean technology, and Waste utilisation*

IVL P-05

## POLYSACCHARIDE-NATURAL OIL EMULSIONS FOR FATLIQUORING

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Softness is one such parameter that any consumer of footwear, garments or gloves looks for. A survey of the literature suggests that 10-15% of the fatliquor offered remains unutilized. The effluent from the post-tanning process thus gets loaded with emulsifiers, metallic soaps, alkyl phenyl ethoxylates, chlorinated paraffin oils and non-volatile hydrocarbons – substances that dominate the restricted substances in leather list. To ensure the sustainability of leather manufacture, presence of such substances in the lubrication process needs to be avoided.

The premises of this work is from the use of biopolymers as stabilizers and emulsifiers in food, pharma and cosmetic industries. Amongst these biopolymers, pectin has a shell like structure that tends to absorb on oil – water interface. An egg phosphatidyl choline can undergo self-aggregation to form lipid bilayers and facilitate encapsulation of both hydrophilic and hydrophobic materials.

We report here the preparation of oil encapsulated biopolymer coated stable liposomes. The influence of oil : lipid : biopolymer ratio on the physico chemical characteristics of the liposome has been extensively investigated and accordingly the ideal ratio has been optimized. pH also was found to influence the physico-chemical characteristics. Acidic pH stabilizes the emulsion by the ionization of the biopolymer and head group of bilayers. The thus prepared fatliquor was found to have comparable properties with some of the conventional fatliquors based on castor oil when employed in fatliquoring.

*Keywords:* Bio-Polymer, Fatliquoring, Oil Encapsulation



IVL P-06

## STUDIES ON THE INFLUENCE OF CLIMATIC CHANGES ON PHYSICAL PROPERTIES OF CRUST AND FINISHED LEATHER

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Leather products are sold highly by rich appearance and brilliance of color. Change in color and appearance of these products due to various climatic conditions will cause loss in the market. The usage of leather products at various climatic conditions will degrade the aesthetic appeal of the leather. Exposure of leather and leather products to different climatic condition causes fading of color, reduction in tensile strength, stiffening and cracking over period of time. Among the various factors UV exposure is the most influential factor responsible for color fading and reduction in strength properties. Compounds which are capable of absorbing UV rays (i.e. UV absorbers) and radical scavengers are used with a view to improve light fastness and to avoid other undesirable effect of changes due to climatic conditions. In the present work, the computability of UV absorbers and radical scavengers will be evaluated along with conventional leather chemicals. Furthermore, possibility of incorporation of UV absorbers during post tanning process is explored. The leather which is treated with those compounds are exposed to various climatic conditions and studied for the impacts. The study provides a molecular insight of understanding the role of UV absorbers in leather manufacture.

*Keywords:* Leather Products; Climate; UV absorbers; Color Fastness; Tensile Strength



IVL P-07

## HYBRID ZINC OXIDE-BORON NANOPARTICLES AS ANTIMICROBIAL AGENTS FOR LEATHER PROCESSING

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To prevent the growth of microorganisms various antimicrobial agents have been used in leather processing from preservation to finishing. Fungicides used in leather processing leads to more environmental and human health hazards thereby leading the tanners to search for clean and green antimicrobial agents. Inorganic materials with good antimicrobial property are promising alternative for organic materials based on phenol derivatives. Here, we synthesized hybrid zinc oxide-boron nanoparticles and applied as antimicrobial agents in leather processing specifically in tanning. The synthesized nanoparticles were characterized using XRD and SEM. XRD analysis revealed the presence of both ZnO and boron. While the SEM images showed agglomerated nature of the nanoparticles. The antibacterial and antifungal activity of the prepared hybrid nanomaterials were analyzed against selected species such as E.coli, Bacillus subtilis, Streptococcus and A.niger, A.flavous and A.fumigatous. The prepared hybrid nanomaterials were also applied on the chrome tanned leather and verified for antimicrobial activity in selected species as well as for other physical properties. The antimicrobial nano-agent treated leather did not show any sign of microbial attack and it is benign to human and environment.



## **WASTE TO WEALTH APPROACH: DERIVING HIGH VALUE PRODUCTS FROM RAW HIDES AND SKINS TRIMMING WASTE**

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Leather industry plays a notable role in today's global economy. Raw hides and skins are the by-products of the meat industry and serve as raw material to the leather industry. During the process of leather manufacturing, the huge amounts of hide and skin trimmings are generated. These trimmings account for a minimum of 5% of the total quantity of raw material processed in tannery. Raw skin or hide trimmings contain proteins especially collagen and keratin. These trimmings currently find use in very low value application. 50-60% of the total solids associated with trimmings are collagen. Hence skin trimmings are either dumped or used for making identical glue. Collagen, its pure form or denatured form could derive high value which is untapped in current practices. The paper will focus to highlight the utilization of the raw hide/skin trimmings from the tannery for making products of high value such as collagen, gelatin, protein hydrolysate, biodegradable packing materials etc.

*Keywords: Trimmings, Collagen, Gelatin, Protein hydrolysate*

IVL P-09

## NEW BIOCIDAL AGENT BASED ON GLUTARALDEHYDE FOR THE LEATHER INDUSTRY

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Nowadays biocides used in leather industry have some disadvantages because of environmental legislation. In this study, glutaraldehyde, which is used as a high level disinfectant in different sectors, is used as a biocidal agent in soaking process and created new formulations. According to data, antimicrobial activation of newly produced biocidal agents are effective and can be use soaking process.

*Keywords: Glutaraldehyde, leather, biocidal agent.*



## CASEIN-BASED $\text{SiO}_2$ NANOSPHERES VIA PICKERING EMULSION POLYMERIZATION FOR ANTIMOULD LEATHER FINISHES

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Casein-based hybrid composites are expected as good candidates for high-quality leather finishing materials. Herein, size-tunable casein-based  $\text{SiO}_2$  hybrid hollow nanospheres were achieved by Pickering emulsion polymerization utilizing casein-caprolactam/nano  $\text{SiO}_2$  micelle as the Pickering stabilizer. Followed by swelling process, the antimould agent was loaded in by encapsulation. The hollow morphology of antimould-loaded nanospheres was elucidated by Transmission Electron Microscopy (TEM), Dynamic Laser Scattering (DLS) and Atom Force Microscopy (AFM). Specifically, air permeability and opaqueness properties of coatings as a function of nano  $\text{SiO}_2$  usage were separately investigated. Furthermore, the properties of the hybrid films and its application in leather finishing were both examined.

The results revealed that the prepared nanospheres in the presence of the outer silica layer with antimould agent inside were 150nm in size. Additionally, the hybrid films exhibited good mechanical performance, high sanitation properties, and long-lasting antimould property as well as good compatibility with polymers, which render it a functional coating forming agent itself. Overall, the antimould and air permeability sheds light on the use of casein-based hybrid composite for upscale finishing agents.

*Keywords:* Pickering Emulsion Polymerization, Casein, Hollow, Leather Finishes, Nano material

IVL P-11

## INNOVATIVE AND BUILT-IN SURFACE TECHNIQUES ON LEATHER FOR VALUE ADDED PRODUCTS

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With growing trends in fashion and smart production the essence of craftsmanship on a leather product is neglected beyond its “classics”. This paperwork examines the past techniques of surface embellishments and finds a way in exploring directional usage of the surface in the product lines. Inspired from the zero-waste pattern making of Mark Liu, where the darts are inverted and are further cut along the fold to act as a decorative element throughout in his collections. Driven by this thought, the base concept of inverted darts is subtracted to pin tucks and where the explorations are made from the folds of the pin tucks. The research report follows this innovation towards embellishing the surface of leather through explorative and modelling research methodology. Keeping the robust aspects of built-in embellishment, the researchers have brought innovations in the traditional techniques of tessellations using motifs that are repetitive and progressive are depicted through the pin tucks that results with both tactile and visual textures. Furthermore the techniques that involved the flesh side of leather reveal through the pin tucks accentuated the latter side of leather. Leveraging such innovative techniques would change the perception of leather as an embellishment material. Though the fabrication may seem slightly exorbitant; but with increasing innovations in material developments and the desires of the consumer to gape for newer looks, it is the responsibility of the manufacturers to deliver proficiencies in their trade. Thus, the techniques dealt in this research work ease out these responsibilities of the manufacturers to offer a range of innovative and value added products to the fashion consumers. The leather jacket with one of the techniques used, momentarily directs to the surface embellishment appreciating the essence of the same. This brings us down to the discrete analysis to the paralysed thoughts for the “classic” product lines in leather could be changed with innovative surface techniques. As the technique is pristine, the scope for future work ensures in greater extent for innovations in fabricating the concepts.

*Keywords:* Built-in-techniques, Leather embellishments, Leather, innovation, Pin-tucks, Surface design, Value added products



## FILM CHARACTERISTICS OF DIFFERENT PATENT FINISHING APPLICATIONS

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Patent is one of the most popular finishing technologies applied for the leather goods especially to shoe upper leathers and bags. Solvent based patent coats are widely used for the patent finishing applications and surface of the leathers, which applied patent coatings, has high glossy appearance. This glossy effect is obtained by the use of organic solvent and cross linkers. However, environmental legislations, increasing consumer expectations and environmental-responsibility are forced the leather manufactures to find satisfactory, better and eco-friendly solutions. Therefore, water based finishing systems have begun to use for patent coating applications. But it is known that this water based patent finishing system give lower leather quality in comparison to solvent based patent finishing techniques. For this purpose, it is aimed to determine the characteristic properties of the solvent and water based patent finished goat upper leathers such as dry rubbing fastness, wet rubbing fastness, leather fastness to water spotting, finishing adhesion, flexometer and water vapour permeability test to reveal the differences in the characteristic properties of the solvent and water based finishing techniques. The quality requirements of the patent finished leathers for shoe upper and leather goods are presented as a result of the study and found that they have commercial value.

*Keywords: Finishing, Patent finish, Solvent, Leather*

IVL P-13

## THE EFFECT OF COMBINATION VEGETABLE TANNING MATERIALS AND SULFITED OIL ON THE PHYSICAL PROPERTIES OF JACKET LEATHER

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This research was aimed to determine the combination of vegetable tanning materials and Sulfited oil on the physical properties namely tensile strength, oil content, elongation, softness and shrinkage temperature and to determine the factors that affect tensile strength, oil content, elongation, softness and shrinkage temperature leather tanning results. Raw hides/skins were processed up to acidification, pH was set to be 5 then tanned with the variation of vegetable tannin 15%, 17,5% and 20% respectively. Fatliquoring process used sulfited oil with variation of 12%, 15% and 18%. The jacket leather produced were tested using SNI 4593:2011 Kulit Jacket domba/kambing. From this combination of treatment provided 9 (nine) treatment variation, each treatment was preformed triplicate. The results showed that the combination of vegetable tanning materials 17.5% and 12% of sulfited oil was the result of variation in the optimum treatment for the leather to produce 208.29 N/mm<sup>2</sup> tensile strength, oil content of 10.02%, 50.39% elongation and softness 5.13 mm and meets the requirements of SNI: 4593: 2011 with the temperature shrinkage was at 79 °C. From the analysis of variance showed vegetable tanning material is the dominant factor affecting the tensile strength, oil conten and shringkage temperature. Sulfited oil is a factor that affects the oil content, elongation and softness.

*Keywords:* Tensile Strength, Leather, Jacket



IVL P-14

## SELF ASSEMBLED COLLAGEN-PVDF-GRAPHENE OXIDE THIN FILM AS PIEZO-ELECTRIC SENSOR

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Collagen - Poly vinylidene fluoride (PVDF), Graphene Oxide thin films were made by self assembling aqueous solution of PVDF and collagen with graphene oxide substrates in PVC trays at room temperature. SEM micrographs showed that the surface of the films were uniform and distributed with the nano particles. X-ray diffraction (XRD) studies showed that the PVDF films settled in two dimensional phase. Raman results together with XRD studies confirmed that the synthesized films are single phase PVDF graphene with good stoichiometry. FTIR studies of the films showed a strong piezo spectra obtained at low temperature (25°C) exhibit better resolved Piezo electric peaks of the CV caused by the combination. The dominant peaks observed in the FTIR, Characteristic spectra confirmed the high quality of the Collagen-PVDF- Graphene thin film piezo electric sensor.

*Keywords: Collagen, PVDF, Graphene oxide, Characterization, Piezo electric sensor.*



IVL P-15

**NATURAL PHENOLICS PREVENTING AGING IN LEATHER****Ivo Reetz\*, Alper Kilikli, Francina Izquierdo***Pulcra Chemicals, Beylikbagi Mh 341 Sk No 1, Gebze, Turkey**Pulcra Chemicals, P. Ind. San Vicente, 08755 Castellbisbal, Spain**Pulcra Chemicals, Isardamm 79-83, 82538 Geretsried, Germany**\*Email: ivo.reetz@pulcrachem.com*

Gallic acid esters are a class of polyphenolics that have been found in our previous work to be very suitable antioxidants for leather securely preventing the formation of Cr(VI). In fact, alkyl gallates with long carbon chain have an efficiency that is comparable with commercially successful fully synthetic antioxidants, and far superior to tara or gallic acid. In this work we compare gallic acid derivatives with tocopherol and tocopherol derivatives, discussing the results in antioxidant efficiency in leather in the framework of the polar paradox and the efficiency of the very phenolic groups. The final aim of this work is the improvement of sustainability of leather including the increase in quality and durability of leather articles and a better protection against the formation of Cr(VI) by natural ingredients.



## STUDY ON THE FACTORS OF FINISHING CRACKING FOR COWHIDE UPHOLSTERY

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The finishing cracking of cowhide upholstery leather was investigated, because the upholstery leather usually mill long time (8-12hrs) after finishing, and we found that the elongation of finishing film and crust are the key factors influencing the finishing cracking. The quantitative relationship between the finishing film and the crust was discussed. The ratio of elongation of finishing film to crust has significant impact on the finishing cracking. The finishing film includes different kinds of resins (L UP/L2185/L3060/SF-1/RA155), additives (Wax FI52/Filler 418) and pigment, which has impacts on the elongation of the finishing film. The elongations of crust from different position (belly/back/butt) of the hide are very different on each thickness (1.0-1.2/1.2-1.4/1.4-1.6mm) of leather. Furthermore, the coating conditions, which include the quantity of finishing, the temperature/ time of drying and the mechanical operation (mill/toggle/iron), are the factors influencing the finishing cracking also.

Our results show that the ratio (1.9-13.7) of elongation of finishing film to crust vary, and the whole hide have no finishing cracking after milling 8 hrs, only when the ratio of elongation is above 9. The test shows that the finishing cracking was serious when the ratio of elongation of film to crust is 1.9-2.2, it became less serious when the ratio was 2.3-5.8, and much less when it was 5.9-8.2, then the cracking disappeared when the ratio is above 9. The elongations of acrylic compact resins (L UP/L2185/L3060/SF-1) vary significantly (150%-568%). They could be increased by adding pure acrylic resin (RA155 from TFL) which has high elongation (825%). The elongation of resin is decreased by adding pigment/wax/filler. The influence differs with different resins: compact resin L3060 decreased more than L2185 on pigment and filler, L2185 decreased more on wax. The elongation of crust varies also (41.35-79.19%), and elongations of belly from different thickness crust are all the highest (79.19/69.32/69.57%), it is 1.46-1.75 times of back and 1.32-1.54 times of butt. As the result, the finishing cracking happened much more on belly than back and butt. So to avoid finishing cracking, the elongation of crust should be controlled to the highest extent especially on belly and the elongation of resin used need to be increased to the highest extent also. To reduce the elongation of crust before finishing, the belly should be stretched and fixed during the re-tanning and drying process. The finishing cracking is related with the finishing quantity, and was also influenced by dry time and temperature. The finishing was less cracked when the quantity was 6-8g/sqft (wet weight) than 4g/10g. 100°C/10 minutes (80°C on leather) gave the suitable drying of the finishing film in the test. The leather finishing cracked more when it was less or more than 100°C/10 minutes. The cracking was less on the leather which was milled (40°C/35% humidity/ 8hrs) directly, it was more serious when the leather was toggled (40°C/3hrs) or ironed (100°C/30bar/8m/min). So after finishing, drying and leaving, it is always better to mill the finished leather directly than to iron or toggle to avoid the finishing cracking.

**Keywords:** Upholstery Leather, Finishing Cracking, Ratio Of Elongation Of Resin To Crust, finishing agent, mechanical operation

IVL P-17

## FABRICATION OF COMPOSITE FROM DECHROMED LEATHER SHAVINGS FOR INSOLE

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Disposal of chromium containing leather shavings, wet blue scraps, trimming etc. are a major environmental concern. Land co-disposal with chromium containing shavings leads a threat to groundwater resources because of leaching heavy metals e.g. chromium at pH 5-9 (Sundar et al.2011). In this study, chromium containing shavings was dechromed with organic acid and used to fabricate composite by incorporating chemicals to obtain physical properties. The fabricated composite was dried, pressed, buffed and finished. Finally, the finished composite was inspected, tested for the tensile strength and elongation at break using SATRA STD 172 tensile tester. The tensile strength and elongation at break of the composite was  $84.01 \pm 3.5$  kg/cm<sup>2</sup>,  $7.5 \pm 0.3\%$ , respectively. Result was indicated that the fabricated composite could be used as insole in the footwear production. This will enable a substantial reduction of environmental pollution consecutively will produce valuable product.

*Keywords:* Chromium, Leather shavings, Dechroming, Organic acid, Composite, Insole



## A NOVEL METHOD TO PRESERVE GOAT SKIN WITH INDIGENOUS PLANT EXTRACT TO REDUCE SALINITY IN THE EFFLUENT

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Hides/skins, the outer coverings of animals are used as the basic raw material for the leather industry. After flaying, hides/skins are susceptible to bacterial attack which causes putrefaction of the proteins and make it inapt for the production of quality leather (Vijayalakshmi et al. 2009). Proper preservation is essential to save the hide/skin before to start the tanning process.

In tropical countries like Bangladesh, India conventionally fresh hide/skin is preserved by wet-salting method using 40-50% sodium chloride. Although it is cost effective, easy to practice and available those countries but the method suffers heavily from the environmental perspective. Wet-salting contributes 350-450 kg of salt as TDS per ton of leather processing in the wastewater. Chlorides remain a burden to the environment because it is not affected by effluent treatment. The high amount of salt contained effluent will increase surface salinity, thus reducing the fertility of soil resulting poor crops yield (Preethi et al. 2006). In the last few decades, numerous works have been carried out with various curing agents efficiently to preserve the hide/skin to reduce pollution load from the effluent. Unfortunately they are not commercially viable because of its limitations.

In the present study, an attempt has been made to preserve the goat skins with the extracted oil from the seed of indigenous plant. The oil was applied on the flesh side of the skin in different concentrations. The efficacy of the curing method was periodically (1<sup>st</sup>, 4<sup>th</sup>, 7<sup>th</sup>, 14<sup>th</sup>, 21<sup>st</sup>, and 30<sup>th</sup> day of curing) assessed by analysis of the cured skin for hair slip, odor, moisture content, bacterial count, total extractable nitrogen, and shrinkage temperature and compared with control skin. The results confirmed that the system is effective in preserving goat skins for more than a month. The small scale production of cured skins revealed that the pollution loads from soaking is significantly reduced. The leather produced from experimental skins show comparable strength properties with that of control skins. The developed oil based method is proven to be an auspicious alternative to the traditional wet-salting by reducing pollution from leather processing.

*Keywords:* Hide/skin curing, Wet-salting, Pollution, Environment, Indigenous plant extract

IVL P-19

## PHYSICAL PROPERTIES APPRAISAL OF THE FABRICATED COMPOSITE FROM FAT EXTRACTED LIMED FLASHING

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In beamhouse, just after liming pelt has to pass through an operation known as 'Fleshing.' It is one of the most indispensable mechanical operations in leather processing where substantial amounts of inevitable solid waste (fleshings) are produced. The 'fleshing operation' involves cutting or removing unwanted part from the flesh side of pelt to improve the diffusion of tanning agents and chemical uptake into pelt from the flesh side. It is the 50-60% of total solid wastes generated in the tannery (Kanagaraj et al. 2006). It contains proteinaceous substances that are hydrolyzed to amino acids through proteolytic bacteria; further amino acids are hydrolyzed by bacteria, which liberate gaseous ammonia, hydrogen, carbon dioxide, volatile fatty acids (VFAs) etc., that are directly merged to the air (Shanmugam and Horan 2009). It contains fat 4-18% (Lupo 2006). Many efforts have made to utilize fleshing to produce feed ingredients (Rai et al. 2010), compost (Rvindran and Sekaran 2010), biogas (Ravindranath et al. 2010), and biodiesel (Šanek et al. 2015). Here an attempt was made to fabricate composite from fat extracted limed fleshing and assessment of physical properties.

The collected fleshing was washed with water to remove free lime and chopped with knife into small size. Then, chopped fleshing was delimed with 2% boric acid for 5-6 h to remove chemically bound lime. The pH of delimed fleshings was adjusted 6-7 by the diluted hydrochloric acid and further washed with water. The delimed fleshing was subjected to heating at water bath in a beaker with water for several hours. After clearly separated fat from fleshing, the mixture was then transferred to the separating funnel; finally fat was separated from the aqueous phase. The fat extracted fleshing was sun-dried and grinded to make 0.5-1.0cm size. Then, grinded fleshing was mixed with epoxy resin and hardener. The mixture was then poured into 210 × 210 mm aluminum sieve. The physical properties of fabricated composite were investigated and it shows good young modulus and tensile strength. This approach will enable a substantial reduction of environmental pollution consecutively will produce valuable product.

*Keywords: Fleshing, Fat, Composite, Young modulus, Tensile strength*



## COLLAGEN HYDROLYSATE SYNTAN: A PRODUCT OF HIGH VALUE FROM LIMED TRIMMINGS

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Ethiopian tanneries processing from hides result in the generation of significant amount of limed trimming wastes. Annually about 2000 tons of limed trimming are generated from Ethiopian tanneries. Most of these trimming wastes go unutilized and utmost find use in industrial glue, a product of low value. This study reports a methodology for making syntan from these limed trimming waste thus not only internalizing the trimming waste problem but also generating high value product from waste. In addition, such a syntan would be an ecofriendly alternative to syntans based on phenol-formaldehyde or other resin syntans. In order to meet the property requirements brought about by the combination of other syntans, preparation of the collagen hydrolysate composite with varied molecular weight fractions is required. Collagen hydrolysate syntans with varied amount of alkali of hydrolysis has been prepared and characterization of the collagen hydrolysate syntan has been carried out. Further, the application of these syntan in retanning for the manufacture of various types of leathers and characterization of the leathers has been carried out to determine the effectiveness of the collagen hydrolysate syntan for retanning purpose. Thus, this study will solve not only solid waste disposal problem but will also generate high value returns from waste.

*Keywords:* Collagen Hydrolysate; Trimming Waste; Syntan; Retanning

IVL P-21

## MAGNETIC LEATHERS BY SURFACE COATING OF BIMETALLIC IRON-CHROMIUM OXIDE NANOPARTICLES

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Leather, a unique consumer material, does not offer any smart or advanced applications due to the non-conductive and poor magnetic behavior. Both chrome and iron tanning are expected to discharge chromium and iron containing effluent. Further, several other industries such as mining, pigment, scarp iron processing, etc release soluble iron containing wastewater. An approach has been made to utilize the chromium tanning effluent in combination with iron containing wastewater to prepare magnetic nanoparticles. Here, we synthesized iron-chromium oxide nanoparticles (hetero-metal oxide nanoparticles) using a simple co-precipitation technique and coated on the surface of the leather to provide distinctive magnetic properties. The as-synthesized nanoparticles predominantly comprised of bimetallic nature with a particle size of  $20\pm 5$  nm and magnetic value of 11 emu/g. The existence of coated bimetallic nanoparticles with the commercial leather finishing dispersion noticeably seen on the leather surface up to 21  $\mu\text{m}$  thickness through the scanning electron microscopic analysis. Vibrating sample magnetometric measurements show that the bimetallic nanoparticles coated magnetic leather exhibits both superparamagnetic and weak ferromagnetic behavior. The derived magnetic leathers have slightly improved heat resistance and comparable physical properties to that of conventional leathers. Therefore, these results suggest that the bimetallic nanoparticle coated magnetic leathers can be used for advanced applications such as smart/interactive clothing, adhesive-free wall covering, energy harvesting and electromagnetic interference shielding.

*Keywords:* Iron-chromium oxide, Nanoparticles, Coating, Magnetism, Physical properties.



IVL P-22

## USING BIOMASS MATERIALS COLLAGEN, VEGETABLE TANNIN TO IMPROVING MOISTURE PERMEABILITY OF SUPERFINE FIBER SYNTHETIC LEATHER BASE

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Collagen and vegetable tannin are considered to be the largest renewable animal and plant biomass resources in the world. However, Although collagen is mainly used for leather making, the application rare is less than 50%. And more than 80% collagen exists in leather solid wastes. The natural polyphenols, tannins, are extensively distributed in root, bark, stalk, and fruits of plants as metabolism products. In this work, The present study proposes a “two-step” method of grafting collagen and chrome-vegetable tannin (C-CrT) on nylon fiber of superfine fiber synthetic leather base for improving the moisture absorption and transfer abilities. The two-step surface modification is developed, involving sulfuric acid hydrolysis and grafting of C-CrT on nylon fiber. Compared with that of pristine nonwoven materials, the static water-vapour transmission rate (SWVT) and Liquid wicking rate(LWR) of modified nonwoven materials was improved greatly. And the surface modification mechanism was analyzed and reported.

*Keywords:* Collagen, Chrome-Vegetable Tannin, Superfine Fiber Synthetic Leather Base, Surface Modification



IVL P-23

## PHOTOCHEMICAL STABILIZATION OF COLLAGEN USING METHYLENE BLUE AND ERYTHROSIN-B IN GREEN SOLVENT MEDIUM

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Collagen is a major structural protein and it is also the basic raw material for many biological and industrial applications. Water plays an important role in the structure, stability and properties of collagen. Here, we aim to improve the physicochemical properties of collagen by photochemical crosslinking in green solvent medium, ethanol. Photosensitizers such as methylene blue (MB) and erythrosine B (EB) were used to bind with collagen and further activated by absorbing photons from broad spectrum of visible light. The excited states of the activated photosensitizers and the photoproducts such as reactive oxygen species react with surrounding molecules like tyrosine and phenylalanine which leads to the crosslinking of protein matrix. The change in the triple helical conformation of collagen was studied using circular dichroism (CD) spectra as a function of concentration of photo sensitizers. The conformation and thermal properties of the photo chemically cross linked collagen were investigated using Fourier transformed infrared spectroscopy (FTIR), fluorescence spectroscopy and differential scanning calorimetry (DSC). The shrinkage temperature of collagen irradiated with 1.0 mM solution of MB and EB was observed at 97 and 88°C, respectively and it is concentration dependent. In addition, the enzymatic stability was studied in vitro to evaluate the stability of radiation crosslinked collagen. The results of this study show that the photochemical crosslinking of collagen using MB and EB is found to be efficient and suitable for biological applications.



## **A STUDY ON SELECTIVE SURFACE IDENTIFICATION IN CRUST LEATHERS USING VARIOUS CLUSTERING ALGORITHMS**

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The assortment of leather used to be carried out based on the various parameters like surface level inspection (visual), thickness of the leather and many more. Out of the various parameters of the assortment the surface level inspection been taken for the further study to understand the classification by using various classification algorithms. The proposed method could provide many more data in the area of image processing on surface level digital inspection.

*Keywords:* Crust Leathers; Clustering; Algorithm; Leather Surface; Digital Inspection

IVL P-25

## CREATIVE DESIGN CONCEPTS AND NEW PRODUCT DEVELOPMENT STRATEGIES FOR RECYCLING OF FINISHED LEATHER WASTES

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Zero waste or minimization of waste is now a strongly emerging issue for the industrial development especially in leather and leather product industries where an integrated waste management system is the need of the hour to sustain in the leather business. Leather industry generates a significant quantity of solid wastes that are affecting the environment as well as the industry economically. It is estimated that the industry produces about 1.4 Million tons of processed waste per year worldwide, with the majority as sludge, being disposed as landfill. This waste disposal mechanism is in conflict with increasing legislation and environmental drivers to encourage avoidance of waste and waste disposal. The implementation of stringent environmental regulations has led to increasing disposal costs also to the industry. The tanning processes generate even greater quantities of leather wastes, few alternatives are at present commercially available like fuelling. Leather scraps represent a large part of these wastes. In most cases, internal reduction solutions cannot reduce the quantities of waste very much and most of these industries end up selling these scraps to the local collecting agents. It's a loss for these industries when they have to sell these scraps for Rs.10-20 per/kg or sometimes even less, to small vendors.

Also, from the literature review done, it has been found that attempts have been made by the previous researchers to utilize the wastes from the leather industries by turning them into leather boards or composite boards, etc. Not much research work or design interventions have been done in the previous years for converting the leather wastes into commercial leather products for the market.

In this context, the main objective of this research work is to understand the problem of solid leather wastes particularly finished leather scraps that has been generated by the leather industry and to reduce the leather wastes by converting the scrap leathers into useful products thereby reducing the impact on the environment and also minimizing the loss for the industry due to huge disposal of unused leathers and scraps as wastes. The research work presents the strategies for the collection and assortment of different types of finished leather scraps generated by the leather manufacturers, footwear, leather goods and leather garments industries. Then, suitable design concepts and product development techniques are applied for converting the scraps into innovative leather products which are commercially feasible and can be marketed domestically as leather lifestyle products at affordable price to the mass consumers.

*Keywords:* Design Concepts, Leather Wastes, Leathers Scraps, Life Style Products, Leather Recycling, New Product Development, Sustainable business, Waste Management



## INVESTIGATIONS ON IRREVERSIBLE DEFORMATION PROPERTIES OF LEATHER

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In upholstery and automotive interior genuine leather material is well established for premium covering applications. Affected by users body weight as well as heat and moisture impact of the environment the leather material is intensively loaded during usage. Consequently, relevant deformations might be formed. Next to an unaesthetic appearance resulting waves and wrinkles induce a reduction of comfortability and, potentially, premature failure is caused to the covering material. In consequence, customer complaints are associated with high costs to the industry.

Within the scope of the poster presentation, the quantification of appropriate leather's elongation and relaxation behaviour by means of relevant parameters like elasticity, viscoelasticity and permanent distortion are presented. Leather specific deformation performances have been examined in pre-defined application-oriented test scenarios by adjustment of different loading modes and constructional upholstery setups as well as varied microclimatic conditions. In order to determine leather qualities a newly developed testing instrument is presented and, compared to standard physical leather testing, a more lifelike test method is introduced.

IVL P-27

## CLEANER RETANNING PRACTICES WITH TRANSGLUTAMINASE ENZYME

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Tanning industry is under increasing pressure owing to the environmental pollution arising from leather manufacturing processes. Clean manufacturing processes are of vital importance in order to minimize the effects of the manufacturing process and product on the environment. In clean manufacturing processes, the use of enzymes or enzyme aided methods instead of the traditional technologies look promising among the new alternative technologies targeting the minimization of environmental pollution. Transglutaminase enzyme (TGase) is a transferase class enzyme which is commonly used in food manufacturing to change the functional properties of the proteins. The most crucial characteristic feature of TGase enzyme is that the increase in the generation of cross links. In this study, the possible use of TGase enzyme in retanning process was investigated, and the effects of TGase enzyme on the properties of the leather and the pollution load of the process wastewaters was presented. Three different groups were formed and in the first group, the optimum TGase proportion was determined by means of using a variety of 1, 2, and 3% TGase enzyme respectively. In the second group, during the retanning process no filling agents were used in fatliquoring and dyeing processes. Where as in the third group a traditional retanning method was performed. In all three groups the fatliquoring and dyeing processes were carried out by the same procedure. The pollution load of the wastewaters, the hydrothermal stability of the leathers, color properties, tensile strength, elongation at break and tear load and organoleptic properties were investigated for each group. The result of the study has shown that the enzyme aided retanning method was improved the physical properties of the leathers in comparison to the other two methods employed. As for the hydrothermal stability of the leathers; the stability was found to be higher in the samples aided by TGase enzyme. The most remarkable result among the methods was obtained by the pollution load of the wastewaters. It has been revealed that the use of TGase enzyme in retanning process was reduced the demand of chemical oxygen (COD) by a rate of 47% and the total nitrogen by a rate of 50.4% in contrast with the traditional retanning method.

*Keywords: Ecofriendly, Transglutaminase Enzyme, Leather, Retanning*



IVL P-28

## UTILIZATION OF KERATIN BIO-WASTE GRAFT ACRYLIC COPOLYMERS FOR LEATHER RETANNING PROCESSING

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Bio-waste material was obtained from hair (animal/human) and it was collected from tanneries. The cysteine was removed from keratin for pharmaceuticals and other medical applications and the remaining part of the keratin were dumped as waste material with unpleasant odour and difficult to dispose. These bio-waste materials have functional groups such as -COOH, -NH, -SH, these functional groups were grafted with acrylic monomer by using free radical polymerization technique for complete conversion of monomers to copolymers. The bio-waste keratin-graft-methacrylic acid (BK-g-MA) copolymers were synthesized by varying different parameters like pH, temperature and time. The product of BK-g-MA copolymer has good solubility and useful products are challenge in various industries including leather. The copolymers was applied on skin/hides and shown to exhibit better tensile strength 42.37 MPa, tear strength 97-107 N/mm, modulus 61-104 MPa, grain crack properties 45 MPa and effective water vapour permeability 11-15 mg/cm<sup>2</sup>/h, due to protein-polymer interaction on leathers. This novel copolymer product is used in coating cum retanning process in the leather sector.

*Keywords:* Keratin, Methacrylic Acid, Cysteine, Coating, Retanning, Leather

IVL P-29

## **INNOCUOUS LEATHER PROCESSING: A CONJOINED BIO-POLYMERIC HYBRID COMPOSITE AS A CLEANER ALTERNATIVE FOR CHROME IN LEATHER**

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An increase in customer demand for high performance, durable and functional leather production in a sustainable manner has created an opportunity for the hybrid composite to be integrated into leather processing. Nano-bio-composites are integrated systems that combine the functionalities of the each component together with new physico-chemical properties originated by their complexity. Such composite materials have primary importance in the area of leather processing especially in tanning/post tanning for reduction of toxic waste and good property supplement. In order to improve the mechanical properties of leather, bio-polymeric based hybrid materials are preferred. In this work, Hydroxyapatite (HA) based composite has been developed and utilised as a retanning agent. Here, we present the synthesis and characterisation of nanocomposite developed from hydroxyapatite nanoparticles surface tailored with Poly (lactide co-glycolide) (PLGA) co-polymer. The functionality provided by this hybrid composite makes this material best suitable as a retanning agent in leather processing. This hybrid composite would be employed not only for uniformity of leather but also for better coating of collagen fibrils with improved heat resistance and strength properties. These properties coupled with increased softness and fullness of leather suggests that HA-PLGA composite may potentially have a superior role in the leather application, especially as a retanning agent. Furthermore, the developed bio-polymeric composite shows less environmental burden exploring the retanning process in a cleaner route.

