

“All-in-one” biomass based chrome-free tanning system for reducing the carbon footprint to leather production process

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The People's Republic of China: **Basic policies and regulations**

2015

"**Made in China 2025**" emphasizes that the leather industry, as a traditional manufacturing sector, developing **ecological chrome-free tanning technology**.

2016

The "**Green Manufacturing Implementation Plan**" emphasizes the transition to **green manufacturing** and calls for enhanced construction of **environmental protection** facilities in the leather industry.

2019

The "**Guidelines on Promoting High-Quality Development of Light Industry**" proposes **technological innovation and green transformation** in the leather industry.

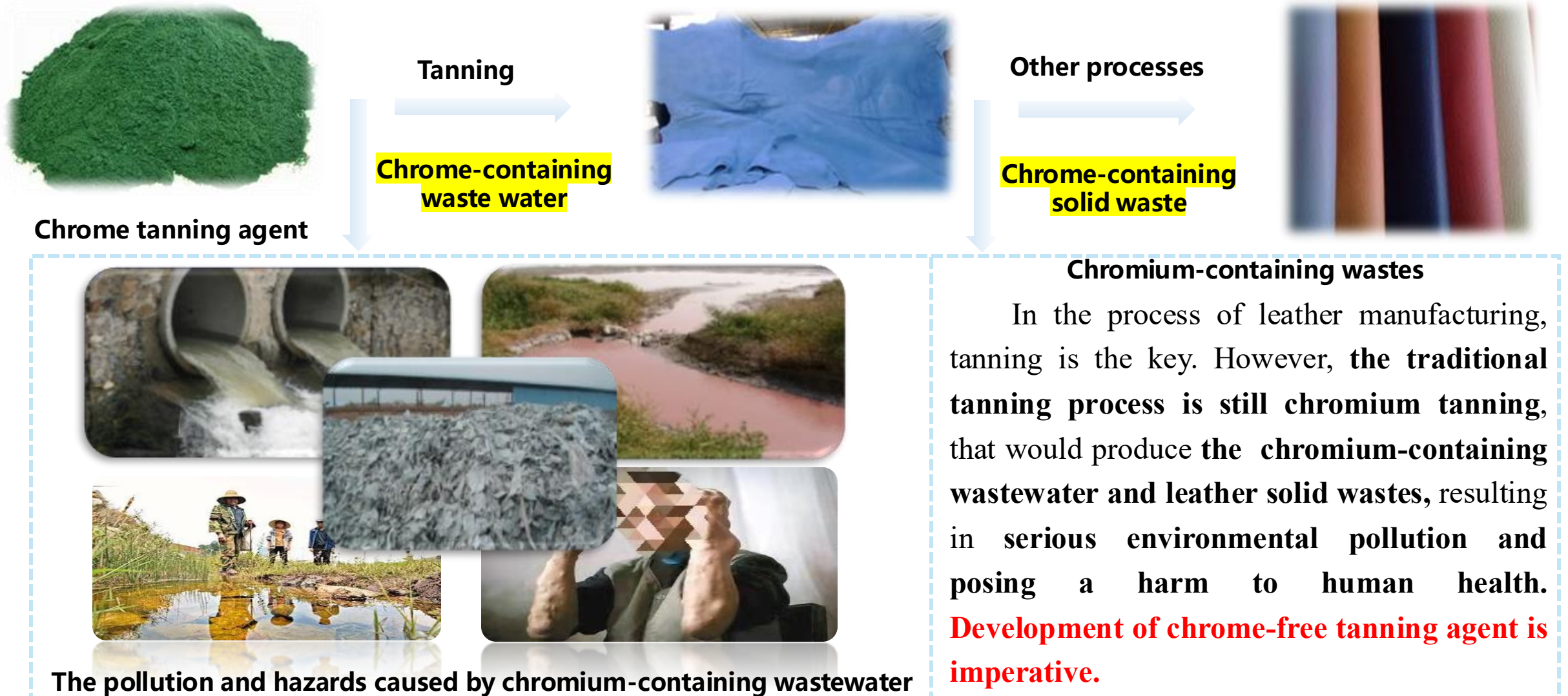
2021

The "**Guidelines for Leather Industry Development (2021-2025)**" encourages research and development of **environmentally-friendly leather processing technologies**.

Eco-leather manufacturing technology

The leather industry, as an important part of **traditional manufacturing industry**, faces the dual challenges in **green transformation and pollution control**. In recent years, the national governments have continuously introduced relevant policies to promote the green upgrading of the manufacturing industry. **Developing eco-friendly leather manufacturing technology has become key to driving the transformation of the leather industry.**

1.1 The pollution caused by chromium tanning agents



1.2 Typical chromium-free tanning agents

Organic synthetic tanning agent

- Unstable tanning performance
- High production costs
- Limited applicability

Metal: Al, Zi, and Ti

- Low T_s , poor wash fastness
- Stiff leather texture
- Relatively high cost

Chromium-free tanning agent

Zeolite & Rare Earth Elements

- Low T_s value
- Resource constraints

Formaldehyde/glutaraldehyde

- Poor yellowing resistance
- With free formaldehyde release

Vegetable tanning agents

- Dark coloration
- Heavy leather texture
- Prone to mildew

Currently, common chrome-free tanning