*Keywords:* Nano-bio-composite, Tanning/post tanning, Hydroxyapatite, Poly (lactide co-glycolide), mechanical properties, environmental burden.



## ETHANOL BASED POST-TANNING PROCESS FOR ENVIRONMENTALLY BENIGN LEATHER MANUFACTURING

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Leather industry generates wastewater with high levels of pollutants resulting in environmental pollution. Various approaches have been made to reduce the pollution load in leather processing. Here, an improved post tanning process has been developed for the manufacture of leather in ethanol medium. Minimal amount of water was employed to emulsify the fatliquor and also to dilute the formic acid. The post tanned leather and liquor were characterized for physical and chemical properties. Whereas the tensile strength of experimental leathers is comparable with control leathers, a notable increase in the tear and grain crack strength was observed in experimental leathers. Compactness of fiber bundles in the experimental crust leathers is comparable to the control leather prepared by conventional water based post tanning process as visualized using SEM. Color measurements show that the color of experimental leather is darker than the control leather thereby leads to potential reduction in the offer of dye. The effluent discharge in the newly developed process is reduced completely by recycling and reuse of the used solvent. This process also helps in the reduction of COD, BOD and TS loads (53, 57 and 66% respectively) in spent liquor. Hence, this process provides alternative way to post tan leather thereby reducing the pollution load.



IVL P-31

**ACACIA ALBIDA AS AN ALTERNATIVE TANNING AGENT****Solomon Fessehaye***Leather Technology Directorate, Leather Industry Development Institute 24692 code  
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Faidherbia albida, an indigenous tree in Ethiopia, is a fast growing tree with multifaceted benefits like nitrogen-fixing. It is widely distributed throughout the country, except in the wet humid south western region. Because of its wide range of distribution, the species is known by a variety of local names: garbi in Orominga, grar in Amharic, garsha in Tigringa, qeretor in Gamonga, and bura in Sidaminga. In December 2011-Durban Climate Change Convention, the late Prime Minister announced a Faidherbia programme - a government initiative to plant hundred million Faidherbia albida trees on smallholder cereal croplands (15 million hectares) across the country within three years (until 2014) in order to improve the food production and livelihoods of smallholder drought prone farmers. Primarily, this very plant species is grown for cover, as a source of nutrient, food for animals, firewood and other benefits like carbon sequestration. According to the recent research findings the use of farming strategies that help boost agricultural product and productivity and at the same time serve other related purposes are highly needed. One of the side benefits, as a leather technologist that we can think of is the use of Faidherbia albida for leather processing. The wood bark, leaves, fruit, seed and roots of Faidherbia albida are going to be investigated for phenolic compound content. By characterizing the tannin extract, the tannins are going to be applied on leather. Hydrothermal stability, organoleptic and strength properties in comparison to locally used commercial tannins are going to be studied.

Keyword: Faidherbia Albida, Phenolic Compound, Firewood



IVL P-32

## A NOVEL DYE LEVELING AGENT FOR UNIFORMITY AND CONSISTENCY IN LEATHER DYEING

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Dyeing is an important process step of leather manufacture that is performed to impart color and aesthetics to tanned hides and skins. However, the intrinsic character of the skin structure with differential fiber density across the regions may cause unevenness of dyeing. Intensity variation and inconsistency in color characteristics among a batch of leathers processed are major concerns of tanners. Variations in final leather color result in either rework or rejection of leather leading to significant productivity and economic loss. Moreover, to produce certain natural-look leather products, uniform dyeing of the entire leather surface and color uniformity of the leathers among each batch is absolute necessity.

In this study, a chemical dispersion has been developed and used as dye leveling agent in leather dyeing operation to enhance the shade intensity of the leather and color uniformity among different pieces of leathers. The physico-chemical characteristics of the dispersion and its efficacy towards achieving the objective have been studied. The amount and time of addition of the dye and the dye leveling agent during the dyeing process was optimized based on the performance towards color uniformity. The color uniformity among skins (from different sources) processed in the same batch, with and without application of the developed dye leveling agent, was assessed visually as well as using spectrometer in order to ascertain the efficacy of the developed dispersion. The physical tests for color such as fastness to rubbing, perspiration and light, were performed to assess the changes occurred due to the use of the developed dye leveling agent in leather dyeing. Leathers processed using the developed dispersion showed excellent color uniformity and consistency with no detrimental effect on fastness characteristics of the leather.

*Keywords: Dye Leveling Agent, Leather, Color*

## IVL P-33

**PREPARATION OF VALUE ADDED COMPOSITE BOARDS  
USING FINISHED LEATHER WASTE AND PLANT FIBERS - A  
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Preparation of composite materials with better mechanical properties and agreeable use is a need of the time because it is eco-friendly. The recycled leather (RCL) as control and its composite boards (CBs) which are the mixtures of leather fibers with plant fibers like jute (*Corchorus trilocularis* L.), hibiscus (*Hibiscus cannabinus*), sisal (*Agave sisalana*), palm (*Phoenix dactylifera*) and enset (*Ensete ventricosum*) in the proportion of 10, 20, 30, and 40 percent are characterized for their physicochemical properties (tensile strength, elongation at break, stitch tear strength, water absorption, water desorption, flexing strength), Scanning electron microscope (SEM), Fourier transform infrared (FTIR), Thermo gravimetric analysis (TGA) and differential scanning calorimeter (DSC). Composites exhibited better mechanical properties compared to those of control boards. SEM pictures showed the composite nature of the boards. TGA studies revealed better thermal stability for composites. In the DSC study, the composite boards of sisal and palm exhibited higher melting point values than those of jute, hibiscus and enset samples.

*Keywords:* - Waste, Composite, Plant, Leather, Fiber, Natural Rubber, Recycle



## PROTEIN GLOWING: EXCITED STATE CHARGE STABLE MULTIPLE ACCEPTOR WITH TPA BASED ORGANIC DYE NANOPARTICLES FOR LEATHER APPLICATION

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Organic dye nanoparticles with photostability, biocompatibility, and good functionality towards protein binding are in great demand. Especially in leather dyeing, the preparation and application of organic dye nanoparticles with biocompatibility is very limited. Even though leather dyeing auxiliaries were developed to enhance the dyeing properties, but their biocompatibility is questionable. Hence in this work, Multiple donor(D)-acceptor(A) systems based on rhodanine-3-acetic acid were synthesized and their photostability were improved by silica infusion through microemulsion technique. By adopting this technique core-shell model of encapsulated quadrupolar dye was developed. A host of technique like Transmission Electron Microscopy (HR-TEM), Fourier Transform Infrared Spectroscopy (FT-IR), Dynamic Light Scattering (DLS), and Zeta Potential measurements were used to characterize the novel organic dye silica nanoparticles by particle size, functionality, and morphology, as well as by  $\zeta$ -potential and physical stability. UV-visible spectroscopy confirmed that the chromophores were involved in the charge transfer interaction between the silica and dye. Our studies indicate that the silica matrix inhibits the aggregation and decomposition of dyes by external factors thereby leads to enhanced photostability. Interaction of the protein for each of the different nanoparticle terminals was unique, indicating a strong dependence on surface chemistry. Furthermore the particle toxicity, indicated by membrane integrity and mitochondrial activity was measured by lactase dehydrogenase (LDH) release, and tetrazolium reduction (MTT), in normal cells. As a result, compared to bare dye, organic dye nanoparticles with core shell model showed less toxicity to normal cells with good biocompatibility. Silica available on the organic dye nanoparticles leads to direct binding of the encapsulated dye to the protein and can have the potential to be used as dyeing agent in leather dyeing with good dyeing characteristics along with photostability and biocompatibility.

*Keywords:* Organic dye nanoparticles, leather dyeing, TPA, Rhodanine-3-acetic acid.

IVL P-35

## LEATHER JACKET FISH SKINS - EXPLORED POTENTIAL RAW MATERIAL FOR LEATHER INDUSTRY

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Increasing price of conventional raw material and absence of technology among tanners for the conversion of alternative raw materials into leather poses a niche area. There is a great potential to develop technologies for the conversion of skins from unexplored sources into leather for the tanning industry. Leather jacket fish skin has been explored as a potential raw material due to the availability and exotic grain pattern. Leather jacket fishes are non-endangered species and consumed without the skin. Skins of these fishes are removed and discarded as waste before being exported from fish processing centres. Experiments were carried out to investigate the feasibility of turning these fish skins to leather.

Leather jacket fish skins were explored for their aptness in leather manufacturing process as a raw material by analyzing the physical, chemical and histological characteristics. Suitable modifications were done in the pretanning process and appropriate enzymes were utilized to achieve proper fibre opening and to remove melanin from the skin. Leather process technology was developed and standardized for the conversion of fish skin into leathers. Histological characteristics were studied at different stages of processing using optical microscope and the structural characteristics were analyzed using scanning electron microscopic technique. Organoleptic properties and physical strength properties of the crust leathers were analyzed.

Development of leather process technology using this explored new raw material would enable to make wealth from waste.

*Keywords:* Leather Jacket Fish Skin, Potential Raw Material, Exotic Pattern, Fibre Opening, Histological Characteristics, Organoleptic Properties.



IVL P-36

## SUBSTANCE IMPROVEMENT AND VALUE ADDITION IN LEATHER THROUGH ECO-BENIGN APPROACH

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A large proportion of hides/skins especially of Asian origin lack substance and possess inherent defects leading to difficulty in producing high quality leathers. In this regard eco benign, simple and cost effective methodology has been developed to improve the substance (bulk properties) as well as surface characteristics of leather using select polymers and bio-degradable materials. The effect of this treatment has been studied during various stages of leather processing. The substance improvement has been quantified. Strength property and pore-size analysis have also been studied. The results indicate that there is up to 30% improvement in substance for different types of substrates and end products. This methodology could be a lucrative way of upgrading low value leathers.

*Keywords:* Leather, Substance Improvement, Bio-degradable, Eco-benign, Value addition

## IVL P-37

**AN ECO-FRIENDLY LEATHER COATING MATERIAL****U Venkateswarlu***Bio-Physics Lab, Central Leather Research Institute, Adyar, Chennai, India**\*Email: venkateswaralu@clri.res.in*

Hen egg white (A) and gelatin (B) composition that was used as a bio-degradable binder was prepared and the product is cross-linked with Glutaraldehyde (C). The composition thus formed (ABC) was standardized with tensile strength and characterized with FTIR, TGA, CD spectra. The tensile strength test was conducted on ABC composite at a speed of 5 mm/min and it shows an optimum tensile strength of 40 Mpa with elongation (170%) for AB and C at the ratio of 50:1. The Circular Dichroism (CD) spectra was performed between 185 nm-250 nm and the AB composite shows an helical structure that confirms presence of peptide bond and for ABC composite an unordered random coil structure with negative peak at 197 nm i.e. helical structure was converted into random coil that confirms the concept of cross linking of AB composite with Glutaraldehyde. The FTIR spectra of AB composite shows protein peaks at  $1654\text{ cm}^{-1}$  (Amide-I),  $1561\text{ cm}^{-1}$  (Amide-II),  $1244\text{ cm}^{-1}$  (Amide-III) whereas for ABC composite, the amide-III band was absent, this is due to glutaraldehyde link with amide group. Thermal gravimetric analysis of AB composite shows 60% weight loss between  $235^{\circ}\text{C}$  to  $400^{\circ}\text{C}$  and for ABC composite it was 8% between  $235^{\circ}\text{C}$  –  $375^{\circ}\text{C}$ . Water absorption studies were conducted on samples and it was concluded that the AB composite was disintegrated within an hour whereas ABC composite (in the ratio AB:C = 50:1) was intact even after 24 hours and has water absorption capacity of  $173\%/mm^3$ ,  $233\%/mm^3$ ,  $245\%/mm^3$ ,  $153\%/mm^3$  after 1 hr, 2 hr, 3 hr and 24 hrs respectively. The ABC composite is tested for peel strength by giving a coat on a standard leather surface and it was found to have 4.8 N/mm on dry condition and 3.2 N/mm on wet condition. Therefore the proposed hen egg white–gelatin–glutaraldehyde (ABC) composite possesses excellent characteristics and can be used as a coating agent for Leather.

*Keywords:* Hen Egg White, Gelatin, Glutaraldehyde, FTIR, TGA, CD, Tensile Strength, Water Absorption



## ULTRASONIC STUDIES ON VEGETABLE TANNIN MATERIALS

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Ultrasonic studies were performed on Myrobalan, Mangustan and soap berry tannin compounds. These tannin materials were extracted using Proctor Method (PR) and Ultra Sound (US) methods. The properties of density, velocity, viscosity, adiabatic compressibility, acoustic impedance, absorption coefficient, viscous relaxation time and free length were calculated at different concentrations and temperatures using both PR & US extraction methods and their results were found to be having similar behavior at temperatures between 20°C and 80°C in step of 5°C. Ultrasonic velocity of the tannins increases with increase in temperature. Viscosity of the tannins decreases with increase in concentration and temperature. Adiabatic compressibility (which is a measure of molecular interactions in binary and ternary mixtures) for tannins decreases with increase in temperature. Inter molecular free length (which is a measure of molecular association) of tannins increases with increase in temperature. Absorption coefficient (structure dependant) for tannins decreases with temperature. Acoustic impedance (which accesses molecular interaction between components) increases with temperature. All the above mentioned ultrasonic parameters show an increase in its values with increase in their concentrations. Finally, it was concluded from the study that the Ultrasonic method is a simple and non-destructive powerful technique in analyzing the tannin materials.

*Keywords:* Myrobalan, Mangustan, Soapberry, Ultrasonic, Proctor, Tannin.



IVL P-39

## LIME-FREE LEATHER PROCESSING USING SODIUM ALUMINATE

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A major contributor to the pollution from the tanning industry is conventional unhairing using sodium sulphide and lime. After the process, a sludge containing lime polluted with sulphides and proteins degradation products forms.

In this study, an attempt has been made to change the lime by soluble sodium aluminate. This material has strongly alkaline properties, non-toxic and good solubility in water. Also, sodium aluminate is an important commercial inorganic chemical for various industrial technical applications.

Therefore, the investigation of the possibility to replace lime by sodium aluminate in unhairing systems was done. There were investigated hair degradation quality, behaviour of hide tissue during unhairing process and the influence of unhairing parameters on the process run and finished leather quality.

*Keywords: Hide, Unhairing, Collagen, Sodium Aluminate*



## FIRE RETARADANT LEATHER FOR FIRE SAFETY APPLICATION

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Leather is used for various purposes including upholstery, clothing, footwear and gloves. Leathers meant for lifestyle applications are close to the human being and the safety of human life can depend on such components in case of the items exposed to fire sources. Here, we report a simple method to produce fire resistive leather using organic nanoclay and ammonium dihydrogen phosphate (ADHP) as flame retardant additives in leather finishing process. Treated leathers were characterized by vertical flame test, tear and tensile strength and thermogravimetric analysis (TGA). We demonstrate that the fire resistance properties of leather improved through treatment with nanoclay and ADHP. Leather treated with 10wt. % nanoclay left more than 20% residue than control leather at 700°C, which indicates the lower decomposition of treated leather as seen by TGA. Additionally, a slight improvement in tear strength was noticed while tensile strength and percentage elongation not altered. Further, we demonstrate that the ignition time for treated leather has increased by more than 5sec and it did not show any flame time after fire source was removed. In general, leather treated with lower content of organic clay (less than 10 wt. %) in combination with ADHP shows better flame retardance as well as physical properties and can be used for higher fire safety application especially for upholstery products.

*Keywords:* Nanoclay, Ammonium dihydrogen phosphate (ADHP), Flame retardance, Upholstery, Thermogravimetric analysis (TGA), vertical flame



IVL P-41

## RESEARCH, DEVELOPMENT AND INNOVATION STATE OF ECOLOGICAL LEATHER MANUFACTURING TECHNOLOGIES AND ITS DEVELOPMENT PROSPECT

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The present paper has systematically reviewed the research, development and innovation state of ecological leather manufacturing technologies at home and abroad comprehensively. It has elucidated the necessity and urgency of the industrialization of ecological leather technology. Specifically, the key technologies of the ecological preparation technology, ecological tanning technology, ecological dyeing and finishing technology have been emphasized. Meanwhile, the basic concepts of ecological leather manufacturing, ecological leather, etc., have been clearly defined. Finally, we put forward the basic ideas and the countermeasures, as well as summarized the developing prospects of ecological leather manufacturing.

*Keywords:* Ecological leather manufacturing; Tanning; Dyeing; Finishing; the present state; Prospect



## STUDY ON PREPARATION AND APPLICATION OF THE YELLOW POLYURETHANE DYE

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The polymer dyes are safe and with low toxicity because they have big molecular size, better chemical and thermal stability, which is not easy to be absorbed by skin. They have not only the characters of polymers with high strength, easy film formation, good heat, and solvent migration resistance but also the colorful features of organic dyes. At present, it becomes the hot spots that the study on polymeric dyes as a substitute for the forbidden dyes or the environmental dyes.

The yellow polyurethane dye was synthesized by self-emulsification method with tolylene-2, 4-diisocyanate, polyethylene glycol, dimethylolpropionic acid, glyceryl monostearate and acid yellow G. The structure was confirmed by Fourier transform infrared spectroscopy. Compared with acid yellow G, it is found that the yellow polyurethane dye has the same color absorption peak in the UV-vis spectra. Experiments show that the color polyurethane film has good heat resistance which shows the starting decomposition temperature is 315°C. The yellow polyurethane dye was used in synthetic leather which shows the dye absorption is more than 99% and the resistance to dry and wet rubbing are more than 4 grades.

Keywords: Yellow polyurethane dye, Synthesis leather; Dyeing; color fastness

SFS P-01

## STUDIES ON THE TOXICITY OF Cr(III), CATECHIN AND Cr(III) – CATECHIN COMPLEX USING BACTERIAL MODELS

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Toxicity of Cr(III), Catechin and Cr(III)-Catechin complex was studied using gram positive bacteria (*B. subtilis*) and gram negative bacteria (*E. coli*) as model organisms. From the results Cr(III) was found to cause more damage towards *E. coli* than *B. subtilis*. Catechin was found to be beneficial as well as toxic (Inhibitory) to the bacteria at a selective concentration behaving as double edged swords causing more damage towards *B. subtilis*. The inhibitory mechanism of Cr(III) and Catechin was by oxidative damage targeting cellular membranes as the mode of action. In case of Complex the membrane damage was found to be lesser than Cr(III) and Catechin when tested individually. The damaging potential of trivalent chromium and Catechin gets reduced upon complexing as Catechin may tune the toxic nature of trivalent chromium. The role of Cr-Catechin complex as a syntan was studied by treating Rat Tail Tendon (RTT) with the complex and performing micro shrinkage measurement. Further the complex could be used as a drug for treating type II diabetes, as trace amount of chromium in trivalent state is necessary for sugar metabolism. Drugs are available as dietary supplement for treating type II diabetes, e.g. Cr(picolate), but due to oxidative damage caused by chromium to the DNA use of those drugs is still questionable. Therefore this complex, as it consists of metal and a poly phenol which possesses antioxidant property could be safe for consumption as a drug.

*Keywords:* Cr(III), Catechin, Complex, Bacterial models



## DYE DEGRADATION BY A FUNGAL LACCASE

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Synthetic dyes are being increasingly used in the textile, paper, cosmetics, pharmaceutical and food industries. Unfortunately, these compounds (chemically classified as azo, anthraquinone, heterocyclic, triphenylmethane or phthalocyanine dyes) cause serious environmental pollution. Most of them are toxic, mutagenic and carcinogenic. Moreover, they are unusually resistant to degradation. The elimination of colored effluents in wastewater treatment systems is mainly based on physical or chemical procedures, such as adsorption, concentration and chemical transformation. However, all these techniques have shortcomings; an effective and inexpensive alternative would be very useful. Among these, degradation of dye using a microbial enzyme (laccase) is quite eco-friendly and enjoys advantages over other systems. Laccase (EC 1.10.3.2), a copper mediated enzyme, catalyzes the oxidation of various aromatic compounds, specifically phenols and anilines while reducing molecular oxygen to water. In this study, an attempt has been made to produce laccase from fungi under submerged fermentation and to evaluate its efficiency in degradation of dyes used in leather processing. The maximum laccase activity of  $10.24 \pm 2$  U/ml was obtained on the 4th day of incubation using  $\text{CuSO}_4$  as inducer. The enzyme was characterized for its effect on pH, temperature and partially purified using ultrafiltration technique. The optimum pH and temperature were found to be 6.0 and  $40^\circ\text{C}$ . The partially purified enzyme showed about 50% of dye degradation at 4h of incubation.

*Keywords:* Degradation, Dye, Fermentation, Fungi, Laccase

SFS P-03

## TREATMENT OF EFFLUENT FROM TANNERY WITH CONSORTIUM OF MICROALGAE

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The processing of animal hides into finished leather generates wastewater with high amounts of organic matter and toxic compounds that must be properly treated to prevent eutrophication of aquatic media. The leather wet finishing and the final finishing are the end stages of production, when raw material receives the characteristics desired like physico-mechanical resistances, softness, color, durability, stamping and protective coating. These processing steps generate wastewater with different types of chemical substances classified in the groups of dyes, surfactants, toxic metals, emulsifying agents, among others. Microalgae have been the subject of many studies in bioremediation due to their ability to assimilate various nutrients and organic matter. Wastewaters generated in tanneries for finished leather have essential elements suitable for the growth of microalgae, but also some toxic compounds that may hinder or restrain the growth of microalgae in this medium. This work tested the growth of a microalgae consortium collected in a wastewater treatment plant of a beam house tannery for the treatment of wastewater streams of a tannery for finished leather (processing wet-blue to finished leather). The consortium of microalgae was incubated for 16 days in a wastewater collected in the following stages of treatments: raw wastewater (RW), wastewater after primary coagulation/flocculation (CF), and wastewater after secondary biological treatment (BT). The wastewater streams were characterized before and after incubation with the microalgae consortium to analyze the removal of total kjeldahl nitrogen (N-TKN), ammonia nitrogen (N-NH<sub>3</sub>), and phosphorus (P-PO<sub>4</sub>). It was verified the growth of the consortium of microalgae in the three wastewaters, with a maximum growth of 0.444 (gL<sup>-1</sup>) in the effluent after primary coagulation/flocculation. The tests reached maximum ammonia nitrogen removal, total kjeldahl nitrogen and phosphorus of 99.9%, 91.85%, and 82.88%, respectively. These results showed that the microalgae consortium was able to grow wastewaters from leather finishing giving efficient removal of the pollutants.

*Keywords:* Microalgae Consortium; Tannery; Wastewater.



## **PRODUCTION OF LEATHER DYE FROM SERRATIAMARCESCENCE USING TANNERY FLESHING SOLID WASTE AND ITS WASTE CONVERTED INTO BIOFERTILIZER USING EARTHWORM**

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Dye plays a major role in the leather sector to attract the customer and improve the sales. Conventionally, the synthetic dyes are used in the leather sector, but it has own demerits such as environmental toxic and human health concerns. Thus, searching renewable and environmentally friendly resources for the production of dye is an urgent need. Plants had been employed in the production of natural dye, but it's not environmental friendly and sustainability due to a large amount of biomasses produced. Practically, fermentation of microorganisms such as fungi and bacteria could be a valuable source of developed of dye. Prodigiosin (PG) is a red dye, produced from manybacterial. But not used in leather industries because of the high cost and energy consumption in the manufacturing of PG. Many researchers developed an effective medium for the PG production such as Sesame oil, peanut oil and coconut oil and brown sugar. However, it does not reduce the cost and sustainable to the environment. The Tannery Fleshing solid waste (TFSW) is the proteinaceous solid waste, generated from leather industries during the leather manufacturing process. The TFSW contains protein about 40-50 %: Carbohydrate, 4-5 % and fat, 10-20%. The TFSW contains adequate carbon and nitrogen contents, besides the essential amino acids and favorable moisture content for the growth of microorganisms. Hence, bacterial fermentation of the TFSW protein will be the best option to yield of essential amino acid for the biosynthesis of PG. Then, the PG was separated from the fermented medium using metal oxides. The Extracted PG was applied onto the leather as a colorant, and its stability was evaluated by the acidic and alkaline medium. The PG removed fermented solution was transferred into vermireactor for the conversation of fermented TFSW transferred into biofertilizer. The fermented animal fleshing solid waste solution about 200 ml medium was transferred into vermireactor. The vermireactor contains cow dung: M. zapotaleaf litter in the ratio of 1:1 (w/w) with 10 earthworm (*Eiseniafetida*) and it had been incubated for 35 days. During the vermicompost, the prodigiosin concentration and pontibacter population were quantified from vermireactor.

*Keywords: Leather dye; Tannery fleshing solid waste; Vermicomposting; biofertilizer; Prodigiosin*



SFS P-05

## REMOVAL OF MICROCYSTIN FROM TREATED TANNERY WASTEWATER USING METAL OXIDE IMPREGNATED EXTRACELLULAR POLYMER

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Microcystin is heterocyclic toxin released from dead cyanobacterial cells and their potential occurrence in drinking water sources prompted investigations into remedial water treatments for their removal. The present investigation employed the copper oxide impregnated extracellular polymer CuO-ECP composite for the effective removal of microcystin from treated tannery wastewater. The extracellular polymer produced from bacterial cell was impregnated with copper oxide to develop CuO-ECP composite. The CuO-ECP matrix was characterized by optical microscope and FT-IR. The CuO-ECP matrix was used for the removal of microcystin from treated tannery wastewater. CuO-ECP matrix removed microcystin by 85% from treated water. CuO-ECP effectively removed the microcystin as the ECP and copper ion integrated matrix is an effective complex with special functional groups such as carboxylic and amide groups to sequester microcystin in aqueous solution. The separated matrix was reused for the microcystin removal and efficiency of recovered CuO-ECP was consistent for the removal of microcystin. The microcystin removal was confirmed by UV-visible spectrum.

*Keywords:* Microcystin, Copper Oxide, Cyanobacteria, Tannery Wastewater



## CHARACTERIZATION OF BIOLOGICAL TREATMENT OF EFFLUENTS FROM TANNED SHEEPSKINS

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The tannery effluent is characterized by a high concentration of organic compounds (such as proteins, lipids), inorganic (as sulphides, chlorides, trivalent chrome) suspended solids (as degraded hair, not dissolved lime), some anilines and other compounds that vary according to the raw hides processed. In this context the little tanneries are those that are more vulnerable as they have not enough means or sufficient space in their establishments. Taking into account these conditions, the aim of this work is to give solutions to the environmental problems for this kind of industries.

With the goal of establish the adequate methodology for testing at laboratory scale, biological treatment in aerobic batch reactors, the effluent obtained in the processes of tanning of sheepskins was used. This effluent, subjected to aeration, settling and precipitation through a physical-chemical process was employed for the experiences of secondary treatment using batch reactors aerobic type, with a culture of microorganisms as the inoculum from a sewage treatment plant effluent. The system was fed progressively up to 100% effluent; volatile suspended solids (VSS) and chemical oxygen demand (COD) were estimated for each step. After adaptation, the treatability assay was performed in order to obtain the kinetic parameters refer to the degradation rate of the effluent for to design biological systems at full scale. Furthermore, the evolution of the system was monitored through qualitative analyses related to macroscopic sludge sedimentation and microscopic observations.

The K (rate constant degradation) and Ks (coefficient of saturation) kinetic settings were obtained using the kinetic model of Monod. From these parameters it was possible to calculate the retention time (60 hours) and the relation food / microorganisms ( $F / M = 0.47 / \text{day}$ ) for an initial 5000mg O<sub>2</sub>/l COD, an allowable overturning 250mg O<sub>2</sub>/l and VSS 3500 mg/l. Microscopic evaluation of sludge allowed to establish the presence of the taxa Litonotusspp during the stages of development, maturation and aging, also were identified and quantified crawling and attached ciliates, metazoa and amoebae.

*Keywords:* Effluent, Adaptation, Sheep, Tannery, Microorganisms

SFS P-07

## CHARACTERIZATION OF CATTLE HAIR WASTE AS ADSORBENT FOR LEATHER DYE

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During the dyeing step in leather processing some chemicals are added to impart characteristics such as color and uniformity of surface appearance to the leather, consequently wastewaters are generated with colored substances that are not easily treated in conventional wastewater treatment plants. Among various treatment systems the adsorption occupies a prominent place for dye removal. The growing demand for efficient and low-cost treatment methods and the importance of adsorption has given rise to low-cost alternative adsorbents. In this work, surface of novel sorbent (cattle hair waste) was characterized and its dye removal ability was tested on aqueous medium of Acid Blue 161 dye. The isoelectric point (pHpzc), functional groups and morphology were investigated. Sorbent surface and chemical composition were characterized using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). The functional group onto CHW was investigated using Fourier transform infra-red spectroscopy (FTIR). The specific surface area and the pore size distribution were determined by analyzes of BET/BJH that showed values considered low when compared to commercial activated carbon. By means of SEM analysis, EDS and FTIR was observed the presence of the dye in the adsorbent tested. The point of zero charge (pHpzc) was 6.5 and the adsorbent showed a good interaction with the AB-161 dye in pH from 1.0 to 3.0. The percentage of AB-161 dye removal on CHW was 70.91 % (pH 1.0) and 70.82 % (pH 3.0) with maximum amounts of AB-161 dye adsorbed of 7.09 (pH 1.0) and 7.08 mg g<sup>-1</sup> (pH 3.0).

*Keywords:* Adsorption; Wastewater; Cattle Hair Residual; Dye.



## DEHAIRING PROTEASE : PRODUCTION, DOWNSTREAM PROCESSING AND EVALUATION

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Globally as well as in Ethiopia the tanning industries are under a high pressure from strict legislation articulated for the purpose of protecting and preserving the environment. In the current situation of Ethiopia this industry is viewed from two perspectives; being an important economic activity and the most environment polluting industry. In order to operate within environmentally compatible limits and sustain the realization of Agriculture Development Led Industrialization (ADLI), the current development strategy of Ethiopia, with respect to the tanning industry, appreciate solutions are essential to help particularly for lime-sulphide unhairing operation. This study deals with production of a dehairing enzyme as green technology alternative for the conventional unhairing practice.

The *B.subtilis* strain was obtained from Department of Biotechnology, CLRI, sub-cultured and characterized for its growth and dehairing protease production in terms of pH, temperature, incubation time and growth and production media composition. The combined effects of pH and temperature on protease production also investigated and they were found to have high interactive effect. Once the culture conditions for production were studied and known, the alkaline protease was produced in a pilot scale fermenter by submerged fermentation using agro media at optimal conditions of pH 6.5, temperature  $30 \pm 10^\circ\text{C}$  and incubation period of 27 hours.

The final protease product was recovered, partially purified and stabilized by primary downstream processing such as crude enzyme formulation, ammonium sulphate precipitation, ultrafiltration and spray drying. The use of the protease products of each technique on sheep skins and cow hide resulted in a highly promising hair removal efficiency that can really compete with lime-sulphide chemical unhairing process.

SFS P-09

## LIFE CYCLE ASSESSMENT AS A DECISION-MAKING TOOL FOR TANNING PROCESS SELECTION AND EVALUATION

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In the tanning process, Life Cycle Assessment studies carried out in accordance with existing and developing Product Category Rules confirm that the production and use of chemicals can account up to 94% of the overall environmental impact of the leather production process. Despite such proven relevance, most of the current LCA studies for leather are realised using Technological approximations of the chemicals used, due to a severe lack of LCA data available.

This study introduces the first EPD initiative to standardize the environmental impacts assessment within tanning chemicals sector. In the first phase, through a LCA study on 3 tanning chemicals (two re-tanning agents from Chestnut extract and a replacement Syntan), new Product Category Rules (PCRs) conformant to ISO 14025:2006 have been defined and published within the EPD international system. The PCRs set the system boundaries, the functional unit to be used for calculations and communication and define the calculation and allocation rules in the tanning chemical industry perspective.

In the second phase, the PCRs have been implemented within a modular analysis methodology, based on an internal inventory system for an Italian company. In particular, a data structure is connected with process parameters and with the internal information system of the factory, to build a parametric monitoring for all consumption and emissions related to the production of selected chemicals.

The results enabled to assess the environmental profile and the biogenic carbon content storage of the three products and allowed to identify the main contributors to the environmental impact generated. The work allowed also to identify improvement areas for impact mitigation.

In a third phase, a LCA Tanning Process Simulation Tool has been used, in order to rapidly identify the most important Life Cycle parameters contributing to environmental impact of leather and in parallel proceed with Eco Design activities on Chemical formulations and tanning process parameters. Prospectively, such LCA simulation tool will allow to anticipate the production of eco-friendly leather through the preventive design of the formulations and the rapid implementation of experimental solutions.



## **PROCESSING OF COLLAGEN BASED MATERIALS, A DOUBLE SUSTAINABLE STRATEGY FOR AGRICULTURE AND LEATHER INDUSTRY**

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The recent restriction of neocotinoids based pesticides (EU directive 485/2013) for seed and plant treatment and increased concerns regarding their impact on health of humans, bees and environment generated the demand for sustainable alternatives in agriculture field. Every year new plant biostimulants based on systemic enhancers are released on the market. The high demand for improvement of carbon footprint of leather industry in a circular economy has stimulated the research in the area of leather industry by-products reclaiming, agriculture being a target area with new directions of applications.

The use of mammalian or fish collagen in compounds for treating cereal or rape seeds is a less studied topic, although film-forming properties, organic nitrogen and free amino acid content, the ability to form complexes with micronutrients and the amphoteric nature provide smart nutritional properties and stimulate germination, allowing reduction of pesticide concentration or seed loss.

The paper presents the preparation of collagen based additives from bovine shavings and raw fish skins for wheat and rape seed and crop treatment in view of increasing yield and reduction pesticide.

The other route of investigations was the use of gelatin for encapsulation of essential oils with fungitoxic and insect repellent properties for improving the collagen hydrolysate functionalities.

The main findings revealed that collagen hydrolysate with average molecular weight of 6000 Da and 11% amino acid content can be used in combination with commercial fungicides in wheat seed treatment and allow the reduction by 70%

of fungicide concentration. Collagen hydrolysate effects are related to increased germination energy and plant density as well as greater resistance of plants to wintering which were attributed to free amino acid fast availability with action in nutrition and systemic protection of plant.

Fish collagen extracts with molecular weight of 12900 Da showed less phyto-toxicity as compared to gelatin (39200 Da) and similar anti-dehiscent properties for rape siliques as compared to commercial synthetic products.

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*Keywords:* Collagen Hydrolysate, Gelatin, Microencapsulation, Seed Treatment, Fertilizer.



## **IMPLEMENTATION OF A MANUFACTURING RESTRICTED SUBSTANCES LIST IN LUXURY LEATHER PRODUCTION : NEW APPROACHES AND EVIDENCES FROM A PILOT PROJECT**

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Kering has recently launched a pilot project for the identification of hazardous chemicals within its leather supply chain. This initiative is propaedeutic to one of the Group Sustainability targets: avoid intentional use of hazardous chemicals in the processes of its supply chains by 2020. This is in line with other initiatives of the fashion industry, shifting from limiting hazardous substances in finished products to their phasing-out from production processes.

The paper analyses some major issues to be dealt with when implementing projects for the identification of harmful substances according to the current structure of the luxury leather supply chain. The Kering Manufacturing Restricted Substances List (MRSL) initiative is introduced, explaining its generation process, coherence with other documents and related background science.

The pilot project approach is a sequence of actions, meant to homogenise and validate information generated by the different actors of the supply chain: tier one suppliers (tanneries), tier two suppliers (chemical companies), customers (Kering brands). The methodology is presented, describing the most important results achieved, working with 11 tanneries. In the first phase, tanneries have performed a self-assessment, structuring data produced internally in the tannery or collected from chemicals suppliers. A sample of wastewater has been tested against the MRSL. In the second phase, Kering performed an integration among the self-assessments, ensuring consistency and creating a database with information for about 4200 chemical products. In the third phase, a selected group of chemicals has been verified through tests, samples of finished leathers and raw hides have been tested.

The analysis allowed to create a smart grid, crosslinking MRSL families, product type and process phase, Evidences show that the 6% of chemical products used in tanneries potentially contains MRSL substances. For half of them, the presence seems due to intentional use by chemical producers, the other half appears to be due to





contamination. The preliminary results rank the chlorinated solvents in degreasing, the aromatic VOCs in finishing products and the chlorophenols in biocides as primary targets for action.

Prospectively, implemented procedure will allow efficient supply chain collaboration for the systematic replacement of targeted hazardous substances.

*Keywords:* Hazardous Chemicals, Sustainability, MRSL, Supply Chain, Luxury, Kering



## DEGRADATION OF THE MICROBICIDE 2-(THIOCYANOMETHYLTHIO) BENZOTHAZOLE BY DIRECT PHOTOLYSIS

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The effluents of tannery industries are characterized by having recalcitrant compounds, which cause problems due the high values of: chemical oxygen demand (COD), biochemical oxygen demand (BOD), amount of dissolved salts and toxicity, the last one is because to the complexity of chemical products used in that process, which complicates the treatability of the effluents. Among these products is possible to mention the application of the microbicides, employed to avoid the biodeterioration of the hides by microorganisms. This problem may lead to harmful characteristics to the end product such as stains, roughness and decrease mechanical properties of leather. Therefore, microbicides, as like the 2 (thiocyanomethylthio) benzothiazole (TMCTB), are applied in distinct steps of the tanning process as an alternative to the chlorinated phenols compounds. The microbicides have low mineralization through usual treatments in the leather industries effluents, furthermore it prejudices efficiency of biological treatment if presents in high concentration. The main purpose of this research is degrade TCMTB by direct photolysis and monitor the degradation by high performance liquid phase chromatography (HPLC) in TCMTB standards solutions. Photolysis tests were performed with a reactor equipped with 250 W mercury lamp (254 nm). At the experiments were used standards solutions of TCMB with 20, 40, 60 and 80 mg L<sup>-1</sup>. The photolysis tests were performed during 7 hours and the degradation was monitored through sampling collected at predetermined periods of time. The monitoring of the TCMTB degradation in the samples by HPLC analysis has proved to be appropriate, since it was possible to note that all samples showed total degradation of the microbicide in the first 30 minutes of the photolysis treatment. Also, it was noted the formation of photoproducts along the photolysis tests, which are reduced to low concentrations after spent 6 hours of treatment. Studies are being performed to apply this effluent treatment process at the leather industries.

*Keywords:* TCMTB, Photolysis, High Performance Liquid Chromatography, Leather

## METAL FREE LINING LEATHER

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Conventionally prepared lining leather poses health risks, owing to the presence of toxic chemicals such as chromium, lead, formaldehyde, etc. Conventionally, chrome tanning has been the most predominant method of tannage for commercial lining leather processing. The present ubiquitous status of chromium as a tanning agent is being challenged owing to its toxic nature. Recent studies suggest that Cr(III) itself may be toxic at higher levels under certain ligand environments. An alternative to chromium tanning system should have the properties comparable to chromium. The ideal tannage to replace chromium tanning should incorporate the following features. Hydrothermal stability 80° C (minimum), Good light fastness, Low environmental impact, Versatility, Comparable cost. Hence, the present demand is that the lining leather must be devoid of chemicals, which are harmful to human skins and health. In order to overcome these problems, many alternatives to metal salts have been found, which are promising one for tanning process. In the present work, it is proposed to make lining leathers employing various combinations of mineral/metal free organic tanning systems and to evaluate the characteristics of the leathers. Combination tanning systems are vegetable tannin-glutaraldehyde, vegetable tannin-polyaldehyde, vegetable tannin-oxazolidine, aldehyde- polyphosphate, soft wattle-soft quebrachotara. Hydrothermal stability of combination tanned leathers are tested and crust leathers are evaluated for tensile strength, color fastness, softness, sweat resistance and water vapor permeability. Hence the metal free lining leather would made and evaluated its testing results.



## GREEN BIOPOLYMERS FOR ECOFRIENDLY LEATHER

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Green and eco-friendly tanning agents based on Biopolymers will be developed within the LIFE BIOPOL project co-financed by EU. The new Biopolymers represent an innovative, suitable alternative to traditional products based on petrochemicals. Biopolymers are non hazardous and safe for laborers and users.

BIOPOL are obtained from industrial by-products such as animal and vegetable biomasses otherwise disposed of in landfill.

Several protocols involving polymerization, esterification, etc. will be developed in order to produce chemicals able to replace the traditional re-tanning and fat-liquoring auxiliaries.

Biopolymer synthesis will be achieved with a new specially devised prototype plant able to produce green chemicals in a single reaction vessel.

Macromolecular characterization of the BIOPOL will rationalize the synthetic strategy and practical application of the products giving important parameters such as molecular weight and chemical composition of the new biopolymers.

Preliminary performances of new synthesized biopolymers have been inspected and compared with traditional chemicals through leather making process. Chemical analysis of re-tanning and fat-liquoring effluents will be carried out.

Scope of LIFE BIOPOL is to produce polymers in order to reduce:

- 20-30% COD,
- 50-60% of inorganic salts (Sulphates and Chlorides),
- 90% of Cr(III) salts,
- 20% of water used in the leather process.

Moreover LIFE BIOPOL will reduce:

- 70-90% of hazardous substances normally found in conventional chemicals (e.g. inorganic salts, free formaldehyde, Cr(III) salts, heavy metals),
- reactivity enhancement of 30-40% of the new biopolymers compared to the current leather application technology,
- reduction of 70-80% of the Product Environmental Footprint of the new biopolymers related to the state of the art.

*Keywords:* Green Tanning Agents, Leather Industry, Biopolymers, Biomass Recycle, Waste recovery

## SUSTAINABLE DESIGN TECHNIQUE AND DECORATIONS ON LEATHER

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India has largest number of livestock in the world. Leather manufacturing and goods since years have become a major contribution to the world economy. In today's era leather industry is undergoing a complete change through modern leather processing techniques, where sustainability has crawled in every field and aspect of life. Leather is imprutrescible dead hide this report focuses on the brief of leather production process, the byproducts of leather industry and recycling of water with toxic chemicals through ETP (EFFLUENT TREATMENT PLANT). Due to mechanical and biological abrasions 40 percent of leathers gets defected which are given a secondary rating, up gradation of these leathers can help in designing of leather products and standardization of quality and value addition to leather products through different design techniques, decorations and surface finishings on these faulted skins. Design decorations like appliqué, crochet, knitting, typography and pyography including aesthetic surface finishing like printed, embossing, aniline dye, painting, metallic, sauvage, mosaic and many more techniques can hide these defects on secondary rated and rejected leathers.

For durable material like leather it takes around 50 years to decompose instead of this parts of many footwear, clothing, automotive products, saddlery products, upholstery products and accessories can be replaced by leather scraps. Another method for the sustainability of old leather product is by giving them a second life it can be imagined like an old cheesy leather jacket can be used to make hundreds of leather buttons, leather boards and everyday life products. Leather can be combined with eco-friendly fabrics like jute and cotton which can be used to make creative lifestyle products. The aim is to reuse leather which in a way makes it sustainable for the environment and a creative way to recycle a material like leather. People suffer with practical problems with leather products in day to day life. Leather being a rough and tough material but still needs to be handled with care this paper also concentrate on the online serve which informs about different problems people suffer with leather product it also contains solutions to these problems thus enhancing the lifecycle of leather products making it more sustainable.



## ISOLATION OF ENDO-B-1,4-XYLANASE: A TOOL FOR NEW HOLISTIC PARADIGM TOWARDS WHITE LEATHER PROCESSING

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The linear polysaccharide  $\beta$ -1,4-xylan a group of hemicellulose with high biotechnological are one of the major components of plant cell walls. The enzymatic hydrolysis of  $\beta$ -1,4-xylan by  $\beta$ -xylanases into xylose has gained a considerable attention due to the development of biomass-derived value added molecules with a wide range of industrial applications. Hence, xylanase can be explored in various industrial applications including greener processing of hides and skins. In this work, a Three Phase Partitioning (TPP) method has been used for isolation of this enzyme from *Agaricus bisporus* which is an edible basidiomycete mushroom. Then the isolated enzyme extract was assayed to find out the xylanase activity. The enzyme production was optimized under variable experimental conditions such as ammonium sulphate concentration, ratio of culture filtrate to tertiary butanol (v/v) and pH. It was found that all the three experimental variables influence the degree of enzyme production and its activity. Maximum enzyme was obtained in the interfacial phase at 50 % ammonium sulphate saturation (w/v) when the other conditions were maintained constant, whereas at 1:2 ratio of culture filtrate to t-butanol (v/v) and at pH 6 keeping the remaining experimental variables constant individually the same result has been achieved. Unravelling the possible use of xylanase for the soaking, greener cleaning of hides and skin, bleaching of pigments from skin might pave the way towards a greener eco-friendly enzyme based leather processing.

Keywords- Hemicellulose, Xylanase, Basidiomycete, Leather Processing.

SFS P-17

## TRANSFORMATION OF LEATHER SHAVING WASTES TO ACTIVATED CARBONS FUNCTIONALIZED WITH CROMIUM(III) AND (IV) OXIDE PARTICLES

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Leather shavings are undesirable byproducts of the tanning industry. Their production represents a disposal cost for tanneries and a hazardous waste for the environment. Due to their organic nature of the leather shavings, this can be transformed into useful materials including activated carbon (AC). The successful transformation of waste products into activated carbon has the potential of contributing to sustainable leather processing, reducing disposal costs and at the same time, reducing tanneries environmental impact since the AC could be used to aid in the treatment of wastewater in the same tannery. The main challenge is to maintain and guarantee that Chrome (Cr) remains at a (III) oxidation state after pyrolysis of the shavings. To prevent transform to toxic Cr(VI), a low temperature pyrolysis activation procedure can be used in which Cr(III) oxide particles can be formed before Cr oxidizes to Cr(VI).

This work, proposes a chemical activation of leather shavings using  $ZnCl_2$  as an oxidation agent to produce activated carbon. Initial waste shavings were characterized, then impregnated with  $ZnCl_2$  and finally carbonized. A Box-Behnken experimental design was employed. The leather shavings were impregnated with  $ZnCl_2$  at 4 different mass relationships: 0, 0.5, 1.0 and 1.5 and carbonized at 300, 400, 500 and 600 °C held for 1.0, 1.5 and 2.0 h at temperature.

The results showed evidence of Cr particles incorporation into activated carbon. Depending on the synthesis conditions,  $Cr_2O_3$  and  $CrO_2$  particles were formed, corresponding to the (III) and (IV) oxidation states. It is proposed that the gasification of organic matter caused a semi oxidized atmosphere in the reactor tube thus promoting the partial oxidation of Cr(III) species. The succeeding steps in the research include the extensive characterization of the (activated) carbon materials studying their heavy metal(s) content as well as their colorants adsorption capacity.

*Keywords:* Activated Carbon, Leather Shavings, Chromium Oxide, Pyrolysis



## OPTIMIZING OPERATING PARAMETERS OF AN ELECTROCOAGULATION PROCESS FOR THE TREATMENT OF TANNERY EFFLUENT

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The tanning industry is one of the most important productive activities in the city of Leon, producing approximately two-thirds of the total number of skins tanned in Mexico. In the tanning process, an average of 35 liters of wastewater is generated per kg of treated skin when considering the overall process. Due to the presence of compounds and complex chemicals inhibiting the activity of microorganisms, efficient biological treatments are difficult to apply. Chemical treatments such as coagulation, where aluminum sulfate and ferric chloride reagents are added sometimes form toxic sludge, creating an additional problem. Membrane separation methods involve a high cost, so they are often reject by the companies as unsustainable. Electrochemical treatments are, therefore, becoming a reliable option for treating the wastewater effluent of the tanning industry. It has been reported that the electrocoagulation process is being efficiently used to remove organic and inorganic contaminants rapidly and at low cost, significantly reducing levels of COD, turbidity and chromium in these effluents.

In this work, the team carried out the treatment of a real tannery effluent obtained from pilot plant tannery laboratory at CIATEC. The studies were performed by electrocoagulation using iron and aluminum electrodes to determine the optimum operating parameters for a pilot-scale plant treatment process. The one hour experimental studies were conducted at different current densities (28, 111 and 444 mA/cm<sup>2</sup>), on 1 L of effluent held at a 7.0 pH. Following treatment chemical oxygen demand (COD), total organic carbon (TOC), turbidity, total chromium, solids, pH and conductivity were evaluated. With a current density of 28 mA/cm<sup>2</sup>, the removal of COD and TOC was increased using iron electrodes, reaching 69% removal of COD and 60% TOC. Turbidity showed a 99% decrease with aluminum electrodes at the same current density.

The processes costs were also evaluated, the most economic treatment used iron electrodes and a current density of 28 mA/cm<sup>2</sup>. Considering total treatment effectiveness, then, the optimum operating parameters were found using iron electrodes at a current density of 28 mA/cm<sup>2</sup> for 1 hour.

*Keywords:* Electrocoagulation Process, Wastewater Treatment, Iron And Aluminum Electrodes.



SFS P-19

## **BIOSORPTION OF CONDENSED NAPHTHALENE SULFONATE FROM AQUEOUS SOLUTION USING IMMOBILIZED BACTERIAL AND FUNGAL BIOSURFACTANTS**

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The tanneries are associated with the generation of huge amount of liquid effluent. The effluents generating from tanneries are complex waste induced by a series of chemical and biological activity to convert the collagen matrix of the skins/hides in to the leather having high concentration of pollutants. NSA has been detected in tannery effluents at concentrations of between 1 – 30 mg L<sup>-1</sup>. NSA was also found to persist after primary and biological treatments and therefore, present in the final effluent discharged to the environment. Biosurfactants have attracted considerable scientific attention due to lower toxicity, higher biodegradability, specificity better environmental compatibility, lower critical micelle concentration, activity at extremes of temperature, pH and salinity, higher foaming, higher selectivity and possibility of their production through fermentation using cheap renewable resources

The present work investigates the potential use of biosurfactants to sequester sulfonated naphthalene from aqueous solution. The biosurfactants were produced from bacterial and fungal species using fish oil as the carbon substrate and immobilized onto functionalized nanoporous activated carbon (FNAC). The comparison of sequestering capacity of both the surfactants was studied. The chemical changes before and after biosequestration were monitored by High performance liquid chromatography, Thermo gravimetric analysis TGA & Differential Scanning Colorimetry, Fourier Transform Infrared spectroscopy and Scanning electron microscopy. Batch studies were conducted with bacterial and fungal biosurfactant to determine the influence of various experimental parameters such as pH, contact time, temperature, and concentration of dosage. The biosorption of immobilized biosurfactant with sulfonated naphthalene was observed through impedance and FTIR results indicated that ion exchange and complexation might exist during the biosorption. The maximum removal capacity was found to be 89% at 37°C at pH 7 by immobilized fungal biosurfactant. This indicates that the biosurfactant immobilized onto functionalized nanoporous activated carbon was a promising adsorbent for the removal of syntan from aqueous solutions.

*Keywords:* Biosurfactant, Sulphonated Naphthalene Syntan, Functionalized Nanoporous Activated Carbon, Biosequestration.



SFS P-20

## HIGH EXHAUST CHROME TANNING USING CO-POLYMER PREPARED FROM LEATHER WASTES: TWO PRONGED APPROACHES FOR INCREASING EXHAUSTION AND REDUCING SOLID WASTES

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High exhaust chrome tanning using copolymer has been developed and standardized. The product was synthesized from leather-hydrolysate, monomer and an initiator at optimum temperature of 85°C for 6 hrs. The product was characterized by TGA, DSC, FT-IR, particle size analyses that showed mean particle size of 810 nm, relative viscosity of 0.8 cp, solid content of 23% and pH of 4.5. The product exhibited stability against aqueous solution of 3% NaCl, NaOH, formic acid and basic chromium sulphate (BCS). Application of 2% of the product in chrome tanning resulted into 93% exhaustion in the chrome tanning. It has been confirmed from the FT-IR revelations that carboxylic acid, amide I & II, hydroxyl groups and ester groups play major roles in expediting exhaustion of chromium in the tanning process. SEM and SEM-EDX studies confirmed increased exhaustion of chrome in the experimental sample. AFM studies from topography and deflection observations showed clear evidences of increased exhaustion of chromium for the experimental samples that had been treated with co-polymer. The organoleptic properties of leather showed uniformity and flatness in grain, enhancement in the tightness of belly region and filling properties. The color measurement studies revealed comparable properties to the control sample that had been treated with relatively less amount of chromium. The physical strength properties are analogous to the conventional leathers. This methodology helps in mitigating chromium pollution in tanning by exploiting solid waste into high performing exhaust aid.

*Keywords: Co-polymer, Characterization, Chrome Exhaust Aid, Improved Exhaustion In Tanning, Improved Organoleptic Properties, Reduction In Pollution.*

SFS P-21

## ENVIRONMENTAL SCIENCE AND TECHNOLOGY INNOVATIONS IN LEATHER RESEARCH TOWARDS SUSTAINABLE DEVELOPMENT IN LEATHER INDUSTRY: A SCIENTOMETRIC STUDY

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The 'Scientometric study' is an analysis of literature with mathematical and statistical methods in information use and seeking pattern approaches in a particular field of Information products and services for Knowledge Indicators towards Organisational Development. The Impact of Scientific Research on Scientific Community could be testified by citation analysis. The citation analysis is an analytical methodology under Scientometrics used to evaluate research programmes. In view of this, Leather Science Abstracts(LESA) and Indexing International Periodical Publication Knowledge Resources/Information Products and Services serve as a tool for Knowledge Indicators in Environmental Science and Technology innovations in Leather Research towards sustainable development in Leather Industry.

The present case study is dealt with LESA database on Scientometric analysis of literature related to Environmental Science and Technology research trends in leather research. Analyses 4500 citations appended to 331 research contributions published in Environmental Science and Technology during the period from(2001-2005) in LESA database. The design of the study is a 'Citation Analysis Approach (CAA). The purpose of the study is to investigate through citation analysis on Dissemination of Knowledge in Environmental Science and Technology innovations in leather research for sustainability of leather. Descriptive Statistics was used in analysing the data. About 24 Sub-fields were identified under environmental science and technology for sustainability of leather. Out of 331 citations, 48 citations (14.5%) are from 'Leather production and Pollution Control aspects in leather industry'. Based on the survey, the highest number citations/research contributions totalling 67 (20.24%) has emanated from 'Leather Institutions'.

Based on the study, the environmental science and technology research contributions are more 128(38.67%) from 'India' and stand at number one ranking under Country wise distributions of research contributions. It is evident from the study that the majority of the research papers/contributions 214(64.65%) are from co-authored pattern/collaborative efforts in leather research. The analysis indicated that the Scientists preferred to publish research papers in Joint authorship(64.65%) having 0.65 degree of collaboration. The Scientometric Software, 'Scientosoft', technology application tool used for this purpose. The Single authored research Contributions 117 (35.34%) is also well recognized feature in environmental science and technology for sustainability of leather.



The study encourages the researchers to initiate collaborative efforts for interdisciplinary research activities particularly in Environmental Systems Design Modelling and Optimization, Environmental Monitoring, Wastewater Treatment Technology, Environmental Impact Assessment (EIA) and Environment and Health aspects in Leather Industry for sustainable development.

*Keywords:* Scientometric study, Impact on Environmental Science and Technology innovations, Leather Science Abstracts (LESA)database, Knowledge Indicators/ Knowledge Dissemination, Leather Research, Sustainable Development.

SFS P-22

## CUSTOM FABRICATED NANOMATERIAL FROM HAIR WASTE: A TRASH TO TARGET APPROACH

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Tanning industry activities and related process generate large amount of solid, liquid and gaseous rejects. Among solid rejects, biodegradable collagenous waste and non-biodegradable keratin wastes constitute the major share apart from the hazardous sludges generated. Collagen has been explored to full potential for both scientific and commercial applications compared to its equivalent keratin though both being fibrous in nature. This has inspired us to derive a concept to generate value added products from keratin. To harvest the functional property of keratin which is present as tight network of fibers embedded in a matrix, it has to be obtained in a soluble form. This is possible by means of hydrolysis reactions. Keratin source was subjected to five hydrolysis treatments (viz., sulphitolysis,  $\beta$ -mercaptoethanol, ionic liquid, thioglycolic acid and alkali) and assayed for functional groups. This was followed by the prediction of secondary structure using circular dichroism, determining the microstructural level to which the extracted peptide has self-assembled. Sulphitolysis and thioglycolic acid based hydrolysates exist in monomeric conformation, whereas  $\beta$ -mercaptoethanol based hydrolysate exhibited dimeric conformation. The subsequent part of the study is to incorporate these peptides into the nanofibers to study the structural implication of keratin peptides on its characteristics. Accordingly, the peptides were electrospun with PVA and subjected to morphological, mechanical, thermal and biological characterizations. Monomeric nanofiber mat has high tensile strength of around 5.5 MPa and offered lower mass transport resistance, whereas dimeric mat has high  $T_m$  of around 290°C and was more biocompatible. This study thus clearly elucidates the role of extraction in affecting the property of the hydrolysates, thereby providing a direction in which proteinacious wastes can be efficiently utilized to generate functional materials. Also it paves a new direction in the field of electrospun materials where the structure of the protein or peptide can be looked upon before generating a functional material for a specific application.

*Keywords:* Keratin; Nanofibers; Protein-polymer hybrids; Circular Dichroism; Capillary flow porometry



## EVOLVING AN INDUSTRIAL DIGITAL ECOSYSTEM AND DIGITAL ECONOMY FOR LEATHER INDUSTRY

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Digital Ecosystems are the digital counterparts of biological ecosystems and best described as “distributed, adaptive, open socio-technical system with properties of self-organization, scalability and sustainability inspired from natural ecosystems.” The digital ecosystem metaphor and models have been applied to a number of business areas related to the production and distribution of knowledge-intensive products and services, including higher education. The three wheels of digital ecosystems are: Creating new sources of revenue, Rationalizing cost structures, enhancing the speed of technology adaptation. Change in the curriculum, emphasis on Data science to create digital backbone, Mobile marketing, could be the start of this digital transformation. In this work we created an Ecosystem-Oriented architecture of Digital Ecosystems by extending Service-Oriented architectures with distributed evolutionary computing, allowing services to recombine and evolve over time, constantly seeking to improve their effectiveness for the user base. The perspective of this research is providing methods and tools to achieve a set of objectives for world-wide education on leather and allied field and value creation for digital economy.

*Keywords:* Digital ecosystem, Internet of things (IoT), Data Science, Creative ecosystem, Global Higher education

SFS P-24

## A NOVEL METHOD TO PROMOTE OPENING UP FIBER STRUCTURE BY USING XYLANASE IN LEATHER MAKING

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Opening up fiber structure of hide is one of the main purposes in beamhouse, and it is mainly achieved in the liming process with sodium sulfide and lime and the bating process with proteases. However, a great deal of pollutions are produced in the liming process, and the biotechnologies of opening up fiber bundles based on proteases often cause loose and even damaged grain. Hence it is necessary to develop cleaner and more efficient methods to open up fibers. Proteoglycans in skins play an important role in the assembly, formation and connection of collagen fibers and constructing crosslinking network by winding and wrapping with collagen and elastic fibers. It has been widely accepted that there is a close relationship between the content of intradermal proteoglycans and the effect of opening-up fiber. Moreover, much work focusing on destroying intradermal proteoglycans through breaking glucosidic bonds of polysaccharide molecules with carbohydrases, such as amylase, pectinase and hyaluronidase and so on, to accelerate collagenfibers opening-up were reported. However, it is still controversial whether and how these kind of carbohydrases can effectively destroy intradermal polysaccharides, especially dermatan sulfate, because of the high specificity of glycoside hydrolase toward glucosidic bonds. Hence firstly, the effects of a serials of carbohydrases on degrading intradermal proteoglycans were investigated through evaluating the contents of proteoglycan, aminopolysaccharide and total sugar in the wastewaters from treating cattle hides with different glycoside hydrolases, and a kind of xylanase was selected. Further, the xylanase was applied to the enzyme unhairing process based on a special protease with low collagenolytic and elastinolytic activities, and its effect on improving unhairing and opening up fibers was investigated. The results show that the xylanase can promote hair removal and opening up fibers, and the leather has tighter grain and higher softness. It may be attributed to that the xylanase can efficiently cut off the glycosidic bonds of the stucture unit of galactose- $\beta$ -1,4- O-xylose-O-serine/threonine core protein, by which polysaccharide chains connect with core protein, thus polysaccharide chains are released from proteoglycan.

*Keywords:* Opening-Up; Proteoglycan; Glycoside Hydrolase ;Xylanase; Leather making



## **AN EFFICIENT AQUEOUS DEGREASING METHOD WITHOUT SOLVENT AND SURFACTANT BASED ON THE SYNERGISTIC ACTION OF LIPASE AND ALKALI**

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As a cleaner degreasing method, degreasing with lipase has been paid more attention in leather industry. However, at present, most of related studies showed that a significant degreasing effect cannot be acquired when using lipase alone at the its optimum pH or together with surfactants. In order to solve these problems, firstly, a novel approach of evaluating the performance of lipase was established under simulated leather-making conditions, then the characteristics and the optimum condition of lipase catalyzing the hydrolysis of lipids in skins were investigated. The results showed that the enzymatic hydrolysis was obviously inhibited by the products, fatty acids, and surfactants, hence the lipid hydrolysis ratio was lower than 60% for most of selected lipases under their optimum conditions, and they lost activities in the presense of low concentration surfactants. Further, an efficient degreasing method based on the synergistic action lipase and alkali was established. The skins were first treated with lipase and then alkali was added. The produced fatty acids were transformed to soluble soaps and released from the lipid substrate, hence, the product inhibition was greatly reduced. The hydrolysis ratios of lipid were rased to more than 90%. Using the novel method of combining lipase with alkali in the degreasing process of pigskins after soaking, the degreasing ratio was 74.8%; then using the method again after bating, the total degreasing ratio reached 96.2% and the remained lipid was just 1.4%, which was much lower than the conventional degreasing with surfactants. The efficient aqueous degreasing without solvent and surfactant can be achieved by the synergistic action lipase and alkali.

Keyword: Lipase; Fatty Acid; Product Inhibition; Enzymatic Degreasing



SFS P-26

## **BAFFLED MOVING BED BIOFILM REACTOR AS PRIMARY TREATMENT PROCESSES FOR POST-TANNING WASTEWATER FOR THE REMOVAL OF SUSPENDED AND COLLOIDAL SOLIDS WITHOUT ADDITION OF COAGULANTS AND FLOCCULANTS**

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The treatment of wastewater containing suspended and colloidal solids is an important aspect related to strict environmental regulation and wastewater reuse. The coagulants and flocculants are being used in conventional primary treatment process for the removal of suspended and colloidal solids in post tanning wastewater. The conventional treatment pose some disadvantages such as generation of huge chemical sludge and rise in total dissolved solids concentration in wastewater. In the present study, Baffled Moving Bed Biofilm Reactor (BMBBR) was designed for the removal of suspended and colloidal solids in post tanning wastewater without addition of coagulants and flocculants. The BMBBR was operated with an organic loading rate of (OLR) of  $1.94 \text{ g}^{-1} \text{ l}^{-1} \text{ h}^{-1}$  in continuous mode and it showed removal efficiency by 90%. The sludge formed in the reactor was easy to handle as it was a highly mineralised sludge. The measured sludge volume formed in the BMBBR reactor as Sludge Volume Index was observed to be less than  $64 \text{ ml} \cdot \text{g}^{-1}$  and it was about 60% comparatively lower than the sludge formed in conventional treatment methods. The microbial biofilm formation in the BMBBR reactor was confirmed using Scanning Electron Micrograph (SEM) analysis. This study indicated that the BMBBR would be an effective method for removal suspended and colloidal solids in post tanning wastewater.

*Keywords:* Baffled moving bed biofilm reactor (BMBBR), post tanning wastewater, Removal of suspended and colloidal solids.



## HEXAVALENT CHROMIUM REDUCTION BY CHROMIUM TOLERANT BACILLUS STRAIN FROM TANNERY WASTE

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Cr (VI) designated as a priority pollutant or Class A pollutant by the United States Environmental Protection Agency (USEPA), cause mutations and cancer in humans. Tanneries are the major source of chromium pollution, releasing about 40-25,000 mg/L of Cr in their effluents. In addition to this, leakage due to improper handling and faulty storage containers also adds to the accumulation of chromium in the environment. Therefore treatment of tannery effluent containing hazardous compounds becomes necessary prior to their final discharge into the environment. Biological treatments arouse great interest because of their cost effective, safe and lower impact on the environment. Certain species of bacteria are capable of transforming much toxic and highly mobile Cr (VI), into less toxic and less mobile Cr (III) and thus chromate bioremediation is of considerable interest. In view of the potential applications of Cr (VI) reduction, the present study was aimed to isolate and enrich the Cr (VI) resistant strains from the tannery effluents and to mediate biosorption and detoxification of hexavalent Chromium into non-toxic compound. An indigenous chromium-reducing bacterial strain was isolated from the tannery solid waste located at Pallavaram and was identified as *Bacillus* Sp. based on its morphology, physiology and bio-chemical characteristics. This particular strain when grown in media containing  $K_2Cr_2O_7$ , could resist concentrations as high as 300 mg/L of Cr (VI) and was able to reduce the entire chromate when cultured in as low as 10 mg/L after 48 h exposure of incubation.

Scanning electron microscopy (SEM) revealed the distribution of chromium on bacterial cell surfaces. Bacterial isolate was also analyzed by EDAX for confirmation of Cr (VI) reduction. Cr (VI) treatment brought several changes in the FTIR spectrum of bacteria treated with Chromium. Transmission electron microscopy (TEM) of bacteria exposed to 80 mg/L Cr (VI) for 48 h revealed the presence of circular electron dense dark black inclusions in the cytoplasm suggesting the accumulation of the metal in the viable cells. This isolated organism can therefore be successfully used for reduction of significant amount of Cr (VI) in the natural environment as well.

*Keywords: Chromium, tanneries, bioremediation, Bacillus, SEM, TEM, EDAX, FT-IR.*

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## REDUCE POLLUTION LOAD AND VOLUME BY EFFLUENT REUSE / RECYCLE

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Nowadays the bottleneck for production capacity of a tannery is the restricted quantity of effluent water being let out for treatment to Common Effluent Treatment Plant (CETP). This paper analyzes possibility to reuse or recycle various waste water streams generated from various operations in beam house.

Quantity of waste water generated per Kg of Raw skin or hide by conventional wet blue beam house process is 8.5L to 10L. This reuse and recycle suggests reduction of this fresh water quantity to 1.5 L/Kg, where the balance quantities are from this reused and or recycled waste streams. This implies final discharge as effluent to CETP will be less than 1.5 L/Kg.

Waste water streams in a beam house are generated from Pre Soak, Main Soak, Lime, Fleshing, Delime prewash, Delime, Delime 1st and 2nd, Pickle, Tanning, Piling. Beam house waste water streams vary in pH, TDS and few other parameters. After required primary treatment, especially removal of Suspended solids these waste streams shall be used in various processes in beam house. Let's recall our traditional long liming process, where we do not use any sodium sulphide, there sharpening action was done by the old lime liquor, this triggers idea of reusing lime liquor after removing suspended solids. We discuss similar such reuse ideas for different waste streams at different stages.

Analysis on paper is done regarding quantity of treated waste water from different streams, and that shall be used for different operations depending on their contents viz TDS, proteins, fats, other chemicals and pH. This suggests number of iterations of reuse and recycle. Chemical requirement shall be reduced as these treated waste streams have some unused chemicals, especially chemicals such as Sodium Sulphide, Sulphuric acid, Chrome which are hazardous to environment and health.

*Keywords: Effluent Water, Reuse Recycle, Bottleneck Reduction, Suspended Solids, Pollution Load, Unused Chemicals, pH.*



## A QUEST FOR MECHANISTIC INSIGHTS ON BIOACCUMULATION OF HEXAVALENT CHROMIUM: A WHITE ROUTE FOR BIOREMEDIATION

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Indiscriminate use of heavy metals including trivalent and hexavalent chromium, one of the natural constituents of the environment, has become a major environmental concern. Discharge of enormous industrial effluent might be a deleterious health hazard for human life and aquatic biota as it has altered the geochemical cycles and biochemical balance. Several innovative technologies have demonstrated the Cr(VI)-bioremediation by certain microorganisms. Understanding the molecular mechanism of Cr-accumulation might be a possible way to explore numerous biotechnological implications for bioremediation of Cr-contaminated sites. In view of this, removal of chromium using a gram positive moderately halophilic indigenous bacterium isolated from tannery wastewater enriched soil was investigated. The abilities of the strain in terms of tolerance and degradation of Chromium was found upto 350 mgL<sup>-1</sup> and 99.6% within 24 h. AAS and FT-IR studies indicated that changes of metal redox state were accomplished by the strain enzymatically rather by biosorption method. NAD(P)H mediated enzymatic reduction of Cr(VI) under saline condition is found to be optimum at pH 7 and at 37° C. The result indicated that the reduction of highly toxic mobile Cr(VI) to innocuous immobile Cr(III) might be ideal for developing a sustainable green bioremediation of Cr(VI)-contaminated water or waste streams, sequestering metals in soils and sediments to aid in their extraction. The mechanistic understanding of bioaccumulation of chromium can provide insight into strategies for their detoxification.

*Keywords:* Bioaccumulation, Chromium, Enzymatic Reduction, Bioremediation.

SFS P-30

## OXIDATION OF AN ORGANIC DYE USING NANOCRYSTALLINE RARE EARTH DOPED $\text{CeO}_2$ UNDER UV AND VISIBLE LIGHT IRRADIATIONS

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Different types of dyes and pigments are used in large quantities in tanning, textile, food, pharmaceuticals and cosmetic industries. Finally these industries are releasing huge quantities of wastewater containing dyes, pigments and other toxic organics into the aquatic environment. These toxic organics are hazardous to human health and aquatic organisms. So, the dye effluents must be treated before it discharged into the aquatic environment. Conventional wastewater treatment methods may not be applicable for the removal of dyes and toxic organics, because it has complex chemical structure and reactivities. Newer emerging techniques like Advanced Oxidation Processes based on heterogeneous photocatalysis considered to be a better option to treat the dye house effluents. Hence, the present study is focused on the rare earth doped semiconductor materials such as cerium doped dysprosium oxide was synthesized by co-precipitation method and characterized by XRD, FT-IR, UV-DRS, FESEM, EDAX and HRTEM techniques. Band gap of the synthesized semiconductor material was found as 2.8eV which was calculated from UV-Vis-DRS data. FESEM analysis confirms that particles were spherical in shape and size was ranged from 23 to 31nm. The synthesized photocatalyst was evaluated for the degradation of Malachite green dye under UV and visible light irradiations. Experimental parameters like effect of aqueous phase pH, variation of catalyst dosage and dye concentration were standardized to determine the optimum conditions for the photo degradation studies under UV and Visible light irradiations. The maximum dye degradation was observed in the neutral range of pH with 10ppm/10mg of photocatalyst; 91% and 94% of dye degraded under Visible and UV light irradiations respectively. Time dependence studies were also performed for 5 to 25ppm dye concentration under UV and Visible light irradiations. Chemical Oxygen Demand (COD) was monitored and it is observed that the value of COD level decreased at greater extent under UV and Visible light irradiations of the dye molecules. Effect of added electrolytes such as  $\text{MgSO}_4$ , NaCl, KCl and  $\text{Na}_2\text{CO}_3$  also been carried out. The catalyst showed better activity even after third cycle of reusability.

*Keywords:* AOP, Heterogeneous Photocatalysis, Rare Earth Doped Semiconductors



## VALORIZATION OF FLESHING WASTE INTO VALUE ADDED PRODUCTS: A CLEANER MODE

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Leather making results in generation of huge amount of solid, liquid and gaseous wastes. Among them, fleshing is one of the major solid wastes removed from adipose layer of hides and skins. From every ton of hide about 10 kg of fleshing waste is generated, which amounts to the production of about 700 000 tons of fleshing waste worldwide every year. Fleshing waste is considered as hazardous due to the presence of sodium sulfide, a corrosive and an asphyxiating chemical. But it is rich in biological materials like proteins and lipids. An ecofriendly method was developed for the maximal recovery of lipids and proteins from tannery fleshing waste using protease produced from *Bacillus subtilis* MTCC 6537. Maximum lipid yield of 14.96% was obtained in protease assisted extraction method using less volume of solvent compared to other conventional methods. Physicochemical characteristics of lipids reveal that it could be a viable and potential feedstock for biodiesel production. The fleshing hydrolysate recovered from the process was lyophilized and evaluated for its potency as microbiological media supplement. The results showed that it could be used as one of the nitrogenous sources for the growth of bacteria and for the production of enzymes. The solid residue obtained from the enzymatic extraction method was also characterized for its potency to remove dyes from wastewater. The above findings indicate the utilization of fleshing wastes for preparation of value added products and provide comprehensive solution to the issue of fleshing waste disposal with economical returns.

*Keywords:* Enzymatic hydrolysis, Fleshing waste, Lipid, Microbial media, Protease, Tannery

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## COMBINED AND SUSTAINABLE MANAGEMENT OF TANNERY EFFLUENT THROUGH A NOVEL BIOPROCESS METHOD

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Water resources are the significant source for the survival of living organisms. The effluent from leather industries contains many chemical components and complex biowaste that are toxic to the environment when they mix with water sources it damage the ecosystem. Hence, the present investigation was carried out to treat and manage the tannery effluent with a novel bioprocess using microbes and enzymes combination. Initially, the effluent was treated with enzyme a proprietary formulation that contain highly active enzyme mixture that helps in breaking down the large and complex biomolecules in to simple peptides. Subsequently, the treated effluent undergoes biomass utilization Microorganisms is a combination of specialised microorganisms mixture effectively utilize the organic biomass that are already digested by enzymes. Then, in the third process, odoclear is a combination of enzymes mixture that would rapidly remove the odour form treated effluent. Practically, the entire effluent treatment process (ETP) was designed into three section, primarily, the enzyme was added at the concentration of 50 to 100 ppm mixed/stirred well for 30-60 minutes. Secondly, Microorganisms was added at the concentration of 20 to 50 ppm for 24 hours and odoclear was added at the concentration of 500 to 1000 ppm for 2-4 hours. After completion of the bioprocess treatment, the physicochemical parameters are analysed compare to before treatment. The results indicated that combined bioprocess treatment had effectively reduced the TDS, TSS, BOD, COD, odour and colour of treated effluent. This Bioprocess method was successfully applied on pilot plants to biologically treat the tannery effluent. This technology could be adopted for all large scale treatment plants without any modifications in infrastructure. We, at Caprienzymesbrings a new path in effluent treatment process to support tannery industries and to protect the environment.

*Keywords:* Bioprocess, Effluent treatment, Caprizyme-TT, Caprizyme-MOC, CaprizymeOdoclear





## A MODEL OF WASTE RECYCLING - TALL OIL EXTRACTED FROM PAPERMAKING WASTE LIQUID USED FOR LEATHER FATLIQUORING

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There are a lot of suspended solids, organic pollutants and toxic substances in black liquor. Discharging them into water directly will cause serious pollution. If the black liquor is converted into products, it not only decreases the pollution of black liquor, but also has good economic benefit. After standing and stratification, the substance floating on the upper layer is mainly fatty acid sodium soap and sodium rosinate soap which is crude tall soap (also known as crude sulphate soap). After washing, acidification and stratifying, the upper layer of tall soap is crude tall oil.

In the study, the tall oil as main raw material was used to prepare the leather fatliquor, which not only increase the use value of tall oil, but also broaden its application scope with environmental and economic benefits. Through the reaction of tall oil and concentrated sulfuric acid, sulfated tall oil was obtained. And then it was neutralized with ammonia water, sulfated tall oil fatliquor (S-TO) was prepared. The structure of S-TO was characterized by means of FTIR and iodine value measurement. Emulsification, particle size and emulsion stability were also tested. Then the fatliquoring properties of S-TO and commercial sulfated neat oil (S-NO) were compared. FTIR spectrum and iodine value analysis results indicated that concentrated sulfuric acid had a reaction with the double bond in tall oil. Meanwhile the average thickening rate of leather oiled by S-TO and S-NO were 13.40% and 14.91%, the softness ( $\phi = 25$ ) was 7.49 and 7.34, the tensile strength was 10.19 MPa and 11.54 MPa, tearing strength was 36.52 N/mm and 26.95 N/mm, water vapor permeability was 0.9615g/10cm<sup>2</sup>·24h and 0.9774 g/10cm<sup>2</sup>·24h. The application results showed that both of the fatliquors had great improvement for the thickening percentage, softness and physical-mechanical properties of leather. However, the water vapor permeability was reduced. At the same time, the FTIR analysis showed that the two kinds of fatliquors were chemically combined with the leather fiber and SEM results showed that the collagen fibers became looser after the addition of fat. In conclusion sulfated tall oil fatliquor can achieve commercially fatliquoring effect.

*Keywords:* Leather Fatliquor; Sulfated Tall Oil; Sulfated Neat Oil; Property



SFS P-34

## LIFE CYCLE ASSESSMENT FOR TANNING CHEMICALS PROCESS : THE CASE OF AN INNOVATIVE METAL FREE CHEMICAL PRODUCT MODELLED IN AN INDUSTRIAL FACTORY

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Life Cycle Assessment (LCA) has created significant interest in the leather supply chain. The standardisation process is a necessary adjunct for this market evolution: the international EPD System has developed specific Product Category Rules for leather and the European commission is concluding the same process.

Despite increased market interest, most current LCA studies for leather are based on chemical data with limited technical representativeness.

The study presented refers to an LCA for a commercially available tanning agent from Stahl, Granofin Easy F 90, which is based on an organic structure. The framework of the study is based on the Product Category Rules 343 for tanning chemicals. The system boundaries consider all upstream phases and is considered concluded at the factory gate.

LCA considers, in detail, the total system resources used, including transportation processes, production processes, energy consumptions, all meaningful waste streams generated, water consumption, and emissions to air and water. Independent third party certified results would include 99% of total inflows regarding energy, mass and environmental relevance with regards to the core module.

To improve LCA reliability, certain improvements have been made for this study. In terms of activity data inventory, the factory where F90 is manufactured has been modelled in detail. A specific data management procedure has been defined: the LCA data structure has been mapped on the outputs of the company, specific data elaborations have been set up, validated and certified. In terms of data modelling, specific quantitative values have been introduced in order to quantify both data representativeness and data adaptation to an external database.

Results show that an improvement in chemical composition for tanning chemical can address up the 90% of the environmental impact for what concerns the Global Warming Potential Category and Ozone Depletion Potential.

The summary results of this study will allow increasing the production of LCA studies and primary data for tanning chemicals in an efficient and automated manner and ultimately contribute to the development of reliable LCA data for the whole leather supply chain.



## ECO-FRIENDLY NATURAL SURFACTANT FOR WETTING OF LEATHER

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Leather industries commercially use synthetic chemical surfactants for wetting of leather. These surfactants are mostly based on petrochemical origin and thereby it increases the pollution loads. Natural surfactants are becoming an important alternative to chemical surfactants due to their improved properties compared to their chemical counterparts in terms of bio-degradability, reduced toxicity and availability from cheap raw materials. The present study focuses on the use of bio-surfactants from the plants *Hibiscus sabdariffa* and *Sapindusmukorossi* for leather application. The leaves and root parts of these traditional plants showed the presence of various phyto constituents like flavonoids, tannins, protein, sterols etc. Beside, these plants are known for its anti-oxidant, anti-diabetic and anti-microbial activity. It is also found that the soaking and wet back time attained by using the natural surfactants is fast when compared to the conventional method. The use of natural surfactants also ensures the achievement of complete soaking in a comparatively reduced duration than the chemical surfactants. From the BOD and COD results it is clear that the soaking effluent (using *Sapindusmukorossi*) and wet back effluent (using *Hibiscus sabdariffa*) is degradable having BOD/COD values of 0.81 and 0.62 respectively. This makes the discharge treatments easy when compared to the conventionally used non-biodegradable surfactants. Thus the natural-surfactants could be bio-degradable and they also act as eco-friendly agents.

*Keywords:* Bio-Surfactants, Leather, *Hibiscus Sabdariffa*, *Sapindusmukorossi*, Biodegradable .

SFS P-36

## CYCLIC CARBONATE: A GREEN MEDIUM FOR ZERO DISCHARGE TANNING

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Cyclic carbonates are currently attracting the worldwide interest of researchers to develop sustainable approaches for greener environment. Propylene carbonate, one of the cyclic carbonates, was taken as the medium for chrome tanning process. The said process does not require water input and also consumes a lesser amount of chromium and other tanning auxiliaries than conventional tanning process. Enhancement of chromium uptake up to nearly 100% w/w was demonstrated through this process. Furthermore, the used cyclic carbonate can be recycled for the next batch of tanning process without any pre-treatment and the developed process enjoys "Zero discharge of water and chromium". Additionally the propylene carbonate possessing good antimicrobial and antifungal activity, which avoids the usage of any external preservative in tanning process. Performance of the leathers is shown to be on par with conventionally processed leathers through physical/hand evaluation and morphological analysis. Also, the process is proven to be economically beneficial than conventional tanning process.



*Keywords:* Propylene carbonate, Chrome tanning, Greener medium, Antimicrobial activity, Economically beneficial



## **INTERNALIZING THE SOLID WASTE : PREPARATION OF RETANNING AGENT FROM ANIMAL HAIR**

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Huge quantity of solid waste is generated from leather manufacturing. Animal hair, owing to its nature of poor biodegradability, is one of the major solid wastes of tanneries. About 48,000 tons of hair waste is generated per annum. Presently the hair waste is not utilized and needs to be disposed off safely. There is limited work addressing the utilization or secured disposal of animal hair. Hair is fundamentally a structured protein, keratin. Theoretically, it could be a good source for the production of value added products such as amino acids and protein hydrolysate. Conventional method of acid hydrolysis of keratin is carried out at a pH in the range of 1 and 2, while alkali hydrolysis is done at a pH in the range from 10 to 12. The major limitations and disadvantages of acid or alkali keratin hydrolysate based syntans were associated with lack of filling effect, grain tightness in leather and poor stability in syntan. To address the above problems, an enzymatic method was developed for hydrolysis of keratin using a bacterial strain. The hydrolysates were used for preparation of keratinoid-acrylic composite polymeric retanning agent. The product was evaluated in leather processing and found to render many beneficial properties to leather.

*Keywords:* Enzymatic hydrolysis, Hair waste, Protein, Syntan, Tannery

SFS P-38

**PREPARATION OF SYNTHETIC TANNING AGENTS  
USING KERATIN HYDROLYSATE FOR  
SUSTAINABLE LEATHER PROCESS :  
A MICROBIAL ROUTE**

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One of the important criteria determining the sustainability of an industrial activity is the ecological acceptability of the processing and wastes treatment methods. Eco-friendly process and wastes treatment methods employed in industrial production has gained paramount importance and more particularly in tannery sector. Hence, to overcome the problems, solid wastes disposal methods were developed. Great deal of work has been done to address the issue of wastewater. However, not much research work has been focused on solid waste. Conventional method of acid hydrolysis of keratin is carried out at a pH in the range of 1 and 2, while alkali hydrolysis is done at a pH in the range from 10 to 12. The major limitations and disadvantages of acid or alkali keratin hydrolysate based synthetic tanning agents were associated with lack of filling effect, grain tightness in leather and poor stability in synthetic tanning agents. To rectify the above problems, an enzymatic method was developed for hydrolysis of keratin using a bacterial strain. The hydrolysates were used for preparation of keratinoid-acrylic composite polymeric syntan and evaluated in leather processing.

*Keywords:* Enzymatic hydrolysis, Hair waste, Protein, Syntan, Tannery.



## NANOLAYERED GRAPHENE OXIDE/MoS<sub>2</sub> COMPOSITES : A NOVEL VISIBLE ACTIVE PHOTOCATALYST FOR SUSTAINABLE DYE HOUSE EFFLUENT TREATMENT

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The mineralization of various dyes from industrial effluents such as textile, leather cosmetics and food processing industries etc., becomes an important issues pertaining to the environment. So it is important to treat these effluents before the discharge into aquatic environment. Advance oxidation process using semiconductor photocatalytic materials are considered to be one among the good techniques to degrade the toxic organic contaminants into water and carbon dioxide through mineralization process from the dye house effluents. Graphene and graphene based hybrid materials possess as an excellent electron acceptor/transport behavior, large surface area and may be applied as photocatalytic materials for the environmental remediation. Hence, present investigation deals with preparation of nanolayered reduced graphene oxide/MoS<sub>2</sub> nanocomposite materials by modified Hummer's method and sol-gel process. The prepared nanocomposite was characterized by XRD, FT-IR, FE-SEM and Raman analyses and its photocatalytic activities was tested for the degradation of methylene blue dye under visible light irradiation. The XRD result shows the pure crystalline nature of MoS<sub>2</sub> matrix in the graphene oxide layers. The morphology of graphene oxide was analyzed with FE-SEM shows a sheet like form through which the RGO-MoS<sub>2</sub> material were attached in between the sheets of layered structure. Raman analysis shows the purity of the graphitic nature of grapheneoxide. The preliminary photocatalytic studies such as effects of initial aqueous pH in the range from 2 to 11, different dye concentration varies from 5 to 25 ppm and catalyst dosage 5 to 50 mg/10ml were conducted. Neutral pH was showed maximum percentage of degradation and same was optimized for the further experiments. RGO-MoS<sub>2</sub> composite achieves maximum degradation of 96% at 240min under visible light irradiation for MB dye molecules. The kinetic rate constant result proves the photo reaction follows pseudo first order rate equation. The results demonstrate that RGO-MoS<sub>2</sub> could be a potential photocatalyst material for the photodegradation of organic dye molecule under visible light irradiation.

*Keywords: Photocatalyst, Organic Dye, Visible Light Irradiation, Graphene, Nanocomposite.*

SFS P-40

## SOLAR PHOTOCATALYTIC DEGRADATION OF LEATHER DYE HOUSE EFFLUENTS USING HEARTIN LIKE LAYERED BIOBRNANOPHOTOCATALYST

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Dyes and pigments are extensively used in textile, leather, food, cosmetic and pharmaceutical industries, etc. The effluents from these industries are hazardous to human health, aquatic life and mainly cause enormous damages to the environment. So, dye house effluents have to be treated using sustainable treatment technologies are need of the hour. Hence, the present study is deals with an advanced oxidation process using semiconductor solar photocatalysts to degrade the harmful organics dyes and pigments into water and carbon dioxide. In this study, BiOBr photocatalyst was synthesized by hydrothermal method. The characterization of the prepared material was analyzed by using FT-IR, XRD, HR-SEM, UV-Vis DRS spectroscopy. The XRD analysis shows the crystalline nature of the prepared material. The FTIR analysis shows the surface functionalities present in the photocatalyst. HR-SEM analysis shows that the BiOBr photocatalyst, heartin like layered structure which helps to reduce the recombination of the electron-hole pair and enhance the photodegradation process. Band gape energy of the prepared material was calculated from UV-Visible Diffuse Reflectance Spectroscopy analysis data and it was found that 2.92eV. The prepared photocatalyst was tested with real leather wastewater under solar light irradiation. The efficiency of the catalytic process was analyzed before and after the treatment of wastewater with various parameters like Color, pH, Oxidation Reduction Potential, Total Nitrogen, Ammonia, Calcium, Total Hardness, Magnesium, Total Dissolved Solids, Total Solids, Total Suspended Solids, Chloride, Total Organic Carbon and Chemical Oxygen Demand analyses. The chemical oxygen demands for the treated and untreated samples were found as 14000 and 8000 mg/L respectively. Over all experimental results clearly demonstrates that the solar nanophotocatalysts may be a viable option for the development of sustainable environmental remediation technologies.

*Keywords: Photocatalyst, effluent, treatment, layered structure, BioBr, solar*



## SOUND PROOFING NANOFIBERS : AN EFFECTIVE FLESHING WASTE MANAGEMENT STRATEGY

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During leather processing for every ton of raw hide/skin about 700 kg of solid waste is generated and 10-12% of this is fleshings, a proteinaceous waste. Disposal of this fleshing waste is a major challenge faced by the tanners worldwide due to the strict environmental regulations. The present disposal methods have various challenges and limitations. In this study, we propose a novel approach for utilizing the fleshing waste to generate a value added material. Fleshings have been converted into nanofibers through electrospinning as a sound absorbing material for acoustics application. Thereby an effective way of utilization of solid waste for generation of a value added material for a useful application has been developed. Protein hydrolysate, prepared from limed fleshing waste by acetic acid hydrolysis has been blended with poly(vinyl alcohol) and the mixture was then subjected to electrospinning to produce nanofibers by optimizing the electrospinning parameters. Electrospinning is a cost effective, simple and versatile method where electrostatic force is applied to produce nanofibers from polymer solutions. Nanofibers have been crosslinked with glutaraldehyde vapor to improve their stability. Fleshing waste nanofibers have been characterized using various techniques such as Scanning Electron Microscopy (SEM) and Differential Scanning Calorimetry (DSC). Effect of different hydrolysis conditions on the properties of nanofibers has been studied. Sound absorption efficiency of the nanofibers has been measured using impedance tube method. The yield of protein hydrolysate has been found to increase with increasing acetic acid concentration. Diameter range of nanofibers has been found to be around 100-150 nm. Air permeability measured using porometer is found to be lesser in fleshing waste derived nanofibers when compared to neat PVA nanofibers. Impedance measurement shows that the sound absorption ability of fleshing waste derived nanofibers is higher than the neat PVA nanofibers clearly indicating the potential of these fleshing derived nanofibers to be used as sound absorbing materials for acoustics application.

*Keywords:* Fleshing Waste, Leather, Nanofibers, Electrospinning, Sound Absorption and Impedance.



SFS P-42

## MECHANISTIC INSIGHT INTO PHOTACATALYTIC DEGRADATION OF HIGHLY REFRACTIVE PHENOLIC POLYMER AS REVEALED BY ELECTRON SPIN RESONANCE AND SOLID-STATE NMR SPECTROSCOPY

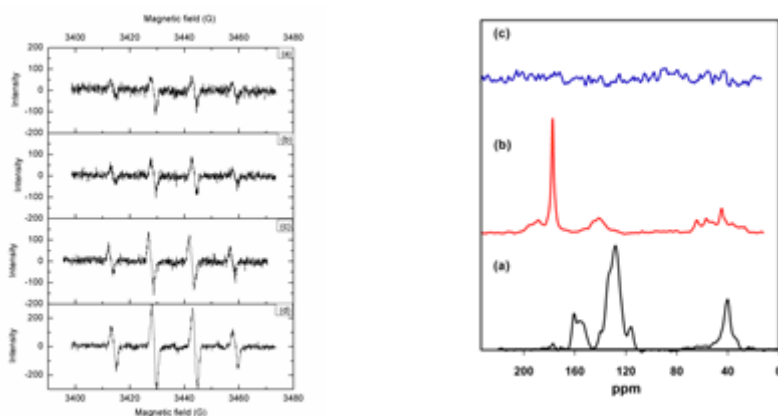
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Advanced Oxidation Technologies (AOTs), which involve the in situ generation of highly potent chemical oxidants such as  $\cdot\text{OH}$  have emerged as an important class of technologies for accelerating the oxidation of a wide range of organic contaminants in tannery waste water. The degradation of phenolic syntan by photocatalytic process was studied in a re-circulated batch reactor. The adsorption of phenolic syntan on  $\text{TiO}_2$  surface was also considered. The generation of hydroxyl free radicals during photo-oxidation was investigated by Electron Spin Resonance (ESR) spectroscopy and found that above pH 9.0 is more congenial for hydroxyl radical generation. The samples of syntan solution collected during the course of photocatalysis were analyzed by Solid-State  $^{13}\text{C}$  Nuclear Magnetic Resonance (NMR) spectroscopy to understand the degradation pathway. In addition, electro-oxidation was attempted to achieve the complete mineralization of phenolic syntan.



X band ESR spectra of photocatalytic degradation of phenolic syntan under different pH. (a) pH 3.0; (b) pH 5.0; (c) pH 7.0 and (d) pH 9.0

$^{13}\text{C}$  CP-TOSS NMR spectrum of phenolic syntan (a) before photocatalytic oxidation, (b) after photocatalytic oxidation and (c) after Electro-oxidation of phenolic syntan



## LIFE CYCLE ASSESSMENT (LCA) BASED APPROACH FOR SUSTAINABILITY OF TANNERY WASTE WATER TREATMENT

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In India, currently, liquid waste generated from tanneries are collected and treated in individual Effluent Treatment Plant (ETP) or Common Effluent Treatment Plant (CETP). Dewatered sludge generated from ETPs or CETPs are disposed in common secure landfill facility in CETPs or common hazardous landfill facility as per the hazardous waste regulation. In some tanneries and tannery clusters, zero liquid discharge (ZLD) system are implemented as per the directions of the regulatory agency. In order to achieve ZLD, in addition to conventional primary and secondary treatment, tertiary treatment, membrane system and reject evaporation are being implemented which are highly energy intensive and in turn results in air pollution and solid residues. In this paper, sustainability evaluation of ZLD system has been made and to estimate its emission factors in terms of major global environmental issues. One of the method for sustainability evaluation is lifecycle assessment (LCA), a computer aided tool. LCA is a holistic approach that can be utilized for the evaluation of ZLD, especially during decision making and in strategic planning. LCA can predict the overall environmental burdens due to the implementation of ZLD system.

*Keywords:* Tannery, Effluent treatment plant, ZLD, LCA

SFS P-44

## THERMAL TREATMENT OF TANNERY SOLID WASTE USING PYROLYSIS

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Thermal treatment of Leather Finished Trimmings (LFT) and Chrome Shavings (CS) from tanneries using Pyrolysis was studied. Initial characterization of leather finished trimmings and chrome shavings from the tannery industry indicated higher calorific value of both the samples which makes it more suitable for thermal treatment. Thermo Gravimetric analysis (TGA) of chrome shavings and finished leather trimmings showed a weight loss of around 80% and 69% at 800°C respectively. Pyrolysis was carried out using a fixed bed type Pyrolysis unit at a temperature of  $500 \pm 10^\circ\text{C}$  for both the leather wastes for a reaction time of 30 minutes and three different by-products were obtained as a result of Pyrolysis. The product yield from the process and its physico-chemical properties were studied. Higher bio-oil yield of 52% and 49% were obtained from the LFT and CS respectively which makes it suitable for Pyrolysis process. The calorific value of the bio-oil obtained from LFT and CS was found to be 28 MJ/Kg and 27.8 MJ/Kg respectively. The flame temperature of the gases burnt after Pyrolysis was measured and found varying in the range of  $637 \pm 10^\circ\text{C}$  and  $665 \pm 10^\circ\text{C}$  for LFT and CS respectively. FTIR and SEM analysis for both the solid wastes before and after treatment were carried out.



## ELECTRO-OXIDATION: A SUSTAINABLE TECHNOLOGY FOR REDUCING THE ENVIRONMENTAL IMPACTS OF LEATHER MANUFACTURING

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Leather industry has been installing various technologies time to time to meet the environmental regulations and to attain the zero discharge. Recent years, advanced technologies such as membrane technologies followed customary treatment technologies are installed in most of the tanning industries. However, RO has been proved to be economically impracticable and moreover there is no feasible solution to dispose the reject securely. To avert the environmental threats to tanning industries, it is important and essential to develop the permanent solution to a perpetual problem.

In this research, it is aimed to develop the sustainable technology for reducing the environmental impact of wastewater based on the principle oxidative degradation of organic compounds so as to render them re-useable. Electro-oxidation is an auspicious technology for the removal of organic compound present in wastewater. The waste streams from different unit processes are segregated and screened to remove the gross solids. The sectional streams were treated following electro-oxidation. Influence of process parameters such as current density, electrolyte concentration, pH and duration were studied and optimized for each sectional wastewater. The oxidation radicals such as  $\cdot\text{OCl}$ ,  $\cdot\text{OH}$ ,  $\text{HOCl}$ ,  $\text{O}_3$ ,  $\text{O}\cdot$ ,  $\text{H}_2\text{O}_2$ ,  $\text{O}_2$  and  $\text{Cl}_2$  generated oxidizes the organic pollutants. The treated waste streams were found to be free from organic pollutants generated during the process. Current Efficiency (CE) and Energy Consumption (EC) were calculated. The resultant treated wastewater was reused appropriately. This indicates clearly that reuse treated sectional streams does not influence on the quality of leathers. Physical properties of the leathers obtained through reuse experiments were akin to those of the control leathers. Thus, the water consumption and the pollution issues can be minimized in tanneries by adopting electro-oxidation. It concluded that electro-oxidation technology is commercially feasible and economically viable to attain the zero wastewater discharge for sustainable leather manufacturing.

*Keywords:* Zero Discharge, Electro-oxidation, Reuse, Sustainable technology, Tannery, Sectional streams.

SFS P-46

## DEVELOPMENT OF DEGREASING ENZYME (LIPASE) USING SOLID WASTE FROM LEATHER INDUSTRY

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Leather making process involves usage of hazardous chemical inputs for the conversion of skin to leather. Pre-tanning and tanning operations contribute to about 80-90% of the total pollution load. Solid wastes generated during the process are majorly organic. Of these solid wastes, hide fleshing wastes accounts for 50-60% of wastes generated from the process. On the other hand, conventional degreasing process of animal skins is done using surfactants and solvents that are environmentally problematic. Fat from hide fleshing wastes was utilised for production of lipase enzyme using lipolytic bacteria sourced from putrefied animal skin. Such lipase was used for degreasing of animal skin. Five lipolytic strains were screened and selected for the study. Among all, two strains such as *Pseudomonas mendocina* and *Staphylococcus xylosus* showed maximum lipase activity and were selected for the purpose of lipase production using fleshing fat as lipase inducer. About 20 - 30 g of fleshing fat was obtained per kg of hide fleshing wastes. An optimised fermentation medium consisting of peptone, ammonium chloride, yeast extract and fleshing fat as carbon and nitrogen sources were used. The crude lipase showed the highest activity of 810 U/ml. The molecular weight bands for crude lipase enzyme were found around 27 kDa, 32 kDa, 43 kDa and 59 kDa using 12% SDS-PAGE gel. The pH and temperature stability of the crude lipase was found to be 9.0 and 40 °C respectively. It was used for degreasing of animal skins containing around 18 - 22% fat at the initial stage. The fat content in the skins was found to be reduced to around 4 - 6% after the degreasing enzyme treatment. The current study focused on researching the possibilities of using a skin putrefying bacteria based lipase for degreasing purpose, which was found to be more specific in its action with respect to natural grease present inside the skin matrix. Also, the fleshing wastes generated from the leather industry was optimally utilized for the cleaner and greener processing, which promised to be a sustainable solution for the industry.

*Keywords: Putrefaction; Lipolytic Bacteria; Lipase; Fleshing Wastes; Degreasing*



SFS P-47

## STUDY ON PREPARATION AND ANTIOXIDANT ACTIVITY OF STURGEON FISH GELATIN FILMS

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In this paper, gelatin film was prepared from the skin of artificial breeding of hybrid sturgeon, and the film properties, such as physical-chemical and reducing power were measured. The results showed that sturgeon skin gelatin has a good film-forming property. When the gelatin concentration in water solution was 5% and the ratio of gelatin and glycerin was 10: 1, the gelatin film will have several properties, such as high transparency, greater surface gloss, tensile strength, tensile elongation moderate, good thermal stability, etc. The antioxidant properties of gelatin films were measured in DPPH method, at the same time the reducibility of the gelatin films were measured to strengthen the authenticate of the antioxidant property. Finally conclusions are drawn that the anti-oxidizability of the sturgeon fish skin gelatin film is better than the anti-oxidizability of cowhide skin gelatin film and the reducibility of sturgeon fish skin gelatin film is lower compare to vitamin C.

*Keywords:* Sturgeon, Skin gelatin, Gelatin film, Anti-oxidizability, Package

SFS P-48

## CONVERSION OF LEATHER WASTES TO AN ECO-FRIENDLY SUPERABSORBENT POLYMER

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To deal with the leather waste pollution, enormous amount of efforts have been made. In this paper, we provide an environmentally sound and economical method to manage the problem of solid leather waste (leather scraps, LW) generated by leather industry, through converting leather waste resources into a value-added product mainly used for agriculture. A leather waste -based superabsorbent polymer was synthesized by grafting copolymerization of neutralized acrylic acid (AA) and ammonized maleic anhydride (MA) onto the hydrolyzed waste collagen obtained from leather waste (PLW-g-(AA-co-MA)). To achieve an improved performance, major factors, that may affect the water absorption of such a superabsorbent polymer during preparation, such as the neutralization degree of AA, ammonization degree of MA, amount of crosslinker and initiator were explored, through which a leather waste -based product with a maximum absorbency of 1618 g/g in distilled water (177g/g in 0.9 wt % sodium chloride solution) was received. Simultaneously, the biodegradability of this polymer has also been investigated via enrichment culture technique and 16S rRNA gene sequence analysis. We isolated a bacterium from soil identified as a strain of *Ensifer* sp. Y1 that can use PLW-g-(AA-co-MA) as carbon source to grow and the samples, before and after the biodegradation of 15d, were characterized by scanning electron microscopy (SEM) and TG. Both the novel water absorbency and excellent biodegradability of PLW-g-(AA-co-MA) showed that the introduction of the wastes into superabsorbent is a green and sound method of utilizing leather wastes, which could not only significantly reduce the production cost, improve the biodegradability of product but also make the technique quite environmental friendly, thus making it more possible for superabsorbent polymer to be used in agriculture and industry fields.

*Keywords:* Superabsorbent polymer; Leather waste; Biodegradability; Enrichment culture technique



SFS P-49

## DESIGN OF ECOLOGICAL PROCESS OF CATTLE UPPER LEATHER BASED ON FE-ZR-AL COMPLEX TANNING AGENT

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The pretanning, main tanning and retanning of cattle hide upper leather were designed by single factor test method and orthogonal test method using pickled cattle skin and Fe-Zr-Al complex tanning agent as main raw material, and were optimized by ecological property and physical-mechanical properties. The results showed that the pretanning with 1% glutaraldehyde GT50, the main tanning with 26% Fe-Zr-Al complex tanning agent, and the retanning with 7% Fe-Zr-Al complex tanning agent, 6% acrylic polymer tanning agent, 2% amino resin tanning agent and 5% vegetable tanning agent, the physical-mechanical properties and sensory properties of the cattle upper leather after drying and finishing were closed to the chrome tanned leather and could meet the industry standard QB/T 1873-2010. Compared with the chrome tanned leather, the production process of Fe-Zr-Al complex tanned cattle hide upper leather was in line with the concept of ecological design, and it has very important realistic significance to improve the level of clean production in leather industry and promote the progress of leather engineering technology.

*Keywords: leather engineering, Fe-Zr-Al complex tanning agent;chrome free tanned; cattle hide upper leather, ecological design*



SFS P-50

## PREPARATION OF FAT LIQUOR CUM RETANNING AGENT FROM FLESHING WASTE : WEALTH FROM WASTE APPROACH

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Fleshing wastes are generated from tanneries during leather processing when flesh of the soaked or limed skin/hide is removed. These wastes contain significant quantity of protein and fat content and are currently being wasted into dumping sites or in open areas, consequently creating the fleshing waste disposal as a major environmental problem of the tanning industries throughout the world. Approximately, 9-14 tonnes of fleshing waste are being generated from Ethiopian tanneries per day. The objective of this work is to develop fatliquor cum retanning agent for use in leather industry from the fleshing waste. The extracted fleshing fat was first emulsified. Then the fleshing hydrolysate, containing the protein fractions was prepared by alkaline hydrolysis. The hydrolysate and the extracted oil were further characterized to find the suitability of production of fatliquor cum filler for retanning process. The fat extracted from the fleshing was characterized for iodine, saponification and acid value. The fleshing hydrolysate was characterized for degree of hydrolysis, solid content, molecular weight, and particle size and zeta potential measurement. For making upper leathers, 8% and for nappa leathers, 16% of the prepared fatliquor cum retanning agent was employed.

The leathers were not found to be greasy, indicating that the product penetrated into the leather matrix. The particle size of the prepared product was also determined and was found in the range of the commercially available retanning agents. Physical characterization of the leathers retanned with this new product were carried out and compared with that of control leather processed with commercial fatliquors and retanning agents. Organoleptic properties were evaluated by experts and found to be on par with that of the control leathers. This study proves that the protein and fat from fleshing wastes can be utilized to make a beneficial product. This process also answers the disposal problem associated with the solid waste (fleshing) generated from tanning industries.

*Keywords: Fleshing Waste; Fatliquor; Retanning; Hydrolysis*



## A SALT-FREE PICKLING CHROME TANNING APPROACH USING A NOVEL SULPHONIC AROMATIC ACID STRUCTURE

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Discharge of chromium and chloride is severe pollution source in leather making industry, which limits the development of leather industry and effects human life. Aiming at minimizing the emissions of pollution, novel materials which are rich in sulfonic acid group were synthesized and optimized in salt-free pickling and less chrome tanning process. The results showed that, the novel method would improve the chromium absorption and distribution in crust leather from 71.6% to 98.6%, compared with conventional pickling chrome tanning, the concentration of residual chromium in spent liquor was decreased to 45mg/L. The SEM indicated the resulting leather treated with novel salt-free pickling showed clean pores and well-dispersed fibrils. Expanding experiment proved this novel salt-free pickling and less chrome tanning methods is feasible in term of organoleptic and physical mechanical properties. The financial assessment showed that the novel method is 46.9% cheaper than conventional approach. This novel pickling chrome tanning method can successfully solve the emission of chromium and chloride, and achieve the cleaner production of leather making industry.

*Keywords:* Sulphonic aromatic acid, Salt-Free Pickling, Chrome Exhaustion, Sodium Chloride

ECT P-01

**PERFORMANCE EVALUATION OF AEROBIC REACTORS FOR  
THE TREATMENT OF VEGETABLE TANNIN WASTEWATER:  
OPTIMIZATION OF FOOD TO MICROBE RATIO AND  
RESIDENCE TIME**

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Vegetable tannins, the natural polyphenols occur commonly in the wastewaters generated from forestry, plant medicine, paper and leather industries. Leather industries carry out a process called tanning to convert raw hides/skin into leather. Tanning can be of two types: chrome tanning and vegetable tanning. The presence of tannins in the vegetable tannin wastewater would cause many problems associated with environmental pollution and wastewater treatment. The treatment of this kind of wastewaters is usually difficult because tannins are highly soluble in water and would inhibit the growth of microorganisms in activated sludge process. In this study, aerobic biodegradation studies were carried out for various food to microbe (F/M) ratio of 0.06, 0.1 and 0.15 for different residence time. As the F/M ratio decreased, the concentration of available microbes increased. Samples were collected in regular intervals of 6 hours and checked for BOD, COD and tannin. The reactor with F/M 0.06 showed higher removal of tannin and COD than the reactors with F/M 0.1 and 0.15. The results showed that the reactor with F/M 0.06 shows 62.8 %, 67% and 81 % removal of tannins, COD and BOD, respectively. Even though F/M ratio of 0.06 showed maximum removal efficiencies of COD, BOD and tannins, other operational factors also need to be considered. The study results indicated that by increasing the microbial population alone is not effective in complete removal of recalcitrant condensed tannins present in the wastewater. The study results indicated that F/M ratio of 0.1 with 24 hours residence time can be adopted in industries for the treatment of vegetable tannin wastewater, which gives 50, 54 and 42 % removal of COD, BOD and tannins.

*Keywords:* Tannin, Recalcitrant, Vegetable Tannin Wastewater, Food To Microbe Ratio



ECT P-02

## ISOLATION AND IDENTIFICATION OF HALOTOLERANT ORGANISMS FOR THE PRODUCTION OF PROTEASE ENZYME FOR THE TREATMENT OF HYPER-SALINE SOAK LIQUOR DISCHARGED FROM TANNERIES

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This present study mainly focuses on the enzymatic degradation of soluble bio molecules (proteins) present in soak liquor that contains high salt concentration ranging 4-7% of NaCl that are discharged from tanneries. The halophilic organisms were isolated from different sources acclimatized with soak liquor and screened for their proteolytic activity at saline medium. The hydrolytic protease was produced from two selected halophilic microbes which were isolated from SL acclimatized tannery soil. The biochemical characteristics and 16SrDNA analysis were done for the identification of organisms. The optimization studies on protease enzyme production were done and the optimum time was obtained at 48 h; with corresponding pH, 7.0; Temperature 30°C, substrate concentration 2% and salinity was found to be 4% resulted in the maximum yield of protease production. The produced enzyme solution was purified by dialysis and the specific activity was evaluated. In addition to it, the stability of protease was determined by varying the pH, temperature, TDS and metal ions. The degradation was carried out at different time intervals and complete degradation of protein content present in the soak liquor was obtained at 90min. The degradation efficiency was evaluated by the conversion of proteins into amino acids. The instrumental analysis such as UV-Visible spectroscopy were performed to confirm the enzymatic degradation of proteins into amino acids in hyper saline SL and which may favour the effective treatment of soak liquor by further unit operations.

*Keywords:* Soak liquor, alkaline protease, halophilic microbes, proteins, enzymatic degradation

ECT P-03

## LEATHER BIOCIDES: A CURRENT REVIEW OF TECHNICAL AND REGULATORY REQUIREMENTS

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Microbial cells were the first living cells on earth. About 3,5 billion years ago as the starting point of the evolution. Microorganisms are ubiquitous present in different amounts and different habitats. Micro-organisms can be useful, harmful, dangerous or material destroying.

In the leather industry many hides, intermediates or leathers are destroyed by microbial attack every year.

Weapons against harmful micro-organisms are characterized as physical method and chemical method.

Also nature has developed so called “natural biocides” , derived from e.g. plants or even bacteria itself. The chemical industry has used these natural biocides as an example for the development of optimized and highly defined biocides to minimize environmental and human risk and to optimize efficacy. The main synthetic biocides used in the leather industry PCMC, OPP, OIT and TCMTB are divided into two “mode of action”, membrane actives and electrophilically actives. Electrophilically actives are in search of substrates to react with which results in its chemical inactivation but cell death. Membrane actives trigger a disarrangement of the membrane by coating the cell wall which results into desintegration of the cell and cell death.

Biocides are intended to kill living organisms and therefore could pose risk to the environment and human health. Risk assessment is a combination of hazard identification and exposure evaluation. The risk of a biocide in a special application, like leather manufacture or the risk of wearing leather shoes can be identified by a risk assessment. Using the example of the European Biocidal Product Regulation (BPR, Regulation (EU) 528/2012) it is intended to show how and why a risk assessment is absolutely necessary and useful.

*Keywords:* Biocides, mode of action, biocide regulation, risk assessment, PCMC, OPP, OIT; TCMTB



## PHOTOCATALYTIC DEGRADATION OF ACID BLUE 113 DYE USING ZNO/SiC NANOCOMPOSITES UNDER UV AND VISIBLE LIGHT IRRADIATIONS IN A SLURRY PHOTO REACTOR

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Removal of organic and inorganic toxic materials from wastewaters is being given prime importance in recent years due to the discharge of untreated industrial wastewater into the different environmental compartments. The discharge of these harmful effluents are mainly from leather processing, pharmaceutical, cosmetic, textile, agriculture and other chemical processing industries. Nowadays, advanced oxidation processes are the most attractive emerging environmental technology for the complete destruction of organic contaminants in water wastewater. Acid Blue 113 is a most widely used di-azo compound in leather, textile, dyeing and food industry as a colouring substance. The wastewater released from these industries contains numerous of organic compounds including dyes and pigments. Hence, these toxic compounds are to be treated before discharge into aquatic environment. In the present study, we are reporting the photocatalytic degradation of Acid Blue 113 dye using a ZnO/SiC nanocomposite as a photocatalyst under UV and visible light irradiations. The photocatalyst was prepared by a simple sol-gel method and were characterized by XRD, UV-DRS, FT-IR, AFM, EPR, FE-SEM, EDAX, HR-TEM and SAED analyses. The analytical results are proved that the prepared photo catalyst were highly crystalline, nanosized and possesses absorption in the UV and visible regions. The UV-Vis-DRS results suggested that the band gap energy was 3.019 eV for the prepared photo catalyst. ZnO/SiC photocatalyst produced OH radicals instantaneously within 60 s and 15 min for UV and visible irradiation respectively which were confirmed by EPR spin trapping technique. This fast rate of OH radical formation is followed through transfer mechanism in the prepared ZnO/SiC photocatalyst. The effect of various experimental parameters such as pH, catalyst dosage and variation of concentration were investigated in detail to optimize the efficient degradation of Acid Blue 113. It is observed that neutral pH was found to be optimum with maximum % of degradation of the Acid Blue 113 dye molecules. Catalyst dosage of 10mg/10ml resulted in higher percentage of degradation. The photo degradation process followed a pseudo first order kinetics and was continuously monitored by UV-Visible absorbance measurement and COD.

*Keywords: Photocatalyst; nanocomposite; Acid blue 113; sol-gel; visible light*

ECT P-05

## HETEROSTRUCTURED (ZNO)<sub>x</sub>(BI<sub>2</sub>O<sub>3</sub>)<sub>1-2x</sub>(DY<sub>2</sub>O<sub>3</sub>)<sub>x</sub>: AN EFFICIENT UV ACTIVE PHOTOCATALYST FOR THE DEGRADATION OF AN AZO DYE FROM SIMULATED WASTEWATER

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Release of effluents containing dyes and other organic compounds has been of top concern in today's world. Dyes are commonly employed as colouring agents in various industries such as leather, textile, paper and plastics. Heterogenous photocatalysis employing semiconductor metal oxides is an efficient method to degrade the recalcitrant dye molecules. In this respect, Bi<sub>2</sub>O<sub>3</sub> is gaining importance as a promising photocatalyst. However, the efficacy of the pristine metal oxide photocatalyst must be further improved by preventing the recombination of photo-excited electron-hole pairs. This can be achieved by doping or combining Bi<sub>2</sub>O<sub>3</sub> with other semiconductor metal oxides. We are here in reporting a heterostructured composite material with enhanced photocatalytic activity formed by combining Bi<sub>2</sub>O<sub>3</sub> with a transition metal oxide (ZnO) and a rare earth oxide (Dy<sub>2</sub>O<sub>3</sub>) with a final overall composition of (ZnO)<sub>x</sub>(Bi<sub>2</sub>O<sub>3</sub>)<sub>1-2x</sub>(Dy<sub>2</sub>O<sub>3</sub>)<sub>x</sub>. The highly nanocrystalline nature of the material was confirmed by XRD analysis. Peaks corresponding to  $\alpha$  Bi<sub>2</sub>O<sub>3</sub>, ZnO and Dy<sub>2</sub>O<sub>3</sub> phases are visible. The band gap energy as calculated from the UV-Vis-DRS spectrum is. HRSEM imaging shows the micro-rod shaped  $\alpha$  Bi<sub>2</sub>O<sub>3</sub> to be distributed amidst the ball like clusters formed by spherical ZnO and Dy<sub>2</sub>O<sub>3</sub> nanoparticles. Shape and morphology was further confirmed by HRTEM analysis. XPS and EDAX analysis confirm the presence of Bi, Zn, Dy and O in the material. The high surface roughness and porosity of the prepared composite was revealed by AFM analysis. The photocatalytic efficiency of the composite material was evaluated by the degradation of a model pollutant-Orange G under UV light irradiation in an annular slurry type photoreactor. Orange G is a commonly employed mono-azo dye in the coloring of leather products. Preliminary studies showed the catalyst to exhibit at neutral pH with an optimum catalyst dosage of 0.5g/L. Kinetic studies carried out with various initial dye concentrations showed the photodegradation reaction to follow pseudo-first order kinetics. The presence of industrial effluents did not affect the photocatalytic efficiency of the material. Catalytic efficiency was retained even after the 3<sup>rd</sup> cycle of its reuse thereby validating the economic feasibility of the system.

Keywords – Photocatalyst, UV irradiation, Orange G, Heterostructured composite





## ADSORPTION OF AMIDO BLACK 10B DYE USING CHEMICAL ACTIVATED CARBON DERIVED FROM TANNERY WASTE BIOMASS: ADSORPTION DYNAMICS AND OPTIMIZATION THROUGH RESPONSE SURFACE METHODOLOGY

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In the modern era of ever growing population and rapid industrialization, pollution prevention and control measures are very important and necessary for a sustainable environment. Wastewater from process industries (leather and textile industries especially) needs to be properly treated before it is let out in to the environment. Adsorption is an attractive option to treat effluents with significant advantages over conventional processes especially from an energy and environmental perspective if adsorptive materials are prepared from waste biomass. The preparation of activated carbon particles from industrial wastes has served two purposes: (1) Disposal of industrial wastes and (2) Generation of wealth from waste for a greener adsorption technology. In the present study, activated carbon is prepared from tannery waste biomass (collected tannery wastewater treatment plant) material by chemical activation method using sodium hydroxide. The prepared adsorbent was characterized by SEM, EDAX, FT-IR, TGA, DSC, zero-point charge and surface functionality. The prepared activated carbon is used for the adsorption of model pollutant for example, Amido Black 10B (AB) dye from aqueous solution. Response surface methodology was used to analyze and optimize the variables affecting the adsorption of AB 10B dye onto chemical activated carbon by central composite design (CCD). Four factors were optimized viz., pH (1.808), adsorbent dosage (64000 mg/L), dye concentration (376.87 mg/L) and contact time (6.15 h). The equilibrium data were analysed by Langmuir, Freundlich and Temkin adsorption isotherm models. The maximum monolayer adsorption capacity ( $q_m$ ) was found to be 61.24 mg/g. The kinetic data were tested with pseudo-first-order and pseudo-second-order kinetic equations. The mechanism of the adsorption process was studied by interpreting the data with intraparticle diffusion model and Boyd plot. The kinetics of the adsorption process was found to follow the pseudo-second-order kinetic model. Film diffusion was determined to be the rate controlling step for the adsorption of AB onto the adsorbent.

*Keywords:* Adsorption dynamics, Isotherm models, Response surface methodology, Optimization, Chemical activation, Amido Black 10B dye



ECT P-07

## ELECTRICALLY CONDUCTIVE AND MAGNETICALLY ACTIVE HYBRID COMPOSITES FOR HETEROGENEOUS APPLICATIONS

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Here, we synthesized conducting and magnetic hybrid composite with the compositions of collagen (C), polyaniline (PAni) and iron oxide nanoparticles (IONP) through in situ polymerization technique for various applications. The FTIR, XRD and SEM analysis showed that the as-synthesized C-PAni-IONP hybrid composite exhibits a homogeneous intermixing of individual components. The electrical conductivity and saturation magnetization values of the hybrid composite are found to be  $1.82 \times 10^{-3} \text{ Scm}^{-1}$  and  $8.32 \text{ emu g}^{-1}$ , respectively. The as-synthesized hybrid composites exhibited excellent photocatalytic activity towards the degradation of methylene blue dye with efficiency up to 81% within 2 h. It also exhibited an efficient oil absorption and easier collection under the magnetic tracking. We have also demonstrated the ability of the as-synthesized hybrid composites to conduct electrons in a light emitting diode lamp and battery setup with varying extents of brightness. The results suggest that the as-synthesized C-PAni-IONP hybrid composites show potential for promising applications in catalysis, biological, electronic and environmental fields.

*Keywords:* Collagen, Polyaniline, Iron oxide, Photocatalysis, Oil absorption.



## STUDIES ON USE OF SODIUM POLY ACRYLATE (SPA) FOR LOW SALT ANIMAL SKIN PRESERVATION

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Animal skin, a proteinous material containing high moisture is a suitable substrate for the growth of microorganism, leads to subsequent putrefaction if not preserved properly. Traditionally, large quantity of sodium chloride (40% or more) is used for raw skin preservation. While processing the cured hides/skins into leather de-salting and soaking steps are carried out during which process salt gets removed. This generates large amount of Total Dissolved Solids (TDS) and chlorides in effluent which is of serious environmental concern. In view of this, salt free or low salt skin preservation methods are attempted using eco-friendly chemicals or bio-based compounds. Many of these methods have few advantages and have some constraints as well. In this study, Commercial SPA is used along with sodium chloride for low salt skin preservation. SPA is a super-absorbent polymer which can absorb water many times of its own weight. The SPA used in this study was characterized using NMR, IR and its water absorption characteristics were determined. Fresh goat skins were taken for experimental and conventional preservation studies. Control skins were applied with 40% salt and kept under ambient condition. The experimental skins were applied with 5% SPA on flesh side and kept for 4 hours then, SPA was removed from the skin by gentle scrapping and taken for drying and reuse for subsequent batch of raw skins. The SPA recovery was found to be more than 95%. Then 15% salt was applied on experimental skins and both experimental and control skins were stored for 21 days. The skins were observed periodically for hair slip, foul smell which is indications for onset of putrefaction and microbial growth as per the conventional method. After preservation period, both control and experimental skins were processed into chrome tanned leathers and tested for their strength and other properties. The results suggest that SPA aided moisture removal along with minimal salt has adequate curing efficiency similar to conventional salt preservation and comparable physical and organoleptic properties with a substantial reduction in TDS and chlorides in effluent. This SPA aided low salt skin preservation if implemented on commercial scale; pollution caused due to sodium chloride would be significantly minimized.

*Keywords:* Pollution reduction, Preservation, Raw skin, Sodium Poly Acrylate, TDS

ECT P-09

## TANNERY WASTEWATER IN EAST CALCUTTA WETLANDS: ECOSYSTEM SERVICES REVIEWED IN THE CONTEXT OF RELOCATION OF TANNERIES TO CALCUTTA LEATHER COMPLEX

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In Kolkata 538 tanneries formed typical agglomerates on eastern border of the city in three different patches namely Tangra (267 tannery units), Tiljala (223 units) and Topsia (48 units) and these units used to predominantly process raw hides to finished leather since pre-independent India. Composite wastewater from tannery agglomerates being mixed with other industrial wastewater and municipal sewage water used to traverse through the web of canals inside the East Calcutta Wetland (ECW; lat. 22°33' -22° 40' N; long. 88°25' -88°35' E) ecosystem. Use and reuse of wastewater in agriculture and pisciculture and by the intervention of wetlands biota such contaminated wastewater had been significantly and naturally ameliorated by the wetland system functioning as the kidney of the nature. Pisciculture and agriculture practices at the ECW, developed by the village artisans, have been surviving sustainably for the past several decades encouraging wise use of solid wastes and wastewaters. However, basing on certain preliminary survey works on pollution aspects made by Government approved survey agencies, tannery agglomerates were decidedly shifted outside the city at Kolkata Leather Complex (KLC), around 15 km away from the city, right on the boundary of the ECW now a Ramsar site (No. 1208) towards Kultigong river, which would ultimately drain out effluent to the Bay of Bengal. The huge effluents (nearly 10,000m<sup>3</sup>) released by the units of KLC would be treated in CETPs and, in turn, the treated effluents would be released to the environment

Serious researches in the past two decades were carried out to unearth the Nature's handiwork at the ECW ecosystem to turn tannery wastes into wealth sustainably and cost effectively. Such ecosystem services of the ECW ecosystem have been discussed in the present paper in details. Nearly for a century, the people in and around Kolkata city had been consuming the produces of the ECW areas and no one had ever claimed that the people of Kolkata suffered from any specific diseases for consumption of such produces of the ECW. It was, therefore, felt imperative to explore scientifically into the practices of wastewater-irrigated garbage farming and sewage-fed aquaculture at the east Calcutta Wetlands to gauge the ameliorative capacity of the wetland ecosystem in one hand and the protective measures at the biota levels that they had developed to thrive in contaminated environment on the other. Relocation



of the tannery agglomerates to KLC has extended an opportunity to assess the changes in the physico-chemical characteristics of the composite tannery wastewater. The efficacy of the CETPs of KLC has been compared with the ameliorative efficiency of the ECW ecosystem in view of the future action plans.

*Keywords:* Ramsar site, ecosystem services, elements, carbon sequestration, metallothionein, stress proteins, enzymes, histology, phytoremediation

ECT P-10

**CARBON AUDIT OF KOLKATA TANNERIES: AN OVERVIEW****Buddhadeb Chattopadhyay\*, Sudin Pal, Sidhartha Datta,  
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Kolkata Leather Complex (KLC; 22.4920° N, 88.5146° E) is around 20 km away from Kolkata city and is situated on the boundary of the Ramsar area (No.1208) of East Kolkata Wetland (EKW) ecosystem. At KLC area 292 leather processing units or tanneries are operating with the consent of the Government and on an average 1000 tons of raw hides and skins are being processed every day. Tanneries are categorized as Special Red Industry by Central Pollution Control Board norms and thereby, it has been felt necessary to have an idea on the carbon footprint of this industry. During processing of raw hides and skins to finished leather significant amount of carbon (C) are released to the environment and also incorporated into wet salted hides-skins. Input/Output overview for the chrome-tanning processing units of KLC grossly considers raw materials and finished products, chemicals, water and wastewater and electricity. Input/output of C depend on the types of raw hides and skins, tannery and operation specific recipe of chemicals and percentages used, the amount of water used, purity of chemicals, spray types, number of coats, types of finished product, mechanical operations and efficiency of the machinery, binding capacity of chemicals and use of electrical energy. However, to prepare an overview of carbon audit of tanneries of KLC area three predominant types of units, viz., gloves, bag and shoe upper leather producing units are selected; nine units in total, taking three of each type are sampled. On an average per metric ton of raw hides and skins contain  $397.03 \pm 8.33$  kg C and the amount of chemicals required to process the raw materials contain  $65.1 \pm 13.36$  kg C; these would be the major input besides ample water and electrical power. Leather processing at KLC utilize  $12007.7 \pm 848.3$  liter of water per metric ton and to supply this amount of water  $5.64 \pm 0.4$  kWh (kilowatt-hour) electricity is used, roughly equivalent to  $1.54 \pm 0.11$  kg C. For processing of 1 ton raw hides and skin to finished leather 11666.6 kWh electricity (thermal power) is consumed for different purposes that amounts to 3177.3 kg C. Processing of 1 metric ton of wet salted cattle hides and skins discharges on an average  $40.54 \pm 3.22$  kg C in the forms of liquid wastes (soak liquor, lime liquor, delime liquor, pickle liquor, chrome liquor, re-chrome liquor, neutralizing bath and dye-fat/fat liquor) to the EKW environment. Whereas, the same processing generates solid wastes (lime fleshing, chrome shavings, chrome tanned splits, buffing dust and trimming cut offs) in the tune of  $279.63 \pm 13.23$  kg C. Farther, as most of the wastes in different forms generated during leather processing at KLC are utilized within the EKW areas, present study on carbon audit has also extended an opportunity to work out the amount of carbon sequestered in abiotic and biotic systems of EKW ecosystem and consequent contribution in C cycle.

*Keywords:* Carbon, tannery, Kolkata Leather Complex, liquid waste, solid waste, carbon sequestration, East Kolkata Wetlands, Ramsar site



## TREATMENT OF TANNERY WASTEWATER USING SEMI-CONDUCTIVE PHOTOCATALYSIS WITH BENTONITE-ZNO CATALYST IN THE PRESENCE OF SUNLIGHT

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Semi-conductive photocatalysis is an advanced oxidation process where a semi-conductive metal oxide is employed to produce hydroxyl and peroxy radical as a function of light absorption. In the present work, a semi-conductive mixed oxide catalyst Bentonite-ZnO has been prepared by simple hydrothermal method and used for oxidative degradation of the post tanning sectional stream from tannery in the presence of sun light. The post tanning sectional stream is mainly composed of used tanning agents, syntans, fatliquors, inorganic salts, etc., which have high molecular mass compounds and pose huge impact on the environmental ecosystem. Conventionally, this wastewater is degraded biologically either in aerobic or anaerobic conditions with the help of microbes and enzymes. However, the treatment method is not 100% effective and also a time consuming process due to the hardly degrading nature of the pollutants. Hence, semi-conductive photocatalysis has been chosen as an alternative procedure to treat the wastewaters in a more efficient manner. The mixed oxide catalyst Bentonite-ZnO, synthesized in this study has been found to be efficient than the bare ZnO. This could be attributed to the hetero-junction formed between the different materials, which create a space charge layer at the interface and would help in reduction of electron-hole recombination rate. The morphology, purity and crystallinity of the catalyst have been examined by FESEM, AFM and XRD studies. The optical properties have been analysed by UV-Vis diffuse reflectance and photoluminescence spectroscopy. The band gap of the catalyst is 3.02 eV, which makes the catalyst effective in the presence of sun light. Under optimal experimental conditions, effective reduction in the chemical oxygen demand (COD) of the post tanning sectional wastewater has been observed under sunlight in a neutral medium.

ECT P-12

## MICROWAVE THERMAL TREATMENT PROCESS FOR THE DEGRADATION OF REFRACTORY ORGANICS IN SECONDARY BIOLOGICAL TREATED POST TANNING WASTEWATER

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Abatement of refractory organics, the organics left after secondary biological treated effluent requires major intervention in order to reduce the overall cost incurred in installation and maintenance of membrane unit processes of effluent treatment plant. This study elaborates feasibility of microwave based thermal treatment for the fragmentation of the refractory organics present in secondary biological treated tannery effluent. The microwave thermal degradation of refractory organic in secondary treated tannery effluent was carried with the variables: Microwave energy (100-400 W), reaction time (1 – 30 min), effect of chemical oxidant ( $H_2O_2$ ), effect of hetero – catalyst (Nanoporous Activated Carbon and Rare earth doped Nanoporous Activated Carbon). The increase in the most probable count of bacteria before and after the microwave treatment of secondary biological treatment confirmed improvement in the biodegradability of the wastewater. The degradation of refractory organics by microwave based thermal treatment was supported with the instrumental evidences such as UV, Fluorescence spectroscopy, FT-IR, HPLC and NMR.

*Keywords:* Refractory Organic Compounds, Secondary Biological Tannery Effluent, Microwave, Biodegradability, Tannery Wastewater.



## RSL / MRSL – WHICH ARE THE REASONABLE LIMITS?

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The restriction of certain dangerous substances according to REACH (Registration, Evaluation, Authorisation of Chemicals as well as the Restricted Substances Lists (RSL) and Manufacturing Restricted Substances Lists (MRSL) requirements promoted by various renowned brands, obliges tanneries to everyday more numerous analysis with undesired conflictual situations on false positive tests results.

Requested limits are in many cases far from analytical detection and quantification limits. Many Leather official methods leave space to doubt on certain parameters such as Chlorophenols, Alkylphenol ethoxylated, Perfluorinated substances and cleavable aromatic amines derived from azo colorants, mostly when applied to an analytical range far from the establishes quantification and detection limits or to the Leather chemical analysis, without considering eventual interferences, and extraction procedures.

This paper also analyses RSL and MRSL requirements from the toxicological point of view comparing the typical requested values with those of other sectors such as food industry.

This paper considers as well some typical false positives cases which may occur when the said official methods are extended to MRSL requirements on different chemical matrixes.

*Keywords:* RSL, MRSL, Restricted Substances.



ECT P-14

## TREATMENT OF COMMERCIAL POST TANNING WASTEWATER USING INTEGRATED BIO-FILTER BAFFLED FLUIDIZED IMMOBILIZED CELL REACTOR

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The wastewater generated from post tanning operations of leather industry is very complex in nature due to the presence of synthetic organic compounds such as syntan, organic dyes and synthetic fat liquors. These organic compounds convey recalcitrance and toxicity to microbes and they are resistant to biodegradation. They tend to escape both physiochemical and conventional suspended biological treatment systems and remain in the environment as persistent organic pollutants.

Therefore, focal theme of this study was to develop a suitable treatment methodology for the post tanning wastewater using bio-filter baffled reactor followed by immobilized cell nano porous activated carbon reactor by using three isolated efficient bacteria (*Stenotrophomonas maltophilia*, *Bacillus cereus* and *Lysinibacillus xylanilyticus*) as inoculums in the presence of native organisms. In this research study, bio-baffle reactor and fluidized immobilized bed bioreactor were fabricated, and nanoporous activated carbon which has high immobilisation capacity of the microbes (developed by one of author) was used as carrier matrix.

The bio-baffle reactor removed suspended solids by 55-60 % without using chemical coagulants. The immobilized system showed better removal efficiency of BOD, 85%; COD, 72 %; TOC, 74 % as compared to CETP's conventional technology removed BOD, 78%; COD, 61% TOC, 66 %. The degradation of organic compounds in wastewater was confirmed with FTIR, TGA, DSC, UV-Visible and fluorescence spectroscopy analyses.

Therefore, segregation of post tanning wastewater and exclusive treatment of it with Bio-baffled reactor and immobilized cell system would increase the performance of the treatment plant without application of coagulants.

*Keywords:* Post tanning wastewater; Nano Porous Activated Carbon; Fluidise Immobilized cell reactor



## UTILIZATION OF ALGAL BIOPOLYMER FOR THE EFFECTIVE REMOVAL OF CHROME CONTAINING WASTE WATER

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Tannery effluent is among the most hazardous industrial pollutants due to its huge organic and inorganic load, which is highly toxic to human life and environment. Currently more than 90% of global leather production is mainly through chrome-tanning process. General Standards for discharge of total chromium in effluent is 2.0 mg/l and hexavalent Cr is 0.1. high concentrations of chromium is toxic, mutagenic, carcinogenic, and teratogenic to live cells. The Commonly applied treatment methods consisting of physical chemical methods and biological methods. These methods are efficient in removing pollution parameters but not cost effective and generating large quantity of sludge which renders the process unviable. Despite, an extensive process is used for the treatment of tannery wastewater, the treated tannery wastewater does not result in zero Cr (III). The trace level of Cr(III) in treated wastewater foul the membranes used in Membrane Separation process. The trace heavy metal ions can be removed by biopolymers, which was focus of the present investigation. The isolation and morphological characterization of algal species were performed by microscopic examination. Extracellular polymer (EPS), the microbial products located on or outside the surface of the cells of organisms that comprises of complex mixture of proteins, neutral hexoses, acid polysaccharides, lipids, DNA, humic acid substances. EPS have different cellular functions, including accumulation of nutrients, diffusion barrier for toxins and heavy metals, cell motility etc. In this study the extracellular polymers were extracted from isolated different algal species from sewage treated waste water and characterized for the removal of trace level of Cr(III) in treated tannery waste water due to its functional groups.

*Keywords:* Tannery wastewater, Cr(III), Biosorption, EPS, Algae

ECT P-16

## PRODUCTION OF PERSISTENT ORGANIC POLLUTANTS (POPS) CHELATING CATIONIC BIOSURFACTANTS

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Persistent Organic Pollutants (POPs) are industrially produced compounds that resist decomposition and linger in the environment. Since these compounds can persist in the environment and food chain, permeate phospholipid membranes, and accumulate in fatty tissues, they present significant environmental and health issues. The POPs concentrations at contaminated soil or sediment sites have been reported to range from 1 mg/kg to several percent by mass. POPs are mostly hydrophobic and are difficult to dissolve in water. This property makes it easy for PAHs to adsorb onto soil particles but difficult for them to dissociate from these particles. As amphiphiles, biosurfactants exhibit the tendency to deposit at the oil/water interface. Biosurfactants may facilitate the transport of hydrophobic contaminants into the aqueous phase through specific interaction resulting in solubilization and micellization. This study deals with the investigation of polycyclic aromatic hydrocarbons present in the contaminated soil and *in situ* bioremediation of these compounds using biosurfactants. Various microbial origin surfactants have been analyzed and the removal efficiency was evaluated.

*Keywords:* POPs, Amphiphiles, Biosurfactants, Solubilization, Micellization



## A LIPOPEPTIDE CATIONIC BIOSURFACTANT FOR BIOREMEDIATION OF CHROMIUM CONTAMINATED SOIL

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The worldwide concern for heavy metal pollution has led to the development of newer and more environment friendly techniques for their removal from various sources. Nearly 80% of the tanneries in India practice the chrome-tanning process. Most of the chromium is discharged into aqueous waste as Cr(III) and Cr(VI). This work describes the bioremoval of Cr from contaminated soil by cationic biosurfactant produced from *Enterococcus faecalis* spe. using chicken tallow as substrate. The results showed that the cationic biosurfactant could able remove Cr by 89% within 6 h equilibrium time for biosorption of Cr from initial concentration of 15.4 mg/g of soil, at pH 5.0, with biosurfactant concentration of 1000 mg/g of soil. The stability of cationic biosurfactant was carried at different pH, temperature and salinity range. It maintained its surface properties unaffected in the range of temperatures between upto 70 °C, pH >7 and at higher salinity it retains 65% of emulsification activity. These results indicates that the possibility for a cation exchange mechanism for the accumulation of chromium in the lipopeptide biosurfactant.

*Keywords:* Contaminate soil, bioremediation, bioremoval, cation exchange, chromium.

ECT P-18

## CHARACTERIZATION OF LEATHER BUFFING DUST MODIFIED BITUMINOUS BINDER FOR FLEXIBLE PAVEMENT

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Bitumen comprises saturates, aromatics, resins and asphaltenes (SARA), has been widely used as road binder. Basically, bituminous binder undergoes two types of aging viz short term aging (ASTM D 2872) at high temperature during mixing, transportation and laying, and long term aging (ASTM D 6521) at ambient temperature during in-service. Binder modification enhance the properties viz. fatigue resistance, stiffness modulus, rutting resistance, stripping potential, temperature susceptibility and oxidation potential with addition of polymer, crumb rubber, sulphur etc.

India is one of the major producers of leather in the world with around 2000 tanneries across the country, processing around 7 lakh ton of raw hides/ skins annually. One ton of wet hide yields only 150 to 200 kg of finished leather with 800 to 850 kg of solid waste in different form. Buffing dust (BD) is a micro fine solid particulate comprising of collagen, oil, tanning agent, dye chemicals, synthetic fat etc.

The objective of this study was to develop a new bituminous binder using the chrome containing BD into a useful product, thereby reducing environmental pollution. A mixture of VG-30 bituminous binder, SBS powder, warm mix additive(Sasobit) and BD, was thoroughly mixed in the laboratory to develop a new binder. Super pave binder tests, Rotational viscometer and Dynamic Shear Rheometer (DSR) was used to test the performance grading (PG) testing protocol as per ASTM D 6373, and was designated as PG-88. The physico-chemical properties such as elemental (CHNS) analysis; FTIR, DSC/TGA, SEM/EDAX, rheological property and aging were assessed.

From the DSR value, it was found that PG 88 gave better fatigue resistance ( $G^* \cdot \sin \delta$ ) and rutting resistance ( $G^*/\sin \delta$ ) resulting, it can be used as an alternative binder for flexible pavements. FTIR for asphalt binders can be used as an indicator of aging: the Carbonyl (C=O) and Sulfoxide (S=O) links are calculated relatively to structural group  $\text{CH}_2$  and  $\text{CH}_3$  in SARA as well as amino acid and peptide group in the leather. This research findings is based on the 12<sup>th</sup> five year plan called Zero Emission Research Initiative for Solid waste (ZERIS) under chemical cluster.

*Keywords:* Bitumen, Buffing Dust, Rheology, Fatigue And Rutting Resistance, Flexible Pavement



## AN INTEGRATED HYBRID SYSTEM FOR TREATMENT OF TANNERY WASTEWATER AND SECONDARY SLUDGE

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During leather processing liquid and solid waste are generated. For processing of one tonne of raw hides and skins, around 30 - 35 cubic metre of wastewater will be generated. The wastewater has to be treated before it is discharged into inland surface water. During this process, primary and secondary sludge is also generated. Primary sludge comes under the hazardous category and has to be disposed off in secured landfill facilities only. The secondary sludge contains organic matter of 50 - 60% and cannot be disposed in secured landfill facilities. At present liquid and sludge generated during treatment of tannery wastewater are dealt separately. In the present study, an integrated system for tannery liquid and solid waste was studied. The secondary sludge was subjected to pre-treatments such as ozonation and thermal treatment separately in order to rupture the cell wall and the pre-treated sludge along with tannery wastewater was treated in an integrated hybrid anaerobic reactor (IHAR). For the pre-treatment of the sludge the process parameters like contact time, temperature were optimized. Further anaerobic digestion studies were carried for pre-treated sludge and biogas generation was monitored. Around 80°C was optimum temperature and increase in biogas generation of 7.31 times was observed per gram of VS added to that of control reactor without pre-treatment of sludge. The contact time for ozonation was about 5 minutes and the increase in biogas generation was 5.48 times per gram of VS added. Whereas pre-treated sludge along with tannery wastewater was treated in IHAR, the biogas generation was 8 times increase in the biogas generation was observed per gram of VS added. Through this process; it is evident that, an integrated treatment system of combined treatment of wastewater and sludge with pre-treatment reduces the investment cost and hydraulic retention time required for individual treatment of wastewater and sludge. The details of the study will be discussed in detail in the present paper.

*Keywords: Secondary sludge, Pre-treatment, Thermal, Ozonation, IHAR, Contact time, Temperature.*

ECT P-20

## A STUDY ON DENSE GAS DISPERSION MODEL

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The Dense Gas Dispersion Model (DEGADIS) is a mathematical dispersion model that can be used to model the transport of toxic chemical releases into the atmosphere. Its range of applicability includes continuous, instantaneous, finite duration, and time-variant releases; negatively-buoyant and neutrally-buoyant releases; ground-level, low-momentum area releases; ground-level or elevated upwardly-directed stack releases of gases or aerosols. The simulations are carried out over flat, level, unobstructed terrain for which the characteristic surface roughness is not a significant fraction of the depth of the dispersion layer. DEGADIS can be used as a refined modeling approach to estimate short-term ambient and the expected area of exposure to concentrations above specified threshold values for toxic chemical releases. It is especially useful in situations where density effects are suspected to be important and where screening estimates of ambient concentrations are above levels of concern. Exposure to an ammonia-charged atmosphere may induce various types of physical effects such as Ocular effects, Skin effects, Respiratory effects. APO is an accident which occurs following the inhalation of vesicant gases ( $\text{Cl}_2$ ,  $\text{NH}_3$ ,  $\text{SO}_2$ ) by breaking down the walls of the pulmonary alveoli which are then inundated with blood plasma. Studying the atmospheric dispersion of ammonia is of major interest for two reasons. Firstly, ammonia is a very toxic, corrosive, flammable and explosive substance under certain conditions. Secondly, ammonia is a very widely used substance with numerous applications, due to its chemical or physical properties. With respect to its chemical properties, the main application of ammonia is the manufacture of fertilisers. Ammonia represents the main concentrated source of nitrogen for agriculture, which consume approximately 85 to 90% of production. Industry uses ammonia as a raw material for the manufacture of explosives, fibres and plastics. It is also used in the manufacture of paper, rubber, in refineries, the leather industry and the pharmaceutical industry.

*Keywords:* Dense Gas Dispersion, Emission control, Simulation and Modelling





ECT P-21

## INNOVATIVE APPROACH FOR THE PRIMARY TREATMENT OF SOAK LIQUOR FROM TANNERIES THROUGH SEQUENTIAL OXIC ANOXIC BIO REACTOR USING FILAMENTOUS BACTERIA AND HALOPHILES

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The present research study was focused on the effective primary treatment of tannery saline soak liquor through the digestion of suspended solids and dissolved organics, using sequential oxic anoxic bio-reactor. The presence of high concentration of dissolved inorganic salts (NaCl) retards the biological degradation of dissolved organics present in the soak liquor. The aim of this study is to grow halophilic organisms using soak liquor nutrient by means of sewage culture, which will assist in removal of these organics in wastewater, which is performed by this reactor. Totally five bacterial strains were isolated from the bio film formed on the plastic packing material and they displayed different characteristics such as ability to synthesize enzymes like protease, lipase and amylase at saline condition. The strain was found to synthesize all the three enzymes by utilizing the components in soak liquor as the substrate, with enzyme activity for protease, lipase and amylase calculated. They acted as the primary reason for the degradation of bio molecules present in the soak liquor. The hydraulic retention time of the reactor 12h was optimized on the basis of maximum removal of proteins, carbohydrates and lipids in this reactor. The noticeable amount of Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) removal were observed. Moreover, the suspended solids removal was achieved up to a maximum level in the presence of Total dissolved solids (TDS) at a range of 3-7%. Instrumental analysis such as UV-Visible, Fluorescence, FT-IR spectroscopic studies also confirmed the degradation of dissolved and suspended organic matter present in soak liquor. And also, the morphology of the biofilm on the plastic baffle material was characterized by SEM analysis. Hence, this combined treatment system promises to be a more beneficial primary treatment option for tannery saline soak liquor by using halophilic organisms and filamentous bacteria in future.

*Keywords:* Sequential Oxic-Anoxic Bioreactor, Removal of Organics, Soak Liquor, Suspended Solids Removal



ECT P-22

**ISOLATION, IDENTIFICATION OF SALT TOLERANT  
MICROORGANISMS FOR THE PRODUCTION OF MIXED  
EXTRACELLULAR ENZYMES USING TANNERY SOLID WASTE  
(ANIMAL FLESHING) FOR THE TREATMENT OF HYPER  
SALINE TANNERY WASTEWATER**

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This present investigation was mainly focused on the handling of animal fleshing (ANFL), majorly contribute in solid waste from tanneries and its usage as the substrate for the production of mixed enzymes for the treatment of tannery saline soak liquor (SL). The isolation of organisms were carried out from different sources acclimatized with soak liquor. The organisms were screened for protease, lipase and amylase activity in order to degrade the organics of soak liquor. The screened organisms were checked their activities in saline medium (1-4%) due to the saline content of soak liquor. Optimization studies were carried out for the production of mixed enzymes from the halophilic organism DS2 and AS1 as a function of time, pH, temperature, salinity and substrate concentration. From the optimization studies we concluded that the activity of DS2 was comparatively better than AS1. The optimized conditions were found to be 48 h, 40°C and retained its activity up to 4% of salinity. Hence further enzyme production was carried out by the organism DS2 using animal fleshing as the substrate. The extracted enzyme was characterized for FTIR studies, TGA-DSC and SDS page for molecular weight determination. Also, the extracted mixed enzyme quantitatively analyzed for its proteolytic, lipolytic and amylolytic activity and it was found to be 140 U/ml, 1360 U/ml and 1306 U/ml respectively. This mixed enzyme further for the degradation of organic bio molecules (proteins, lipids and mucopolysaccharides) of soak liquor at high saline conditions.

*Keywords: Animal Fleshing, Tanneries, Solid Waste, Mixed Enzymes, Halophilic Organisms, Soak Liquor*



ECT P-23

## LIPASE IMMOBILIZED FUNCTIONALIZED CARBON MATRIX FOR THE DEGRADATION OF LIPIDS PRESENT IN TANNERY SALINE WASTEWATER

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The present investigation was carried out for the degradation of lipids present in hyper saline wastewater (soak liquor) discharged from the primary unit operations in Tanneries, through the lipase immobilized functionalized nanoporous activated carbon (LNAPAC). The nanoporous activated carbon was effectively functionalised using ethylenediamine, glutaraldehyde covalent immobilisation technique followed by the lipase enzyme was immobilised on the functionalised support. The optimization studies were carried out for the effective immobilisation of lipase on the surface of f-NPAC via dynamic batch process taken on orbital shaking incubator. The optimized conditions were obtained on effect of time, lipase concentration, and effect of mass of f-NPAC, size of f-NPAC, effect of bulk solution pH, effect of salinity and the effect of temperature which favours the maximum immobilisation of lipase on f-NPAC. The instrumental techniques such as TGA-DSC spectrum, FT-IR spectroscopic studies, SEM and XRD images confirmed the immobilisation of lipase on f-NPAC. The optimized conditions for the degradation of lipids in the soak liquor was carried out and it was proved that the lipase immobilized matrix (LNAPC) was very effective for the degradation of lipids into their smaller units i.e. fatty acids and glycerol which favours the further unit operations for the treatment of soak liquor.

*Keywords:* Soak Liquor, Immobilisation, Lipids, Lipase, Nanoporous Activated Carbon, Fatty Acids And Glycerol

ECT P-24

## TWO STAGE TREATMENT PROCESS USING ANAEROBIC AND AEROBIC REACTORS FOR ALKALINE WASTEWATER CONTAINING HIGH TDS AND HIGH COD

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Nowadays there is a continuously increasing worldwide concern for development of alternative water reuse technologies, mainly focused on industry. The conventional techniques has some demerits due to their high TDS and alkaline condition of wastewater. The combined anaerobic-aerobic process are considered a highly competitive wastewater treatment technology for the removal of organic pollutants. The anaerobic digestion process effectively increase the biodegradability of wastewater then it was treated by aerobic process. In the present study, The UASB was carried out for the treatment of wastewater at different Hydraulic retention time (HRT) in the ranging from 12 h to 48 h and it was showed 65% of COD degradation at 36 h HRT. Further, Fluidized Immobilized carbon catalytic oxidation (FICCO) reactor and Chemo-autotrophic carbon catalytic oxidation (CACCO) reactor was operated at different HRT from 12 h to 48 h. The COD reduction efficiency of FICCO and CACCO reactors were obtained about 90% (24 h HRT) and 96% (1 h HRT) respectively. The results reveal that the anaerobic treatment plays major role in the degradation of COD in alkaline wastewater.

*Keywords:* Alkaline Wastewater, FICCO, CACCO



## CHROMIUM REMOVAL FROM THE TANNERY WASTEWATER USING NATURAL BIOSORBENT

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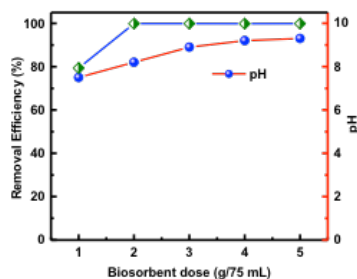
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Chrome tanned leather is the most popular due to its high thermal property. In tanning, 80-90% industries use basic chromium sulphate as a tanning agent to obtain quality leather (Avinathan et al. 2004). On an average, the pickled pelt up takes only 60% of the used chromium and remaining 40% of chromium is remained in the solid/liquid phases, especially in the waste chrome liquor (Fabiani et al. 1997). In conventional chrome tanning wastewater contains 1500–3000 mg/L chromium (Suresh et al. 2001). Chromium (III) is considered as an essential trace element for some metabolic function; a long-term exposure to Cr(III) is recognized to cause allergic skin reactions and cancer (Eisler 1986); thus, the level of chromium in the spent chrome liquor is strictly regulated in many countries.

In this study, an approach was made to remove chromium from the chrome tanning wastewater using biosorbent. The biosorbent was prepared by burning the selected plant bark at 450-550°C, cooled, grinded and sieved on 80-mesh. The prepared biosorbent was directly mixed with chrome tanning wastewater and remaining chromium in the filtrate was determined following the Society of Leather Technologists and Chemists (1996) official method of analysis (SLC 208). Various parameters: biosorbent dose and contact time were optimized in batch-wise technique.

The chromium content in the wastewater was 2920.24 mg/L and after treatment at optimized conditions was 3.5 mg/L. Chromium removal efficiency was obtained at optimized conditions 99.9%. Application of biosorbent could be a better choice to remove chromium from the chrome tanning wastewater.



**Keywords:** Tannery, Chrome tanning wastewater, biosorbent



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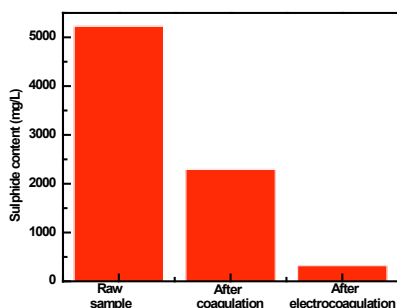
## SULPHIDE REMOVAL FROM THE TANNERY LIMING WASTEWATER BY COAGULATION-ELECTROCOAGULATION

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In tannery, liming is the first and indispensable chemical operation where hide/skin is treated to dissolve keratins (hair/wool, epidermis), non-structural proteins, and subcutaneous adipose layer; to swell up the hide/skin; to separate the collagen fibre; to partially saponify natural fat (Gutterres et al. 2011; Hashem et al. 2016). Hair/wool is dissolved by the treatment of calcium hydroxide and sharpening agents to break down the disulphide bond of cystine. The liming process residues release wastewater containing high sulphide, high chemical oxygen demand, biological oxygen demand, total suspended solids, and total dissolved solids load in the effluent. Soluble sulphide content in wastewater is not dangerous when they are in strongly alkaline medium but if any case pH becomes below 8.0, sulphide emits as poisonous hydrogen sulphide gas (Dixit et al. 2015). In this study, an investigation was carried the removal of sulphide from the drum liming wastewater by coagulation-electrocoagulation process. Firstly, collected drum liming wastewater sample was treated with aluminum sulphate as coagulant and pH was adjusted at 8.5-9.0 by dilute sulphuric acid. The supernatant was treated using direct current electrocoagulation with zinc and copper electrodes to remove the residual sulphide. The untreated and treated aqueous sulfide was analyzed for sulfide quantification by titrimetric following the Society of Leather Technologists and Chemists official method (SLC 202).



The above figure indicates that sulphide removal by the coagulation-electrocoagulation was 94%. The simple process could be used to remove sulphide from tannery liming wastewater as well as also from the sulphide containing wastewater.

*Keywords: Liming; Sulphide; pH; Coagulation; Electrocoagulation; Environment*



## AN ECO-FRIENDLY SHORT-TERM PRESERVATION OF GOATSKIN USING INDIGENOUS PLANT LEAF PASTE

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Hide/skin is the basic raw materials for the leather production, which is the by-product of meat industry. It contains mainly water 60-70% (w/w) and protein 25-30% (w/w) which makes the raw hide/skin susceptible to the microbial attack (Nandy and Das 1956). The degradation of hide/skin starts within 5-6 h after the death of the animal if it is left untreated (Kanagaraj et al. 2005). Application of 40-50% common salt (sodium chloride) is the most popular preservation method of hide/skin; salt preserves the skin by its dehydrating ability and bacteriostatic effect. The hostile effect of sodium chloride is that it generates a huge amount of pollution in the form of total dissolved solids (TDS) and chlorides during leather processing. Sodium chloride preservation accounts for 55% of the TDS and 40% of chlorides in the entire leather processing (Covington 2011). The significant level of chlorides renders the groundwater saline and reduce the fertility of soil.

In the present study, an investigation was made to preserve goatskin using indigenous plant leaf paste. The preservation process was assessed by monitoring different parameters e.g. shrinkage temperature, hair slip, putrefaction odor, moisture content, nitrogen content, and bacterial count in comparison to the conventional salting method. The results indicate that indigenous plant leaf paste could effectively preserve goatskin more than one month. The physical properties of the produced leather were fulfilled the requirement of shoe upper. The method could be a viable option to preserve goatskin which could reduce the pollution load during leather processing.

*Keywords:* Skin, Preservation, Pollution, TDS, Plant leaf paste

ECT P-28

## CONCRETE PAVING BLOCK FROM PYROLYSED LEATHER SOLID WASTE

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The usage of concrete blocks are increasing day- to- day around the building and road sides due to infrastructural development. Due to the evolution of new structures, the availability of raw materials are depleting nowadays. This study involves the replacement of fine aggregate sand with pyrolysed tannery waste. The most suitable and widely used construction material is concrete and is composed of Cement, Aggregate and Water. The production of cement is nowadays easier due to availability of raw materials. At the same time there is intense scarcity of sand in construction stage. The important constitute of concrete is sand which is taken from river and it is depleting the river system. And also due to the high demand of sand is being costlier day by day. The usage of waste materials from the leather industries can be used as a partial replacement for sand. This replacement can make a change in cost of overall cost in construction. The tannery produces huge amount of solid waste which are difficult to dispose off due to strict environment norms. The leather waste was pulse pyrolysed at 800°C. The remains of the pyrolysis was used as replacement for sand which is known as Bottom ash. In the study M<sub>30</sub> mix is adopted with coarse aggregate of 10 mm with mixing of concrete done with water and Chemical Admixture. The fine aggregate was partially replaced using leather waste in percentage of 10,15,20,30 and 40. The sample was tested for compression, flexure, leaching, FTIR, SEM, XRD, water absorption. The main investigation of the paper is to use the Buffing dust from the solid leather waste into useful components. These blocks may be made into interlocking paver blocks of different shape which may be useful in construction.

*Keywords: Pulse Pyrolysis, Paver Blocks, Leather Solid Waste, Bottom Ash*



ECT P-29

## **PRACTICAL ACHIEVEMENTS OF VARIOUS TECHNOLOGIES FOR SUSTAINABLE LEATHER MANUFACTURE IN KANPUR LEATHER CLUSTERS**

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With the overall objective to enable local leather-based industry to sustain conversion of locally available raw hides and skins into exportable products without jeopardizing the livelihood of the human settlements and supplementing various ongoing activities to achieve total environmental security, the UNIDO Kanpur Leather Development Project has been demonstrating various cleaner tanning technologies in volunteer tanneries. These units have been developed as pilot demonstration units (PDUs) as “Show-How” models. The flow of events in these demonstrations is as follows: Implementation on pilot but commercial scale ® Fine tuning the process ® Closely monitoring the operational parameters and analysis of results ® Preparation of technology packages ® Dissemination widely among the industry (through on-site demonstrations, workshops and seminars).



ECT P-30

## DEVELOPMENT OF NOVEL MULTIENZYME SYSTEM FROM A MICROBIAL SOURCE FOR ENVIRONMENTAL FRIENDLY BEAM HOUSE OPERATIONS

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Production and development of novel multienzyme system containing protease, amylase and lipase was studied for leather processing particularly in beamhouse operations for unhairing, fiber opening and degreasing operations in leather processing. *Aspergillus tamarii* MTCC5152 has been identified as a single microbial source for the production of this multienzyme system and it was found to be a high yielding microbial strain for the production of protease,  $\alpha$ -amylase and lipase produced in the same culture medium. The various parameters for maximal production of these enzymes have been optimized by solid state fermentation method (SSF).

The unhairing, fiber opening and degreasing potential of this multi enzyme product has been studied using cow hides and goat skins. The bioprocessed hides and skins were assessed by biochemical, microscopic, scanning electron microscopic (SEM) and Transmission Electron microscope(TEM) methods and subjective analysis. Experimental and control hide/skin samples after beam house operations were processed to chrome tanned crust leathers and assessed for softness, fullness, grain smoothness, grain tightness and general appearance by hand and visual examination and comparable with the traditional chemical methods of leather processing. The results indicate that the multienzyme product has the potential to be used for bioprocessing of hides and skins in beam house operation and the results are comparable with the chemically processed hides and skins. The net benefits envisaged from this approach are: Elimination of several processes, viz., liming, reliming and deliming is possible with subsequent reduction in process time, TDS, COD and total elimination of lime sludge; better exhaustion of chromium in tanning and reduction in the use of chemicals and cost with a reduction in utilities like water.



## PHYCOREMEDIATION OF TANNERY WASTEWATER USING CHLORELLA VULGARIS INTEGRATED WITH ANAEROBIC DIGESTION FOR ENERGY PRODUCTION

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Currently, the tannery effluent generated is treated in individual or common effluent treatment for the removal of suspended solids, BOD, COD, Cr and sulphide. However, the nutrients present in the wastewater are not removed in the existing treatment system. Presence of nutrients in the treated effluent leads to eutrophication of water bodies. Hence, the present study was made to mitigate the nutrients especially nitrogen and phosphorus present in soak liquor and composite tannery effluent through phycoremediation. *Chlorella vulgaris* was selected for the study and batch experiments were carried out to investigate the nutrient removal performance. *Chlorella vulgaris* removed nitrate nitrogen by 62.6%, ammonical nitrogen by 66.7% and  $\text{PO}_4\text{-P}$  by 61.5% respectively from secondary treated soak liquor. In case of secondary treated tannery wastewater, removal of nitrate nitrogen by 85.6%, ammonical nitrogen by 55% and  $\text{PO}_4\text{-P}$  by 60.5% were observed. Experimental results indicated that removal of  $\text{NH}_4\text{-N}$  was higher in secondary treated tannery wastewater and total COD removal is higher in secondary treated soak liquor while removal efficiency of  $\text{PO}_4\text{-P}$  does not show any difference both remains the same. Biochemical characterization of *Chlorella Vulgaris* revealed the possibility of biofuel production. Further anaerobic digestions of grown algal biomass were harvested, anaerobically digested for determination of biogas production. The anaerobic digestion was carried out at mesophilic temperature ( $37^\circ\text{C}$ ). Specific biogas yield from *Chlorella vulgaris* was found to be 209 ml  $\text{g}^{-1}$  VS removed. In phycoremediation, nitrogen and phosphorus in the wastewaters can be used as cheap nutrient sources for algae biomass production. The biogas produced from the anaerobic digestion process can be used to generate energy. In this study, it is observed that the coupling of both processes i.e., algal treatment integrated with anaerobic digestion of grown algal biomass benefits wastewater treatment for nutrient removal and energy production.

*Keywords:* *Chlorella vulgaris*, nutrient removal, phycoremediation, anaerobic digestion, tannery wastewater.

ECT P-32

## ADOPTING ECOLOGICAL CHROMIUM TANNING SYSTEM IN INDUSTRIAL SCALE

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Chromium tanning without pickling process, using less chromium salts at higher initial pH values is one of the approaches offered in recent years in order to overcome environmental problems caused by conventional chromium tanning. However this system could not directly switched to application in industry due to its potential risks. In the present study this ecological approach in chromium tanning was investigated in industrial scale at a leading company in Turkish leather industry. The variables used in the research were; pre-tanning agents (aldehyde, sulphonyl chloride, and synthetic tanning agent), initial pH of tanning (5.0-5.5 and 6.0-6.5) and tanning agents (standard basic chromium sulphate and commercial tanning agent with lower chromium oxide content). In first stage 12 experiments were designed and these variables were tested in trial batches of 50 kg lime splitted hides. In second stage the most successful 6 recipes were verified in 50 kg and 500 kg of batches. Various wet-end and finishing processes depending on 3 different type of product were applied according to company's production line. Chromium contents of the leathers and remaining amounts in effluents were determined for each trial. Also, the physical properties of the leathers were investigated. Additionally, the properties of the final leathers were evaluated comparatively with company's regular products, considering the test results and organoleptical evaluations of experts and it was concluded that many of them were comparable to conventional chromium tanned regular products. Along with maintaining similar properties and quality from the produced leathers chromium remaining in residual baths could be reduced up to 92 and 76% by alternative formulations comparing with conventional tanning respectively in 500 kg and 6 000 kg batches. Besides decreasing the amount of residual chromium, this approach has also the benefits of considerable decrease in load of treatment plant associated with noticeable decreases in chromium and salt in effluents.

*Keywords:* Leather, Chromium Tannage, High Exhaustion



## IMMOBILIZED REACTORS FOR THE TREATMENT OF SLAUGHTERHOUSE WASTEWATER WITH MINIMUM SLUDGE PRODUCTION

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Slaughterhouse wastewater constitutes moderate to high strength complex wastewater containing about 45% soluble and 55% coarse suspended organics. It exhibits high COD and BOD level. The wastewater generated from slaughter house sector is widely fluctuating and thus the efficiency of conventional technology is very much limited. Thus, four stage reactor system comprises two stage Fluidized Anaerobic immobilized Reactor (FAIR – I and FAIR – II) followed by Fluidized Immobilized Cell Carbon Oxidation (FICCO) and Chemo Autotrophic Activated Carbon Oxidation (CAACO) was designed. The common facility centre in Chennai to slaughter goat and sheep was selected for validating the treatment scheme. The slaughter house was to slaughter 100 to 600 animals in a day with the maximum of 600 animals on Sundays. The water consumption of the facility centre varied from 3 m<sup>3</sup> /day to 17 m<sup>3</sup> /day at an average of 30 L per animal. For all four types of reactors, Nanoporous activated carbon was used as the base catalyst. The BET surface area of the carbon is 291.15 m<sup>2</sup>/g with the average pore diameter of 25.91 Å. The overall removal efficiency these reactors of COD, BOD, NH-N and TKN is 82%, 85%, 64% and 71%. Multivariate analysis (PCA and cluster analysis) shows that the COD removal in FICCO and CAACO are more efficient comparing to the FAIR reactors.

*Keywords:* Slaughterhouse wastewater, Immobilized reactors, Nanoporous activated carbon, Anaerobic reactor, Fluidized reactor

ECT P-34

## INTEGRATED TREATMENT FOR HIGH ACIDIC NATURE WASTEWATER CONTAINING HEAVY METALS AND SURFACTANT

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Wastewater with high acidic nature (negative pH) was generated during the cleaning of steam tubes in utility boilers. Cleaning of steam tubes in utility boilers of thermal power station is carried out using solution with mixture of hydrochloric acid, ammonium di fluoride, thiourea, surfactants, citrate ions, EDTA (Ethylene Diamino Tetra Acetic acid) and hydroxyacetic-formic acid. The nature of these wastewater is widely fluctuating so that the efficiency of conventional technology is very much limited. Thus, four stage treatment systems comprising oxidation using potassium dichromate, followed by two stages Heterogeneous Fenton oxidation (HETERO – I and HETERO – II) and finally Fluidized Immobilized Cell Carbon Oxidation (FICCO) was used to treat the above said water. The process HETERO – I, HETERO – II and FICCO uses Nanoporous activated carbon as the base catalyst. The overall removal efficiency of the treatment scheme for COD, BOD,  $\text{NH}_4^+\text{-N}$ , and TKN are 85%, 80%, 70%, and 71%. The degradation of the waste water is confirmed by using UV-Visible, FTIR, and NMR spectroscopy.

*Keywords:* Surfactant, High acidic wastewater, Immobilized reactors, Nanoporous activated carbon, Heavy metal removal, Fluidized reactor

**TREATMENT OF CETP WARANGAL TANNERY WASTEWATER****N Prabhakaran\*, S Swarnalatha & G Sekaran***Environmental Science and Engineering Division,  
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The Enumamulacommon Effluent Treatment plant (ECETP) has a tannery cluster of 10 tanneries. The tanneries are engaged in Raw to finish operations with production capacity of 750 skins/day and wastewater discharge of 20 m<sup>3</sup>/day. The tannery cluster is equipped with Common Effluent Treatment Plant consisting of Primary Chemical treatment, Secondary biological treatment and tertiary treatment. The CETP faces issues such as huge sludge generation and difficult to meet the discharging standard. The main cause for the above two issues may be due to recalcitrance of the organic compounds. The recalcitrance of the organic compounds can be eliminated by fragmenting the organic compounds. The fragmentation of organic compounds can be derived by incorporating advanced oxidation process using hydroxyl radicals. The hydroxyl radicals are generated from Nano Porous Activated Carbon and molecular oxygen from air at ambient conditions. The fragmented organic compounds in wastewater can be mineralised in Fluidised Immobilised Cell Carbon Oxidation reactor (FICCO). The FICCO system incorporates both biological and catalytic oxidation processes i.e. biological oxidation is facilitated by immobilized bacteria in nano porous activated carbon and the biologically fermented organics are subjected to catalytic oxidation. The nano porous activated carbon (NPAC) serves for two purposes, one is to act as a carrier matrix for the immobilisation of bacteria and the second one is to generate hydroxyl radicals using the free electrons of the activated carbon matrix. The scheme of treatment of tannery wastewater consists of Fenton oxidation of acidic post tanning wastewater and is neutralised with alkaline beam house wastewater. The neutralised wastewater is further treated in FICCO reactor to meet the discharging standard. The refractory organics [wetting agents] in treated wastewater was further treated in enzyme immobilized reactor. The treated wastewater was characterised by COD, <250 mg/L and BOD <30 mg/L.

*Keywords:* FICCO, FAACO, HFO, NPAC, Post tanning and Beam house.

ECT P-36

## TREATMENT OF HIGH NH<sub>3</sub> AND HIGH COD CONTAINING INDUSTRIAL WASTEWATER BY INTEGRATED FLUIDIZED BED BIO-REACTOR AND HETEROGENEOUS FENTON OXIDATION PROCESS

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The work was focused on the treatment of high NH<sub>3</sub> and high COD containing wastewater having low biodegradability nature due to the presence of high refractory organics and the variety of solvents used in the various industrial processes. The biodegradability of the wastewater was increased by heterogeneous Fenton oxidation, which is one of the advanced oxidation processes (AOP). Followed by the heterogeneous Fenton oxidation, a fluidized bed bio-reactor namely "Fluidized Immobilized Catalytic Carbon Oxidation (FICCO)" reactor was used for the treatment process. FICCO comprises of Nanoporous activated carbon as the carrier matrix in which the microbial culture for the degradation of organics was immobilized and added. The immobilization of microorganisms on the surface of activated carbon increases the catalytic activity of the microbial oxidation by providing the active sites for the organic adsorption onto support matrix. The hydraulic retention time (HRT), pH, temperature, organic load and the concentration of microbial culture for the maximum degradation of organics were optimized. The combination of AOP-FICCO process results in the removal percentage of NH<sub>3</sub>, COD, BOD and TDS upto 50-80% 65-93%, 70-82% and 25-38% respectively. The instrumental analyses such as UV-Visible spectrophotometer, Fluorescence and FT-IR spectroscopic analyses were carried out to confirm the degradation process.

*Keywords:* High COD wastewater, Low bio degradability; Advance Oxidation Process; Fluidized bed bio-reactor



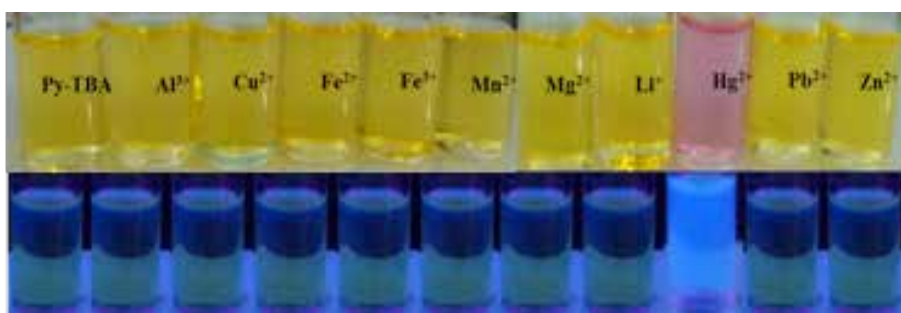
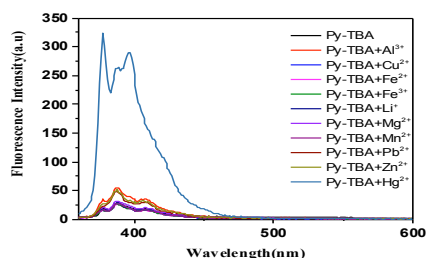
## NOVEL RECEPTOR FOR SELECTIVE OPTICAL AND FLUORESCENCE SENSING OF $\text{Hg}^{2+}$ IONS IN AQUEOUS ENVIRONMENT AND ITS BIO-SENSING APPLICATIONS

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Sensing the toxic molecules, ions offer an effective way of monitoring the pollution in the field without any need for sophisticated instruments, sample preparation methods. The identification methods are very simple; it can be seen even by naked eye or under UV excitation. We have designed a new pyrene based 'turn-on' chemosensor which makes highly remarkable enhanced fluorescence intensity in the presence of  $\text{Hg}^{2+}$  ion and a high selectivity towards  $\text{Hg}^{2+}$  ion over a wide range of metal ions  $\text{Al}^{3+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Li}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Zn}^{2+}$  in aqueous medium. In the presence of  $\text{Hg}^{2+}$  the probe shows selectivity and sensitivity with a 100-fold enhancement in fluorescence intensity in aqueous than in THF medium (~2 fold). The color of probe has changed by the addition of  $\text{Hg}^{2+}$  ions, which we can see by naked eye and also observed in UV and fluorescence studies. The binding mode of  $\text{Hg}^{2+}$  ion to the probe is determined by Job's plot and  $^1\text{H}$  NMR studies. The presence of  $\text{Hg}^{2+}$  in the biological environment can also be detected by turn-on fluorescent methods. The selectivity towards the mercury ions is probably due to the presence thiocarbonyl groups in the pyrimidine moiety.





ECT P-38

## RECOVERY OF SALTS FROM REVERSE-OSMOSIS-RETENTATE FROM DOWNSTREAM OF COMMON EFFLUENT TREATMENT PLANT PROCESSING TANNERY WASTES – A SUSTAINABLE SOLUTION TO SOCIETY

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The main focus in this work is to address the issues in evaporator at the downstream of effluent treatment plant from the tanneries operating in a typical cluster through analysis based on mathematical approach. Since Common Effluent Treatment Plant (CETP) undergoes separation of salts through Reverse Osmosis (RO) method, the reject streams are left behind for the further processing/ enrichment in a multiple effect evaporator. Though the evaporator is designed for maximum chloride concentration of 14 g/L, maximum sulphate concentration of 19 g/L, and for TDS concentration in the range of 25 to 58 g/L, the equipment could be used to make 32%-50% concentrate. However, crystallization can be achieved either with non-aqueous solvent or by employing a thickener at down-stream or by incorporating feed with an altered ratio of organic to inorganic in the feed. A dynamic model for the Seven Effect Backward feed Evaporator with bleed is developed and is validated using observed real-time data. To ensure the operational safety, a Model Predictive Controller (MPC) based on the resulting model is proposed for closed-loop analysis. Parameters such as temperature, mass flow rates, enthalpy of vapour & liquor, density of liquor, boiling point elevation for each effect were calculated. Using the estimated parameters, the mass and energy balance equations are formulated for the seven effect evaporator system. Open loop study was carried out to find sensitivity of parameters on performance of evaporator and on the behavioral dynamics of formation of nuclei for the growth of crystals. An advanced control technique known as Model Predictive Control (MPC) was then formulated and applied on the total system to control the crystal size. The MPC-controller requires the complete state information to be available for feedback and since this is often either very expensive (requires a great number of sensors) or at times even pose difficulty (difficult to measure), a full-state observer was implemented. The MPC was designed for disturbance rejection in the feed concentration. The performance of the MPC scheme was compared with conventional controller

In the present work, modelling of seven-effect backward feed evaporator with bleed is formulated along with design of a Model Predictive Controller. This control algorithm has been designed and tuned for disturbances rejection. The performance of this control algorithm is very satisfactory and is much better than the conventional control strategy. The model is successfully validated using the data obtained from the plant.



## **ALKALINE SALT BASED DELIMING : A NEW HOLISTIC PARADIGM TOWARD A NEW ARENA IN LEATHER PROCESSING**

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Conventional leather processing, a chemically and energetically intensive multistage process, engages various biological, inorganic, and organic materials. Viable white methodology for leather processing is intended to overcome environmental and economic constraints. Growing environmental regulations dictate the prerequisite for the substitutes in the conventional leather manufacturing process. Deliming, one of the unit pre-tanning operations among them, is acknowledged for generation and release of ammoniacal nitrogen gas, resulting negative impact on the environment. In this approach, usage of an alkaline based salt has been explored for performing the above process in order to achieve cleaner leather processing. Lime liquor has been neutralized using  $\text{NaHCO}_3$ . The amount of sodium bicarbonate required for neutralization process is standardized to optimize the deliming process. It has been found that the extent of neutralization of lime liquor is comparable to that of conventionally processed leathers. This direct the way for using alkaline based salt as an alternative in conventional leather making. Further, this newly developed recipe seems to be economically viable.

*Keywords: Deliming, Ammoniacal nitrogen, Ammonia gas.*

ECT P-40

## ENZYMATIC EVALUATION OF CR(III)-TOLERANCE B AMYLOLIQUEFACIENS TCCC 11319 ON DISPOSAL SOLID WASTES

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In recent years, biotechnology has got more and more attention in leather industry due to its high efficiency and cleanness. Compared with chemical degradation, biodegradation usually has more milder reaction conditions. Bacteria, fungi, and their enzyme can be used to treat CTLS since they have proved to be effective in the process. However, most of enzymes are deactivated by heavy metals. The chromium used in leather tanning process results in loss of collagenase activity in the waste-treatment of CTLS disposal. In order to solve this problem, it's important to improve the chromium tolerance of microorganism or enzyme which are used in leather wastes disposal.

In this paper, a strain isolated from tannery's soil has been identified as *B.amyloliquefaciens* and named as TCCC11319, which produced Cr(III)-tolerant fermentation broth with collagenase as the major component. Besides, there are alkaline protease, neutral protease and keratinase in the fermentation broth. All the proteases are significant for the degradation of wastes produced in leather production. Thus the strain can be applied for chromium-tanned leather shavings(CTLS) treatment. Furthermore, characteristics of collagenase in fermentation broth were analyzed. Under optimized conditions of inoculum 5%, pH 8 and temperature 37°C, the collagenase activity of the crude broth reached 900 U/mL and exhibited relatively high tolerance to Cr(III)( $\leq 900$  mg/L). This strain has the potential application value for solid waste disposal of leather industry or other chromium contaminated industries.

*Keywords:* Chromium-Tanned Leather Shavings, Biodegradation, *B.amyloliquefaciens*, Cr(III)-tolerance, collagenase.

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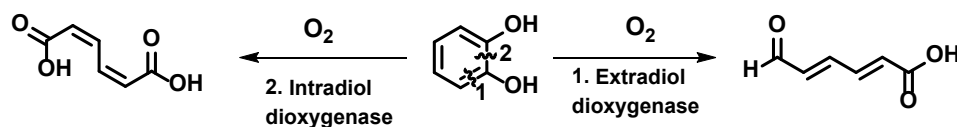
## DEGRADATION OF DIHYDROXYAROMATIC POLLUTANTS BY IRON(III) COMPLEXES OF N<sub>2</sub>O DONOR LIGANDS

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In nature, mononuclear non-heme iron enzymes perform a variety of important biological functions to maintain the carbon cycle. Several mononuclear non-heme iron enzymes activate dioxygen to catalyze key biochemical transformations, including many of medical, pharmaceutical and environmental significance. Biodegradation of naturally occurring aromatic molecules by soil bacteria involves the oxidative cleavage of the catechol and other dihydroxy aromatics, which are the carbon sources for their growth. The catechol dioxygenase are the mononuclear non-heme iron enzymes isolated from soil bacteria. They have attracted much interest because they convert aromatic pollutants in the environment to water-soluble aliphatic products by oxidative ring cleavage with incorporation of both the atoms of dioxygen into the aromatic ring. They are subdivided into intradiol- and extradiol-cleaving enzymes depending on the catalysis of ring cleavage between or outside the two ortho-hydroxyl groups. The differences in iron oxidation state and ring cleavage positions are manifestations of the different mechanisms utilized by the two classes of enzymes. The intradiol cleaving enzymes exemplified by catechol 1,2-dioxygenase (CTD) and protocatechuate 3,4-dioxygenase (3,4-PCD) possess a high spin iron(III) center bound to the protein backbone primarily by the two histidine imidazole nitrogen and two phenolate oxygen (tyrosinate) atoms in a five coordinate trigonal bipyramidal geometry. In contrast, extra dioxygenase utilize an iron(II) (manganese(II)) in a few cases) cofactor ligated by two histidine nitrogens and one glutamic acid in a square-pyramidal geometry. However, in recent years, significant progress has been made in gaining a better understanding of extradiol dioxygenase. In our work, we have synthesized a series of iron(III) complex of tridentate N<sub>2</sub>O donor ligands as functional models for both intradiol and extradiol-cleaving dioxygenase, and characterized by UV-vis, ESI-MS and electrochemical analysis. The dioxygenase ability of the model complexes are explored using 3,5-di-tert-butylcatechol (as a model substrate) and trimethylamine (as an external base) kinetically and the cleavage products are identified and quantified by GC and GC-MS methods.



**Scheme 1. Mode of cleavage of extradiol and intradiol dioxygenases**

**Keywords:** Iron(III) Complexes, Dioxygenase, Carbon Cycle, Catechol

ECT P-42

## REMOVAL OF CR(VI) FROM SIMULATED WASTEWATER USING MAGNETIZED ACTIVATED CARBON PREPARED FROM WASTE AGRICULTURAL BIOMASS *STRYCHNOS POTATORUM*

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Chromium precursors are widely used in leather tanning, stainless steel, plating, paints, pigments, textile dyeing and also in wood preservation. These process industries are releasing large quantities of wastewater which contains different oxidation states of chromium ions and mainly Cr(III) and Cr(VI). Cr(VI) is known to pollute soil and water bodies to a greater extent and considered to be highly toxic to human beings and aquatic organisms. Therefore, it is mandatory to remove Cr(VI) from wastewater before it is discharged into the aquatic environment. Different physico-chemical and biological methods are available for the treatment of wastewater and adsorption process is considered to be promising technique for environmental remediation. Considering cost effectiveness and reusability, there is a need for the development of newer adsorptive materials which may overcome inherent demerits of commercial adsorbents. Hence, the present work is focused on development of novel adsorptive material from agricultural waste biomass and it applied for the removal of Cr(VI) from simulated waste water. The agricultural waste biomass such as *Strychnos potatorum* was carbonized, activated by physical methods and finally the magnetite nano particles were incorporated into the activated carbon matrix by sol-gel technique. The prepared magnetite activated carbon particles were characterized by FT-IR, XRD, VSM, TGA and HR-SEM. The magnetized activated carbon particles was used for the removal of Cr(VI) from aqueous solution. Different experimental parameters were optimized such as effect of pH, variation of adsorbent and adsorbate concentration to maximize the adsorption of Cr(VI) onto magnetized activated carbon particles. Kinetics and thermodynamics of adsorption process also been studied in detail. The adsorption equilibrium experimental data were analyzed by Langmuir, Freundlich and Temkin model equations. The maximum adsorption of Cr(VI) onto magnetized activated carbon was found to at pH 1.65. Adsorption of Cr(VI) onto magnetized activated carbon followed the Langmuir adsorption isotherm and the kinetic data fitted well with the pseudo second order equation. The thermodynamic parameters, such as  $\Delta H^\circ$ ,  $\Delta S^\circ$ , and  $\Delta G^\circ$  were also been determined which suggested that the studied adsorption process was an endothermic reaction.

**Keywords:** Magnetized Physical Activated Carbon, Cr(VI), Adsorption, Isotherm, Thermodynamics



## SYNTHESIS, CHARACTERIZATION AND CATALYTIC APPLICATION OF ZEOLITE BASED HETEROGENEOUS CATALYST OF IRON(III), NICKEL(II) AND COPPER(II) SALEN COMPLEXES FOR OXIDATION OF ORGANIC POLLUTANTS FROM THE TANNING INDUSTRY

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In this study heterogeneous catalysts were synthesized based on the encapsulation of iron(III), nickel(II) and copper(II) with complexes of N,N'-ethylenebis(salicylimine) ligands into zeolite Y supercage using ship-in-a-bottle method of synthesis. The catalysts were characterized by X-ray powder diffraction, BET surface area and pore volumes, Fourier transform infrared spectroscopy, electron paramagnetic resonance, thermo-gravimetric and elemental analysis.

The results obtained from the physico-chemical analytical techniques showed that iron(III), nickel(II) and copper(II) complexes of N,N'-ethylenebis(salicylimine) ligands were successfully formed into zeolite Y supercage without affecting zeolite structure and properties of the metal complexes.

The catalysts prepared were found to be very effective in the removal of organic pollutants from synthetic wastewater. Interactive effects of four factors; initial hydrogen peroxide ( $H_2O_2$ ) concentration, catalyst dosage, temperature and pH on the degradation of selected organic pollutants were determined. Experimental results showed that lower pH and higher temperature were optimal for complete removal of organic pollutants using the prepared catalysts. Moreover, increase in the concentration of hydrogen peroxide ( $H_2O_2$ ) and catalyst dosage, beyond the optimum concentration had a negative effect attributed to the formation of hydroperoxyl radical ( $\cdot OOH$ ). This has a lower oxidation potential than the hydroxyl radical ( $\cdot OH$ ) and aggregation of catalysts, respectively. The extent of reusability for the catalytic oxidation of organic pollutants and the possible deactivation mechanism after successive reuse of each catalyst were studied. The possible intermediate product, degradation pathway and kinetic studies for oxidation of organic pollutants were also studied.

**Keywords:** Ship-in-a-bottle, Azo dyes, 5,5-Dimethyl-1-pyrroline-N-oxide, Metal exchanged zeolite, Hydroperoxyl radical, Oxidation

ECT P-44

## SKIN CURING USING A NUISANCE PLANT PROSOPIS JULIFLORA

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Although bestowed with brilliant antimicrobial properties, *Prosopis juliflora* is considered largely as a nuisance plant due to its noxious invading behavior. It absorbs moisture from the ground as well as atmosphere, thus affecting the growth of all kinds of agricultural plants in the vicinity thus causing worrisome ecological and economic impacts. Also, with its poisonous thorns, it hurts lethally animals and humans alike. Thus, an unwanted plant like *Prosopis juliflora*, for its superlative antibacterial properties, can be exploited liberally than any other plants having significant industrial application elsewhere. The phytochemical route to short term preservation of raw skins is an ecofriendly technique and is promising with its potential for pollution control.

In this study, the experimental skin (goat) samples were treated with 5% Salt+5% *P. juliflora*, 10% Salt +10% *P. juliflora*, 15% Salt + 15% *P. juliflora* and 40% Salt according to the skin weight respectively were preserved for 21 days and were observed for hair slip, smell and putrefaction. Estimation of moisture content and microbial load was tested on the 1st, 3rd, 7th, 14th and 21st day. The experimental skins showed a reduced level of moisture content and microbial load compared with the salt preservation. SEM analysis showed dermis and epidermis layers intact after phytochemical preservation. The experimental skins were processed into leather and their physical properties and color properties were examined. The physical and color properties showed comparable results with the conventional method of preservation. The pollution load in the soak liquor in terms of BOD, COD, TDS, TSS, TS and Chlorides was found to be reduced in the soak liquors of experimental skins. Hence, an ecofriendly curing technology is proposed by neutralizing the nuisance associated with conventional curing such as salinity with the help of a nuisance plant like *Prosopis juliflora*.

**Keywords:** Skin Curing, Ecofriendly, Nuisance plant, Antimicrobial, Pollution control





ECT P-45

## SOLIDIFICATION OF HAZARDS RESIDUALS AFTER THERMAL TREATMENT OF LEATHER SOLID WASTE

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Tannery is one of the leading industries in India which plays major role in Economy of the country and also provides large scale of employment. Though it produces a large amount of solid organic wastes in the form of un-tanned (trimmings, fleshings, splits) and tanned (trimmings, splits and shavings) waste from raw hides and skins, as well as sludge as a result of wastewater treatment. Safe disposal of solid waste generated in the course of tannery process represents a great challenge. This method describes a path for safer disposal of the tannery solid waste. Three tannery solid wastes such as finished trimmings, chrome shavings and dewatered sludge are taken in this study. The pilot scale incineration was done on these three samples and the stack analysis was done. During incineration process, only the volatile organics present in samples were removed. The heavy metals including chromium still remains as residue in the ash of the incinerated sample. The incinerated ash was solidified as concrete blocks by replacing the cement and sand with different ratios on weight basis. The results obtained from the study shows that about 80% of the sand can be replaced and 60% of the cement can be replaced by using these incinerated ashes in the conventional concrete with M-20 grade. The compressive strength of the blocks obtained with replacement of incinerated ash showed almost similar as that of the conventional concrete. Hence this method of solidification of incinerated ash is proved as better disposal method of the solid waste by reducing the hazardous wastes and environmental pollution.

Key words; Finished trimmings, Chrome Shavings, Dewatered Sludge, Incineration, Concrete blocks



ECT P-46

## ELECTRO-OXIDATION: A SUSTAINABLE TECHNOLOGY FOR PREVENTING THE ENVIRONMENTAL THREATS OF LEATHER MANUFACTURING

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Leather industry has been installing various technologies time to time to meet the environmental regulations and to attain the zero discharge. Recent years, advanced technologies such as membrane technologies followed customary treatment technologies are installed in most of the tanning industries. However, RO has been proved to be economically impracticable and moreover there is no feasible solution to dispose the reject securely. To avert the environmental threats to tanning industries, it is important and essential to develop the permanent solution to a perpetual problem.

In this research, it is aimed to develop the sustainable technology for reducing the environmental impact of wastewater based on the principle oxidative degradation of organic compounds so as to render them re-useable. Electro-oxidation is an auspicious technology for the removal of organic compound present in wastewater. The waste streams from different unit processes are segregated and screened to remove the gross solids. The sectional streams were treated following electro-oxidation. Influence of process parameters such as current density, electrolyte concentration, pH and duration were studied and optimized for each sectional wastewater. The oxidation radicals such as  $\cdot\text{OCl}$ ,  $\cdot\text{OH}$ ,  $\text{HOCl}$ ,  $\text{O}_3$ ,  $\text{O}^{\cdot}$ ,  $\text{H}_2\text{O}_2$ ,  $\text{O}_2$  and  $\text{Cl}_2$  generated oxidizes the organic pollutants. The treated waste streams were found to be free from organic pollutants generated during the process. Current Efficiency (CE) and Energy Consumption (EC) were calculated. The resultant treated wastewater was reused appropriately. This indicates clearly that reuse treated sectional streams does not influence on the quality of leathers. Physical properties of the leathers obtained through reuse experiments were akin to those of the control leathers. Thus, the water consumption and the pollution issues can be minimized in tanneries by adopting electro-oxidation. It concluded that electro-oxidation technology is commercially feasible and economically viable to attain the zero wastewater discharge for sustainable leather manufacturing.

*Keywords:* Zero Discharge, Electro-oxidation, Reuse, Sustainable technology, Tannery, Sectional streams.



## ECO-FRIENDLY CURING OF HIDES/ SKINS USING PHYTO BASED LEAF EXTRACT

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The art of leather making have been practiced for decades and so are the effects of pollution generated. Freshly flayed animal skins are preserved with common salt for storage and transport purposes. The salt cured skins pave way for increased TDS (Total dissolved solids) thereby causing water pollution. In order to reduce this pollution, efforts were taken for eco-friendly method of preservation of skins with phyto based extract obtained from citrus. The extract of lemon leaves showed the presence of Terpenoids, Phenols, Steroids and Sterols, Phlubatannins, Saponins and Cardiac Glycosides during phytochemical screening. The GC-MS revealed the presence of 2-[2,6,6-Trimethylcyclohex-1-enyl] cyclopropanecarboxylic acid, 1,2-benzenediol, 3[[3,5-dichlorophenyl) imino]methyl], Pentadecanoic acid and Heptadecanoic acid in the methanolic extract of lemon leaves. FT-IR analysis too confirmed the presence of these functional groups. These functional groups inhibit the collagenlytic bacteria and prevent the skins from degradation. The higher anti-bacterial activity of extract helps in preservations of raw skins for a period of more than 30 days. The pollution load of soaking liquor like TDS, TSS, Cl-, BOD and COD were also reduced to the level of 77%, 69%, 63%, 55% and 53% respectively. The physio-chemical properties of the processed leathers were comparable with the conventionally cured leathers. Hence by adopting this plant based preservation with less-salt will make the industry cleaner and sustainable one by reducing the major problem of salinity by the leather industry.

*Keywords:* Phyto-based extract, raw skin, anti-bacterial activity, preservation, Pollution reduction.

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## PERFORMANCE EVALUATION OF SEPARATION OF CHROMIUM FROM CHROME SHAVINGS UNDER ALKALINE THERMAL CONDITION

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Chromium is a major contaminant of tannery effluent and its discharge into the environment poses an environmental hazard. Though chromium exists in valence states ranging from -2 to +6, Cr (III) and Cr (VI) are of major environmental significance because of their stability in the natural environment. Cr (VI) is toxic, carcinogenic and mutagenic to animals as well as to humans. In contrast, trivalent chromium [Cr (III)] is relatively less toxic and less mobile. Conventionally, chromium (VI) containing industrial effluent is treated by physico-chemical methods such as reduction, precipitation, ion exchange, reverse osmosis and electro dialysis. However, it has been observed that these processes are costly and unreliable. In leather industries chrome shavings are the major polluting solid wastes. By trimming and shaving methods various types of solid waste was generated by the leather processing industries. In india around 20000 tons of chrome shavings are generated per Annum. In this paper, an attempt is made to separate chromium and protein from the chrome shavings through alkaline precipitation under reflux condition. After separation, the supernatant protein can be used for several other purposes like animal feed, biogas production, etc. The precipitated chromium can be reused in leather processes. In this study, method of using lime to precipitate protein and chromium under reflux condition was evaluated. Chrome shavings were obtained from a commercial tannery and it was hydrated with water. Lime was added to bring alkaline condition (pH 10.5) and the mixture was kept in reflux condition. Optimization of reflux time and quantity of lime needed for effective separation of chromium from chrome shaving was studied. After precipitation the supernatant was separated and analyzed for protein concentration. The precipitated chromium was centrifuged and analyzed for chromium content. The results show that after lime addition and four hours of reflux condition brought about 99% of chromium separation from chrome shavings.

*Keywords: Chromium, Chrome Shavings, Alkaline Precipitation*



## **PRODUCTION OF SALINE TOLERANT ALKALINE LIPASE ENZYME BY USING HALOPHILIC ORGANISMS FOR THE TREATMENT OF HYPER-SALINE SOAK LIQUOR DISCHARGED FROM TANNERIES**

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This investigation was mainly focused on the enzymatic degradation of soluble bio molecules (lipids) present in hyper saline soak liquor discharge from tanneries. The halophilic organisms were isolated from different sources acclimatized with soak liquor and screened for their lipolytic activity at saline medium. The lipase was produced from two selected halophilic microbes were isolated from soak liquor (SL) and SL acclimatized deep soil and named as DS-1 and SOS-1. The biochemical characteristics and 16SrDNA analysis were done for the identification of organisms. The optimization studies on lipase production were done and it was found to be time at 48 h; pH, 9-10; Temperature 40°C. substrate concentration 2% and the salinity of 4%, show the maximum yield of lipase production. The produced lipase solution was purified by dialysis and the specific activity was evaluated. Additionally, the stability of lipase was carried out by varying pH, temperature, TDS and metal ions. The degradation was carried out at different time interval and it was found that there was complete degradation of lipid content of soak liquor was obtained at 120 min. The degradation efficiency was evaluated by the conversion of lipids into glycerol and fatty acids. The instrumental analysis such as UV-Visible and fluorescence spectroscopic studies were confirmed the enzymatic degradation of lipids into their smaller units in hyper saline soak liquor and it may favour for the effective treatment of soak liquor by further unit operations.

*Keywords:* Tannery Saline Soak Liquor, Lipase, Halophilic Organisms, Lipids, Enzymatic Degradation

ECT P-50

## RESEARCH ON SS/CR MEMBRANE SEPARATION SYSTEM OF THE WASTE LIQUID OF LEATHER WET PROCESS AFTER TANNING BASED ON TRIZ

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In order to overcome the disadvantages of the traditional method for the treatment of waste liquid of leather wet process after tanning with alkali and precipitation, including excessive chromium content, a large amount of chromium containing sludge and easily causing secondary pollution; Membrane separation technology was attempted to introduce, but a preliminary study found that the suspended matter in the waste liquid is easy to be blocked the pore of membrane, which seriously affects the efficiency of membrane separation. Here using TRIZ theory to redefine the problem of SS/Cr membrane separation of leather wet process after tanning, using resource analysis, function analysis, causal analysis and so on to analysis the problems and to find a starting point to solve the problem, and trying to find the solutions of the problem by using the technology contradiction and contradiction matrix, the physical contradiction and the separation method, the material field analysis and the standard solution as well as the technical system evolution law, then the scheme is transformed and optimized for the practical solution, and the results show that the verification scheme has good application effect.

*Keywords:* Leather Engineering; Theory of the solution of inventive problems; membrane separation, Functional analysis; Material field analysis, Technical evolution law



## STUDY ON THE TREATMENT OF DYES SOLUTION BY IMMOBILIZED TRAMETES VERSICOLOR

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The biological method was used to treat leather dye solution, immobilized *Trametes versicolor* gel particles and immobilized *Phanerochaete chrysosporium* gel particles were prepared by entrapping the hypha into calcium immobilized. Acid yellow G dye solution was treated by some immobilized gel particles. The change of decoloration rate and the laccase activity were determined. When the existence of chrome tanning agent and NaCl, the decoloration rate of immobilized *Trametes versicolor* to the acid dyes, direct dyes, basic dyes solution were researched. Results indicate that immobilization *Trametes versicolor* gel particles to the acid golden yellow G dye (50mg/L) has a high decolorization rate, the 8 days decolorization rate was 96.86%. The existence of NaCl (1%) did not influence immobilized *Trametes versicolor* to dye decoloration rate. Under the gradient changes of dye concentration, immobilized *Trametes versicolor* gel particles to dyes showed good decolorization rate. The uv-visible spectrum research found that the maximum absorption peak of dye disappeared or decreased. The immobilized *Trametes versicolor* gel particles showed a broad spectrum of dye decolorization which has better decolorization effect for different types of dyes. At same time, the laccase was proved to have an important action on dye decolorization.

Keywords: White Rot Fungus, Immobilization, *Trametes Versicolor*, Dye Decolorization, Laccase

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## RESEARCH ON FORMALDEHYDE EMISSION CHARACTERISTICS OF FORMALDEHYDE TANNED LEATHER BY SEALED JAR METHOD

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This study presented a first effort to focus on the formaldehyde emission characteristics of formaldehyde tanned leather. Formaldehyde release tests were carried out according to ISO 17226-3 standard-sealed jar method. Effects of temperature on the release behavior were investigated. The formaldehyde emission model of formaldehyde tanned leather in sealed system was established according to the law of mass transfer under several reasonable assumptions and verified by the fitting of actual release data. Application and prospect of release theory were discussed.

The results showed that formaldehyde emission could be divided into three stages: the linear free release, barrier release and chemical release stage. The linear release time inversely correlated with mass transfer coefficient which positively correlated with temperature. The release temperature had significant promotion impact to release during linear release time. The higher the temperature was, the faster the formaldehyde release. Because of the difference of porosity, different types of leather showed different release characteristic. The average release speed of sheepskin was faster than that of cowhide at the same temperature. The release of formaldehyde in cowhide was more sensitive to the temperature. The temperature increased from 30 to 60°C, the formaldehyde release speed of sheepskin increased 19.39% for every increase of 1 degree Celsius by average, and that of cowhide increased 29.92%.

*Keywords:* Formaldehyde, Emission Model, Leather



DIP P-01

## CREATIVITY AND INNOVATION : THE STRATEGIC TOOLS FOR BENCHMARKING THE QUALITY STANDARDS FOR LEATHER AND LEATHER PRODUCT SECTORS

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The globalization of the consumer markets and the emerging trends in the consumerism challenge the marketability of the leather and leather products and sustainable supply of the products. This challenge has aroused due to the demands in the markets driven by the consumer with high desires and changing preferences with their variety seeking and quality conscious behaviors. The assurance of quality standards for variety of leather products coupled with competitive pricing become a great task for the manufacturers and marketers. Adapting and applying the concepts and techniques of creativity and innovation play a major role in achieving these tasks and ensuring the sustainable business in the rapid changing market scenario.

There are common needs for materials research and product innovation across different sectors of leather industries like Finished leathers, Leather Footwear , Leather Goods, Leather Garments , Leather Saddlery& Harness, Leather Upholstery etc., notably a stronger support for research and a framework for more effective and more upstream collaboration. There is a need for creativity-driven or design-driven innovation. It is crucial to bring talents from different creative and technological backgrounds together on equal footing and to find a common language. When new materials, products and production processes are conceived together, the industrial take-up time as well as time to market is minimized. It is necessary to add functionalities to materials in order to increase the added value of the products and services. This will enhance the competitiveness and also make it more difficult to copy a product. As the values are also transmitted by materials, the choice and use of materials communicate a message and contribute in shaping the image of a person, company and brand. For instance, using waste or process by-products to produce new materials and products, facilitating the transfer of materials across sectors, creative solutions for combinations of materials and multi-material products would enhance innovation.

In this context, this paper presents the concepts, various components and techniques of creativity and innovation with respect to materials, processes, new product development, and organizational strategies and their impacts on establishing and benchmarking the quality standards for the variety of leather products. Exploratory and descriptive research methods are applied and the recommendations are presented based on the concepts evolved out of research literature, practices in trends, and also by analyzing the data collected from other secondary resources.

*Keywords: Benchmarks, Creativity, Innovation, Leather Design, Lifestyle Products, Quality, Standards, Sustainability*



## DESIGNS AROUND SHOES

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The cost components of the shoes are so high that unlike garments and dresses they are not brought in large numbers by individual users. In order to make the shoes attractive, various designs are applied on the shoes. The designs applied on the shoes are two dimensional and three dimensional. Though there are number of varieties, most of the shoe designs are “applied” on the shoes during the manufacturing. Therefore, the design remains with manufacturers’ choice. Technological development has resulted improved durability of soles of the shoes. However, any damage, wriggle or tear on the surface leads to disposal of shoes. With increased technological advancement & complication, it is almost impractical to repair the damaged shoes.

So far, the 3D designs on the shoes applied either above the quarter and counter or collar or in some case towards to toe areas. The rear half of the shoes, the quarter, vamp and counter or collar, in most cases, are bare of any three dimensional designs. Only two dimensional designs are applied on these parts. The new design is based on removable and reusable three dimensional designs, which can have instinct appeal, if so desired, and applied to the shoes with minimum addition of functional aspects during the manufacturing process of the shoes. The replaceable designs applied on the shoes will enable the users to change the design as and when s/he wanted to do with other designs that too fit into the shoes.

The new designs are matching pieces of clothes or other materials attached to the top edge lining of the counter, quarter and/or collar at the one end and welt or sole portion of the shoe where counter and vamp join on the other end. The clothes or other such matching material is attached with the shoes either by zip, Velcro or other sticking materials.

Its advantages include (i) removable design – with ease, (ii) replaceable design – comfort, (iii) reusable design – cheap, (iv) washable material – bright and (v) ease of change in design like changing cloths after wash.



## SURFACE DESIGN TECHNIQUES AND EMBELLISHMENTS FOR SUSTAINABLE LEATHER PRODUCTS

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India has the largest number of livestock in the world. Since several years particularly from 80s, manufacturing of Leathers, Leather products and Footwear have become a major contribution to the world economy. In today's era leather industry is undergoing a complete change through modern leather processing techniques, where sustainability has crawled in every field and aspect of life. As known, the natural animal skin or hide undergoes various chemical processes and mechanical operations to be converted into fine leather. Being made from the natural material and also due to the influence of mechanical, chemical and physical treatments a remarkable portion of the materials gets defected during the conversion. These defected materials are rated as poor selections and rejections and are disposed as wastes or sold for very lower prices. Up gradation of these defected and waste leathers can help in reducing the waste and resulting in the efficient utilization of unused leather. In this context, the researchers present this work which deals with the up-gradation of leathers that can be achieved through different design techniques, decorations and surface finishings on these faulted leathers. Surface design techniques and embellishments like appliqué, crochet, knitting, typography and pyrography including aesthetic surface finishing like printed, embossing, painting, mosaic and few more techniques which can hide these defects on the lower selections and rejected leathers. These upgraded materials are then applied for designing of leather products and life style fashion accessories with the standardization of quality and providing value addition to final leather products to ensure sustainability in leather product development and marketing them as commercially affordable products.

The research work also give suggestions and design concepts to combine the leather with other eco- friendly fabrics like jute, denim and canvas for making creative lifestyle products with an objective to reuse leather with natural materials for providing a sustainable environment.

*Keywords: Surface Design, Leather Embellishments, Typography, Pyrography, Mosaic, Leather Combinations, Sustainable Products*

DIP P-04

## **GREEN CONSUMERISM – AN INNOVATIVE DESIGN APPROACHES FOR SUSTAINABLE LEATHER LIFESTYLE ACCESSORIES.**

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Sustainable product design is an approach considering cleaner and green environment for the future. The most important measures that need to be tackled are the form or shape of the leather products that are being purchased by the end users and the global impact by reducing the materials consumption at the production process for producing those products. The other challenge would be creating sustainable fashion with due consideration to product styling, design, quality measures and the product costing during the development process. Achieving the zero waste during the full product development is the major area that would be also focused on sustainable product design. The five major areas that are to be considered are 5R namely Reduce, Reuse, Recycle, Recover and Refuse. By concentrating the 5R, the styling of the product would be designed and developed. The usage Eco friendly materials such as natural fibres and organic material in the development of Green consumer based products for the sustainability of leather lifestyle accessories is new in the market. Form development and the size of the product play a vital role in material consumption of the leather. The other factors that were bought in consideration while designing the leather lifestyle accessories are form follows function concept. The basic requirement that an accessory serves the purpose that it needs to do as well as it aesthetically synchronize with the user attire. In this research an intensive study on the various features that are incorporated in the accessories haven been carried out. The design matrix is obtained by analysing the various attributes from the values of the customer's survey index. The psychological studies on the influence of style and fashion with eco-friendly leather from Vegetable tanning process with the modern consumers were also conducted.

Survey were conducted with 160 female consumers of various age groups to understand the impact of colour, physical and technical features in the accessories that they use on day to day as well as special occasions. The major factors those influences the purchasing of accessories in the consumer market was taken further analysed and discussed.

*Keywords:* Sustainable Product Design, Green Consumer, Fashion, Design Matrix, Eco-friendly materials.



## PRODUCT EXCITEMENT – DESIGN INNOVATION AS A TOOL

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Design is a life skill. Design is a behavior. It has been the core force in the evolution of mankind.

*Sitting pretty in many a ways, man today is operating design towards rewiring people's mental makeup and living. Disruption is the new buzzword and disruptive technology is turning all prevalent. The 4th Industrial revolution is characterized by fusion of technologies. Innovation has never been so prolific and fast. This inertia of innovation in one field has a cascading effect that impacts others fields too. Leather has not remained unimpacted.*

Having said so, a material considered exotic, its usage has been limited and restricted in many a ways. While finishes on leather have hit the tipping point, conversion into products still is low on the innovative curve. This paper explores on this aspect of leather value chain – innovation and innovative products through design.

Design innovations in the category will be attended to as: 1/ innovations in the existing chosen product category/sub-categories. 2/Innovative products in the category/sub category.

1/ Innovations in existing product category: The methodology would be to research on chosen existing product category/sub-categories and treat it as a product for constructive discontent. Where required, primary data and empathy mapping will be the guide in identifying silent areas of discontent that call for design intervention.

2/ Innovative products in the category: The methodology would be to study existing product category/sub- categories and introduce new innovative products within the category or creating new product sub-categories. Gap Identification ,Latent need analysis and a lifestyle want/need creation could be some of the methods adopted to create sub categories.

The paper will depict diagrammatically the innovative concepts/designs. While some of the concepts will be futuristic and may raise eyebrows, the researchers will present the same firmly believing it is only a matter of time before the concepts turn into reality.

*Keywords:* Constructive discontent, Category, Concepts, behavior

DIP P-06

## FASHION INTELLIGENCE INTERPRETATION & TREND RETAIL ANALYSIS

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**The Big Picture :** Monitoring the flow of trends over past few seasons based on: Retail Research; Trade Fair information and predictions; Information on Colour, Leather and Materials;

**Categories:** Formals, Casuals, Sports

**Components :** Toes, Outsoles, Trims

**Trend Forecast:** Men's, Women's and Children comprising Commercial Reality, Key details, Essential footwear styles

### SHOE RETAIL TRENDS

The Shoe Retail Trend covers new and breaking trends from the world's fashion capitals and focuses on trends which will be influential for the future.

It monitors the fashion life span of each trend and discusses very new trends, rising trends, trends at their peak and downward trends.

Stops on retail trips to track down key footwear trends of the season and spell out the key directions for the season in address.

This is a Scientific Analysis of the market trends and helps the shoe manufacturers to understand the Trends in Retail and gear up with apt products for exposition at leading International Fairs such as LINEAPELLE, Garda, WSA, MICAM and the GDS.

This gives pointed directions on making collections which would be apt for the fashion markets world-wide and helps the manufacturer decide on making a focused collection which would enhance the sale ability of his products.

The Scientific Analysis of the market trends has helped the shoe manufacturers to understand the Trends in Retail and gear up with apt products for exposition at leading International Fairs.



A scientific analysis of the trend patterns of the different styles for Men, Women & Children and the various silhouettes covering toe shapes, heels and outsoles are studied and graphically plotted to highlight the rising and falling trends seasonally.

CLRI's Shoe Retail Trend not only highlights the Trends as seen at current retail in the fashion capitals; but also at important Leather and Leather Product Fairs.

In summary, Reality Check @ Retail: Retail Trend Analysis tracks the 'Trends' and predicts what will be important for the Autumn Winter and Spring Summer seasons ahead.

**“To make sure that you can feel the design’s heartbeat and know what is important to you. By means of store checks a brand or retailer gets current information from different outlets.”**

*Keywords:* Scientific analysis, store-check, spring summer, autumn winter, shop windows, big picture, trend forecast, outlets, retail research, fashion intelligence.

DIP P-07

## REJUVENATION OF TRADITIONAL LEATHER CRAFTS WITH INNOVATIVE SURFACE DESIGN INTERVENTIONS - A CASE STUDY APPROACH

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Indian handicrafts have a deep dug history behind its existence of over 5000 years from now. The tradition of crafts in India has grown around religious values, needs of the common people and also the needs of ruling elites. In addition to these factors growth of foreign and domestic trade have also played an important role in the evolution of crafts in India.

Moving from the historical past to modern India, the country is fortunate enough to have skilled artisans who are carrying forward the legacy of their forefathers. But the very roots of our Indian handicrafts are being exploited by over use of machine made products. In the contemporized world of ours we have found the machine oriented products easily accessible and economical. If we turn on to the other side of the coin we see every second person wearing the same designs and silhouettes creating monotonous fashion which is unlike our perception of uniqueness that we had while purchasing the product. The most luxurious sight of the leather products in black and brown hues is not worthy enough to be inculcated as a fashion, where each person has a different colour choice for their wardrobe from clothes to accessories.

When we see the experienced hands of ethnic India creating beautiful handcrafted products which posses a high renowned beauty and uniqueness which they have developed over the period of time by representing their creative thoughts. In the present scenario where everyone wants to represent them as the unique entity, handcrafted products can serve as a source which is unique and economical for the pockets. The leather handicraft is basically deals with embroidery, hand painting, embossing, tie and dye, cut work and batik on the surface of leather. Since the leather handicraft could not establish itself in the fast growing fashion world due to the lack of marketing sources. But these techniques on leather carried by the artisans can be a big boom for the fashion world as it can give a simple plane surface an aesthetically appealing look. So thereby with the objective of rejuvenating the traditional leather batik handicraft this project is undertaken. It also serves the objectives- To give / create new designs on the leather, to hide various defects on leather, to increase the market value of leather and to promote batik on leather.



So to define batik, a form of art and craft which uses the technique of dye resisting. The resistor used on leather is Babul Gum. In this process Babul gum is applied on leather where ever we want to maintain the surface hue and the rest of the surface is dyed with a dye of a particular colour which results into an aesthetically appealing surface which can be used to create various artefacts.

The major intervention is done under the project is in textures and motifs. As cracks remain the signature texture for the background so few new textures are developed using leaves, petals, stems and other natural products which can be easily found everywhere. Few new motifs are also being developed taking various animals silhouettes like snake, butterfly, and frog as inspiration for creating interesting designs.

Batik can turn out to be a very useful technique for industries as it doesn't require any special machinery for carrying out the process it requires primitive tools like bowl, brush, pencil etc to create wonders on the surface. Secondly, it can be a very useful technique for hiding various defects on leather

as this process can increase its market value. Since this technique is carried out in the crust stage of leather so there is no need to spend a lot on hiding the defects by applying expensive finishes. It can even serve as a trend to the fashion world as alike garments now customised leather products can be developed according to consumers need.

Since batik is simple process which doesn't require any sort of huge machines or technical advancements. There is no need of very skilled labour force for carrying the process as this technique can be learned in few days so thereby this process will serve as a priceless advancement for leather fashion industry which can be used to earn a lot of profit and create new products.

*Keywords:* Simple process, Primitive tools, Unique designs, Customised leather products, Colourful, Ethnic, Visual textures.



DIP P-08

## STANDARDIZATION OF FOOT SIZES OF PATIENTS WITH DIABETIC FOOT ULCER THROUGH ANTHROPOMETRIC SURVEY

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It is well proven clinically that the off-loading of plantar pressure at ulcer site is one of the therapeutic interventions for fast healing of diabetic foot ulcer (DFU). Due to peripheral neuropathy and vascular disease, the foot anatomy of patients with diabetes is significantly different from that of normal persons. Presently the therapeutic footwear or other off-loading devices for patients with DFU are customized which will ultimately delay the treatment intervention. The objective of the present study is to derive standardized foot anthropometric data for patients with DFU to use as a reference for developing pressure off-loading devices. The measurement of foot dimensions for 100 patients with DFU and 50 age matched control subjects were recorded using 3D laser foot scanner. The statistical analysis of data such as regression analysis and cluster analysis was done using SPSS software. By regression analysis the significant difference and correlation between normal and patients with DFU were studied. By cluster analysis 3 groups for male and 3 groups for female were derived. The groups were homogeneous within themselves and as much as possible heterogeneous to other groups. From the statistical analysis of groups, 3 average sizes for male and 3 average sizes for female that can accommodate 70% of patients with DFU had been derived. Development of pressure off-loading devices based on the developed sizes and trial with patients are on-going projects of this study.



## A NEW APPROACH TO DESIGN A FOOTWEAR BASED ON FOOT BIOMECHANICS

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Footwear is an essential product for the entire population of the world. Although fashion plays an important role while designing a footwear, comfort and functionality needs to be considered while designing a footwear. Last, which is the replica of foot is the base for any footwear on which the shoe will be made. The last will have the proportional measurements of foot in order to have a proper fit. The main purpose of footwear is to give protection and comfort to the feet while performing many activities like standing, walking, running, trekking, etc. Also the footwear should not hinder the respective activity. At present, this objective is achieved by providing the proper fit of the footwear. Proper fitting is achieved using anthropometric dimensions of the feet. Thus, feet dimension plays the vital role in providing fit and comfort to the user. But the biomechanics that are involved while performing particular activity is not considered while thinking about the fit and comfort. It is suggested to consider the Biomechanical actions involved in the feet before designing a shoe. It is challenging to consider all the mechanics involved in the feet for designing a footwear, because multiple movements will be involved in each activity. Thus it is suggested to incorporate the kinetics, kinematics, electromyography of few important muscles and plantar pressure distribution data along with anthropometric data before designing a footwear.

*Keywords:* Biomechanics, Footwear design, electromyography, plantar pressure

DIP P-10

**SELF ASSEMBLED COLLAGEN-PVDF-GRAPHENE OXIDE THIN  
FILM AS PIEZO - ELECTRIC SENSOR****T P Sastry \*, S Inbasekaran***Senior Technical/Research Officer, Department of Biological Materials,  
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Collagen - Poly vinylidene fluoride (PVDF), Graphene Oxide thin films were made by self assembling aqueous solution of PVDF and collagen with graphene oxide substrates in PVC trays at room temperature. SEM micrographs showed that the surface of the films were uniform and distributed with the nano particles. X-ray diffraction (XRD) studies showed that the PVDF films settled in two dimensional phase. Raman results together with XRD studies confirmed that the synthesized films are single phase PVDF graphene with good stoichiometry. FTIR studies of the films showed a strong piezo spectra obtained at low temperature (25°C) exhibit better resolved Piezo electric peaks of the CV caused by the combination. The dominant peaks observed in the FTIR, Characteristic spectra confirmed the high quality of the Collagen-PVDF- Graphene thin film piezo electric sensor.

*Keywords:* Collagen, PVDF, Graphene oxide, Characterization, Piezo electric sensor.



DIP P-11

## INNOVATIVE COMPUTER AIDED DESIGNING AND MANUFACTURING FOR FOOTWEAR INDUSTRY

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Indian footwear industry's potential is huge and it can serve both, international market as well as domestic market simultaneously. This potential is largely untapped because of bottleneck in manufacturing and logistical sector. The necessity for high quality puts additional stress in already pressurized product making sector. The swift change in fashion and trend makes it essential for the designer to quickly adopt the change and transfer that into a product. However, it is essential to reduce manufacturing lead time without compromising quality and design. In this context, computer aided designing and manufacturing made fabulous effect in footwear industry and it has much more scope to make it further versatile. Even though the CAD / CAM tools were developed much earlier to cater this need, the use of those tools were largely neglected and underutilized. These tools are very flexible, power full and very useful to quickly overcome difficulties which are faced in designing and in manufacturing as well. By using Advance CAD / CAM tools, footwear industry can reduce their product making lead time, which in turn increases market share and profitability drastically. The key tools are pattern digitizers, 2D scanner, 3D scanner, foot scanner, die less cutting system etc., This paper makes an attempt to present the advances in Computer aided designing and manufacturing for footwear industry by giving glimpsed of few CAD/CAM tools and its applications.

DIP P-12

## MAKING YOUR LEATHER CAR UPHOLSTERY SENSE HYDROGEN

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From olden day onwards, leather is an ideal material has been widely used to protect against external environment. Leather shoes, belts, jackets and handbags are part of many people's everyday clothes and also commonly found in our homes and vehicles, for example in the form of leather upholstery. If leather is made to sense conditions in environment it becomes smart materials. In this work, nanocomposite material was prepared through sol-gel method followed by calcination process. We have made nanocomposite incorporated leather by finishing method. The prepared nanocomposite incorporated leather exhibit a reversible hydrogen gas sensor with fast response at room temperature when exposed to hydrogen gas environment. Physical and chemical changes of nanocomposite and nanocomposite incorporated leather were characterized through X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), High resolution transmission electron microscopy (HR-TEM), and Brunauer–Emmett–Teller (BET), Scanning electron microscopy (SEM), Differential scanning calorimetry (DSC), Instron mechanical testing instrument and LAB method techniques. Our result shows that nanocomposite incorporated leather exhibit higher physico-chemical property than control leather. This work would be increasing the unit value realization from leather through a multifunctional advantage as a sensor in automobiles.

*Keywords:* Nanocomposite, PdO-TiO<sub>2</sub>, Hydrogen gas, Selectivity and Leather sensors



## DEVELOPMENT OF INNOVATIVE SURFACE DESIGNS ON LEATHER FOR LIFESTYLE PRODUCTS

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Consumer behavior has changed substantially over the past decade. As the old technologies have been exploited more especially in developing and marketing fashion products, companies are getting new possibilities for fulfilling customer needs with product varieties. As present days lifestyle has to be fast and up to the trend for the fashion consumers, these consumers are attracted with more trendy and innovative products with one-of-a kind designs.

Development of new surface finishes and embellishments with viable techniques are in need to develop innovative products and also to add uniqueness and value to the products. Earlier surface techniques like patchwork, appliques and embroidery etc., involved use of more skilled labor to make hand-sewn designs on leather apparel. In today's context these age-old techniques are considered to be traditional, cumbersome and time consuming. These techniques require small sections of fabrics sewn together or treated separately to form a part of the main product design. Newer surface techniques are emerging to replace the older and more time consuming ones.

In this context, this research work presents a few innovative surface techniques on leather like laser engraving, laser cutting using the Bemis, Toledo spray and leather quilting. A new range of surface design is created using these techniques that are applicable on different types of leathers for making a variety of leather products. The design concepts are created manually then the design explorations are developed in computer-aided design (CAD) using the design software like CorelDraw, Adobe Illustrator and Adobe photo shop. The designs and patterns are then acquired and the new innovative leather samples are developed. The most innovative designs are selected and applied to create a range of leather products that include a tote bag, a clutch bag and a sling bag. Thus, this research work of innovative surface development of leather with application on the leather products is very much useful and appreciated by the industry as the entire range of creative works are sponsored by a well-known leather products manufacturer and exporter in South India. The researchers strongly feel that this research work would help the industry in many ways and would benefit the company in terms of cost, innovative variety of products with commercial viability.

*Keywords:* Surface Design, Innovative texture, leather products, laser cutting, laser engraving, leather quilting

DIP P-14

## CARBON BLACK FREE RUBBER SHOE SOLES FROM TANNERY LIMED FLESHING

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Rubber compounding, a vital research area in the automotive and other consumer products market, involves manufacturing of quality rubber compounds employing innovative processes and technology. Conventionally, carbon black, a potential carcinogen<sup>1</sup> is used as filler in the process. This study is aimed to reduce the impact of this pollution load by replacing with eco-friendly filler derived from tannery solid waste. Limed fleshing, a major solid waste from tannery industry is used as a source to prepare activated carbon. Limed fleshing was pre-processed and pyrolyzed to prepare Calcium Oxide embedded Activated Carbon (CaO-AC). The CaO, due to the lime acts as a crosslinking agent thus improving the vulcanization process. CaO-AC was morphologically and structurally characterized. On testing the physical properties of soles with CaO-AC as filler, the properties obtained were similar to that of the soles with carbon black. Thus this approach, apart from reducing the pollution load also paves way to upgrade the quality of existing products.





EHC P-01

## **TRIMS : A SOCIO-ECONOMIC BUSINESS MODEL FOR FASTER INCLUSION OF TRIBES INTO THE MAINSTREAM SOCIETY**

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The Indian leather industry occupies a prominent place in the Indian economy in view of its massive potential for employment, growth and exports. The exports are projected to reach USD 9 billion by 2020 and the domestic market is expected to reach USD 18 billion by 2020. The Indian leather industry comprises of major segments like footwear, finished leather, leather goods, leather garments, leather gloves, footwear components and harness and saddlery. All these segments have high growth potential. The tribes of India are among the poorest and most marginalized sections of Indian society. Although numerically only about 8.6% (2011 census), they disproportionately represent the people living below the poverty line, are illiterate and suffer from extremely poor physical health. To illustrate the poverty among scheduled tribes were 47.1% in urban and 28.8% in rural for the year 2009-10. The scenario has been similar in the sphere of education and health. The literacy of tribes in 2011 was 58.96% as compared to 72.99% of the total population. Moreover as per the National Family Health Survey, (2005-06), the Infant Mortality rate was 62.1 per 1000 live births among tribes and Under-five mortality was as high as 95.7 per 1000 live births. The development of the tribal population in India has been a major concern of the government, voluntary agencies, NGOs, social reformers, social scientists, etc. The unemployment rate among urban scheduled tribe men and women were 3.4% and 4.8% in 2011-12 respectively, while in rural areas, unemployment rate for scheduled tribe men and women were 1.3% and 1.1%. Unemployment often leads to immense poverty. This socio-economic business model, TRIMS (Tribal Integration into Leather Manufacturing Systems), aims to cut down the tribes from the edges of the society, adorn them in the mainstream and create a state of equality. The feasibility of training the scheduled tribes in leather and leather products manufacturing and integrating them into the leather manufacturing system has been discussed in this paper.

*Keywords:* Indian leather industry, tribes, poverty, training, integration, manufacturing system



## **TALENT MANAGEMENT PRACTICES AND CREATION OF A HIGH PERFORMANCE WORKFORCE WORLD-WIDE**

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The Leather Sector worldwide has become one of the potential sectors, which is envisaged to have a colossal growth in the near future. The global leather sector is characterized by rapid advancements in technology and growing skill requirements. Implementing suitable talent management strategies/programmes at all levels is essential to cope up with the prevailing conditions and tap the immense human resource potential. Though several studies have been undertaken to study the effect of general human resource development practices on leather/product industry, a study with special reference to talent management practices is the need of the hour for nurturing human capital. Thus the study focuses on assessing the talent management practices followed by the leather product industries in India. The study will employ descriptive research design and utilize employ suitable data collection tool. A preliminary study through review of literature will help in identifying the talent management practices which could be utilized to formulate the data collection tool. The tool will be employed to gather quantitative as well as qualitative insights from employees of various leather product industries. Various statistical tools will be employed to analyze the primary data collected. Thus the study will be helpful in analyzing the overall effectiveness of the talent management practices in leather product industries and come out with the current talent management framework/model followed by the industries. The study will also further investigate into the effectiveness level of talent management practices with respect to different demographic groups among employees of the leather product industries.

*Keywords:* Global Leather Sector, Talent Management, Human Capital



## MASSIVE OPEN ONLINE COURSES FOR ENRICHING HUMAN CAPACITY

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Indian higher education system has expanded at a fast pace by adding nearly 25,000 colleges and more than 8 million students in a decade from 2001-01 to 2010-11. By 2050, India is projected to have 1 billion employable people (Source: Indian National Academy of Engineering, Vision, Mission and Values – INAE2037). The human resource must be channelized into enhancing national and intellectual property and productivity. Massive Open Online Courses (MOOCs) has caught up in India, and many corporations are using this platform to train people and supply the industry with skilled labor. This paper proposes a framework for MOOCs and eLearning system for higher education. Knowledge management is all about creating an environment where information can be readily shared. The ability to understand and inventory tacit knowledge and to be able to manage and deliver that information to those who need it when they need it is achievable today. Creating a learning organization culture is critical. The future of integrated teaching and learning systems provides exciting opportunities to create new interactive learning environments quickly and at a much lower cost.

*Keywords:* Standards, System Architecture, Global education, MOOCs, eBooks, Lifelong learners, Global Network

GRAP P-01

## **BRANDING STRATEGIES FOR R & D SERVICES IN LEATHER SECTOR : IDENTIFYING THE KEY STRATEGIES FOR DEVELOPING A GLOBAL BRANDING MODEL**

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New economic research on global brand investment has revealed that companies spend nearly a half-trillion dollars annually on branding. CSIR-Central Leather Research Institute (CLRI) has contributed to the industry in terms of various cutting edge technologies in different dimensions, testing and training services and consultancy services. The brand image of CSIR-CLRI is one of the core strengths of the Institute and it is essential to study the key branding strategies of the Institute. This study is essential to come out with a roadmap with respect to branding for R&D services. Branding requires careful consideration of our organization's mission, creative thinking and a strong desire to connect with the customers who ultimately form the core of Research and Development (R&D) business. Thus the study will focus on the branding strategies specific to the Institute and how the Institute's branding approaches interact with its innovation strategies showcasing that branding is one of the most important mechanisms for firms to secure returns on investments in R&D. The impact of the branding strategies of CSIR-CLRI on the positioning of the Indian leather industry in the global arena will also be analyzed. The possibilities for branding investments that could be made by the Institute with respect to strategic marketing, communications and other bought-in services that contribute to brand perception can be suggested through this study. Thus the importance of branding for R&D in leather sector can be brought out with CSIR-CLRI serving as a role model.

*Keywords:* R&D Services, Branding Strategies, Brand Image, Branding Investments





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Founded on 25<sup>th</sup> July 1948, CECRI is one of the largest electrochemical laboratories in the world, carrying out innovative R&D work in all branches of electrochemistry and allied fields, viz., Chlor-Alkali, Corrosion, Electrochemical Materials Science, Electrochemical Power Sources, Electrodeics & Electrocatalysis, Electroplating and Metal Finishing, Electrometallurgy, Electrochemicals, Functional Materials, Nanoscale Electrochemistry and Instrumentation. The institute has excellent Knowledge Resource Centre (Library), Computer & Networking Unit (CNU), world class Instrumentation facilities and Characterization & Measurement Laboratory. CSIR-CECRI has three extension centres at Thoothukkudi, Mandapam and Chennai.

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For further details, please contact:

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CSIR-Central Electrochemical Research Institute  
Karaikudi-630 003, Tamil Nadu, India

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Fax: 04565 – 227713 or 227851  
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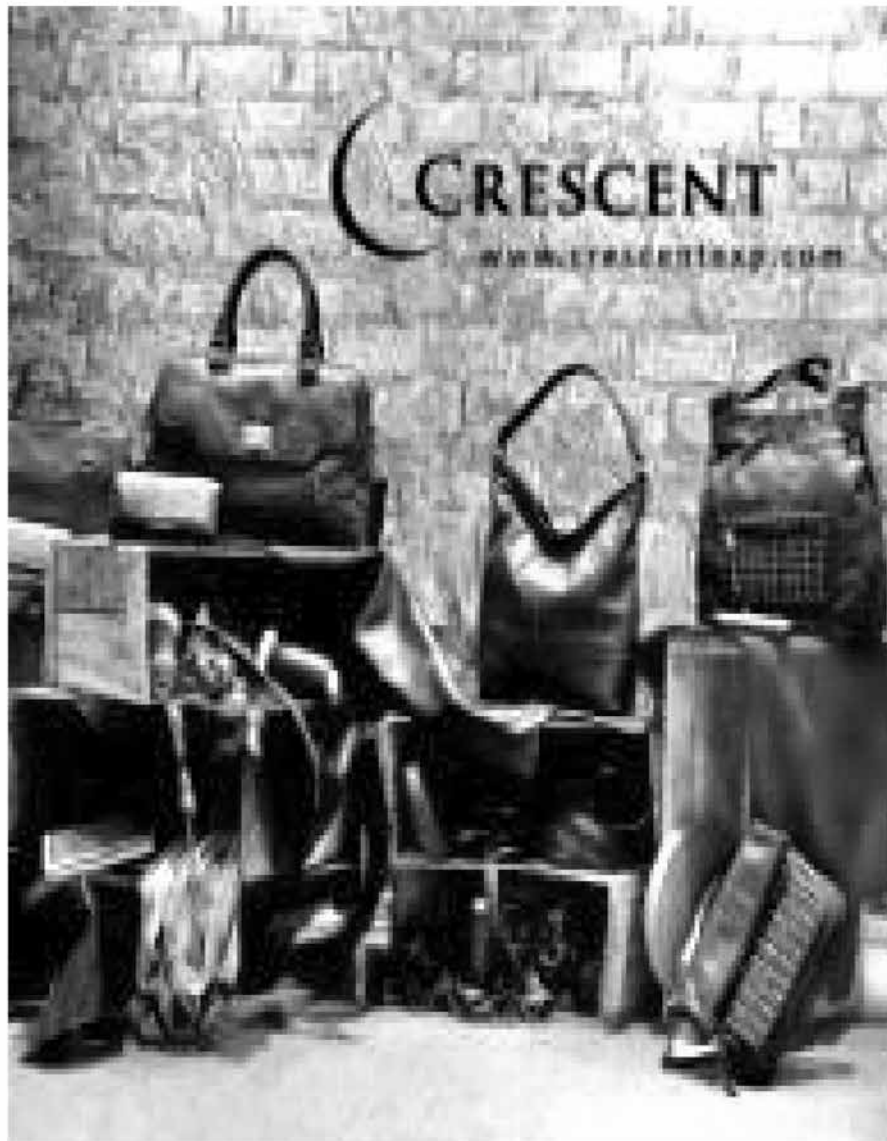
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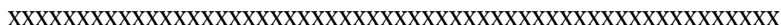
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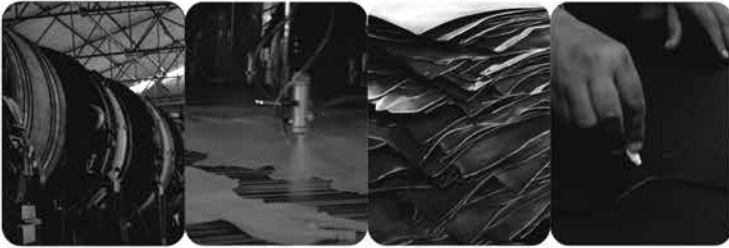
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33, Dr. Rajendra Road, Unit – 1A,  
Kolkata – 700 020, INDIA

Tel : +91-33-24869928/2459051, Fax : +91-33-24753449

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**Email :**

top\_grain@vsnl.com

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Kolkata – 700 039  
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**Tannery :**

Kolkata Leather Complex,  
Zone – 3, Plot No. – 219, 220 & 221,  
Bantala, 24 Parganas (South),  
West Bengal, India

**Contact :**

+91-98302 31536 / +91-98301 90046 / +91-98363 45861

**Email :**

[info@tridentexports.in](mailto:info@tridentexports.in)

*With Best Complements from :*

# ULA LEATHERS

\*\*\*\*\*

**Registered Office:**

114H, Matheswartala Road,  
Kolkata – 700 046  
West Bengal, India

**Factory :**

Kolkata Leather Complex,  
Zone – 5, Plot No. 347 & 348,  
Karaidanga, South 24 Parganas

**Phone / Mobile:**

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JOY IS A CHOICE

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cavalli  
CLASS

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 Plot No. 35, Kolkata - 700 046, India  
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 e [office@uniqueinternational.com](mailto:office@uniqueinternational.com)  
 w [www.uniqueinternational.com](http://www.uniqueinternational.com)



*With Best Compliments from :*

# **VINAIN ENTERPRISES**



**ASSOCIATES : GRACE CRAFT PVT. LTD. (ISO 9001:2008 COMPLIANT)**

**Factory :**

Plot No. 1628, Zone – 9, Leather Goods Park,  
Kolkata Leather Complex, Bantala – 743 502  
West Bengal, India

**Office :**

5B, Stephen Court,  
18A, Park Street,  
Kolkata – 700 017  
West Bengal, India

**Contact :**

+91-90516 13855

**Email :**

[info@vinainenterprises.com](mailto:info@vinainenterprises.com)

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**Tannery at :**

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**Contact :**

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E-mail : [leather.chemicals@skicorp.net](mailto:leather.chemicals@skicorp.net) / Web Site: [www.viechemie.com](http://www.viechemie.com)



**CLC TANNERS ASSOCIATION**  
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*We care for the environment*

# CLC TANNERS ASSOCIATION

(Company incorporated under Sec. 25 of the Companies Act, 1956)

CIN NO. : U91110WB2004NPL100050

CALCUTTA LEATHER COMPLEX  
CETP, KARAIKANGA  
24-PARGANAS(SOUTH), PIN – 743 502  
TEL : 9007515958, 8584862129  
EMAIL : [clctanners@gmail.com](mailto:clctanners@gmail.com)  
WEB : [www.calcuttaleathercomplex.in](http://www.calcuttaleathercomplex.in)





Contact us :-

**CLC TANNERS ASSOCIATION**

Calcutta Leather Complex, C.E.T.P., Karaidanga, 24 Pgns (S) West Bengal - 743502

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*The foundation of the future have been laid.  
Now what remains is giving finite shape to infinite dreams.*



Giving birth to new initiatives, Asian Leather Private Limited is thrusting forward towards a definite future direction. With the infrastructure and expertise already in place, today the saga continues transcending the benchmarks of previously unconquered heights of achievement. The intelligent leather goods multiplex for integrated operations with TQM specification and quality monitoring cell puts this **ISO 9001:2008, ISO 14001:2004, OHSAS 18001:2007 & SA 8000:2008** certified Company a step ahead. Compliance to human right norms put Asian Leather in the same benchmark with companies that symbolize the future of excellence.

**Annual Capacity :**

Leather Handbags	1.5 million pcs.
Leather Wallets	4.5 million pcs.



**Asian Leather Private Limited**

Manufacturer & Exporter of Leather Bags & Small Leather Goods

Registered Office : "Asian House", E.M. Bypass, Kasba, Kolkata - 700 107 (India)

Fax :91 33 2443 2000/2443 3000, Phone : 91 33 2443 4000; E-mail : mail@asianleather.com, Website : www.asianleather.com





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*info@cel.co.in*

The background of the advertisement is a composite image. The top portion shows several glass beakers and flasks in a laboratory setting, with a soft, bokeh light effect. The bottom portion shows a close-up of water with many bubbles, creating a textured, shimmering effect. The overall color palette is dominated by light blues and teals.

**Exemplar**

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**Contact No. : +91-9831012655/9903446688**



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Leather Wallets • Purses • Handbags • Portfolios • Men's Bag

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# ILPA TECHNICAL SCHOOL

Center For Skill Development & Training



Plot 1625A , Zone 9, ILPA Leather Goods Park, Calcutta Leather Complex, Bantala, 24 Parganas (S), E-mail : [mail@ilpindia.org](mailto:mail@ilpindia.org)



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Design & Sample Development Center



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Best Leather  
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Training



**A UNIT OF  
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Plot 1647 , Zone 9, ILPA Leather Goods Park, Calcutta Leather Complex, Bantala, 24 Parganas (S), E-mail : [freya.iidf@gmail.com](mailto:freya.iidf@gmail.com)

Indian Leather Products Association

ILPA



kolkata



*The Bag City*



Indian Leather Products Association

**ILPA**



## INDIAN LEATHER PRODUCTS ASSOCIATION (ILPA)

**The Indian Leather Products Association (ILPA)**, established in 1987, is a premiere representative body of manufacturer-exporters of superior quality leather and leather products with head office in Kolkata and several regional offices in the prominent leather clusters across the country.

### IMPORTANT ACTIVITIES OF ILPA :

- Brings together manufacturer & merchant exporters on a common platform.
- Stimulates growth & development of the industry as a whole.
- Promotes export of leather & leather products.
- Develops & maintains symbiotic liaison with international trade bodies & Chambers of Commerce.
- Organises trade delegations to international fairs & seminars.
- Organises various Seminars/workshops both the benefit of its members and industry.
- Promotes International Fairs and RBSMs like India International Leather Fair Kolkata.
- Organises the ILPA SHOW : Leather on the Ramp ,one of the most prestigious and sought after Fashion event in Eastern India.
- Closely involved in setting up the Calcutta Leather Complex(CLC).
- Runs and manages the Freya Design Studio : a CLE award winning Design Studio both for leather goods and footwear.
- Runs and manages the ILPA INFRASTRUCTURE DEVELOPMENT FOUNDATION (IIDF) – a state of the art Common Facility Centre.
- Imparts Skill Development Training through ILPA Technical School.

Indian Leather Products Association  
14th Floor, Suite No. 6, Chatterjee International Centre  
33A Jawaharlal Nehru Road, Kolkata- 700071  
West Bengal, India  
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Contact Details : **Mr. Y. K. Luthra, Editor & Publisher**

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- Bangalore
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### CONTACT PERSON

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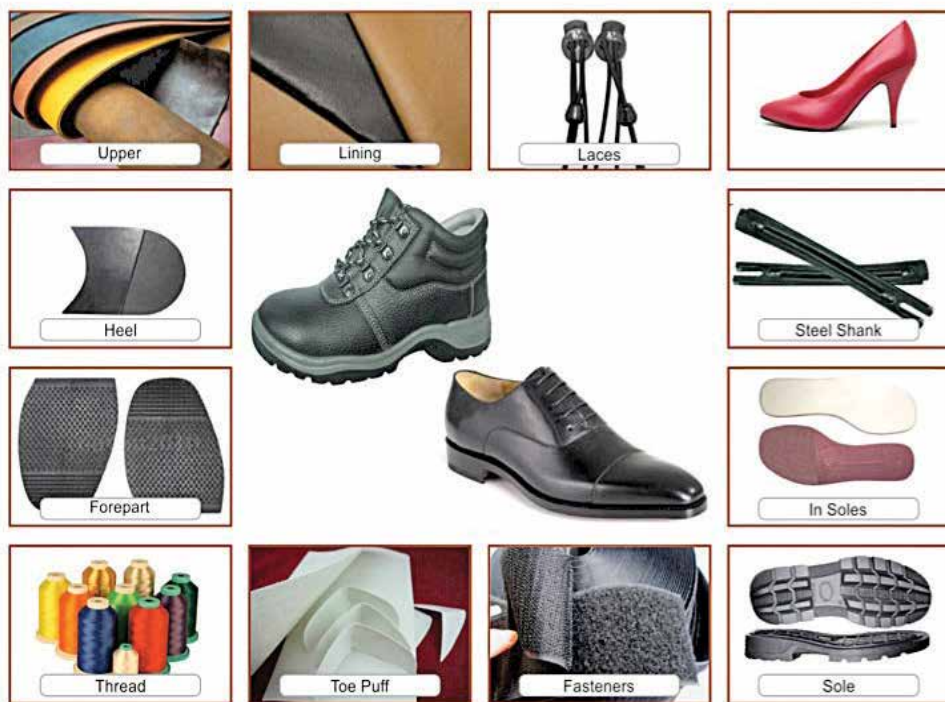


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### **Raghu Exports (INDIA) PVT. LTD.**

12 Leather Complex, Kapurthala Road,

Jalandhar-144 021 (Pb) INDIA)

Phone: +91 181 5033771-73

e-mail :- [info@raghuexports.com](mailto:info@raghuexports.com)

Website - [www.raghuagroup.com](http://www.raghuagroup.com),

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## CSIR-CENTRAL LEATHER RESEARCH INSTITUTE

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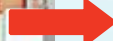
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No  
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**Ethiopian  
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## **Technology Outline and Benefits**

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- Total elimination of pickling and basification
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- High chrome content in leather
- Quality of the leather is comparable to conventionally processed chrome tanned leathers
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  - Reduction in BCS offer by 1 to 2%
  - Reduction in water usage
  - Reduction in wastewater volume
  - Elimination of chrome recovery
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- Simple process and does not demand additional infrastructure or new chemical
- Suitable for both Hides and Skins

## **For Technology Transfer**

CONTACT

**Director**

**CSIR-Central Leather Research Institute**

(Council of Scientific & Industrial Research)

Adyar, Chennai 600 020, India.

Phone: 044-24910897 / 24910846, Fax: +91-44-24912150,

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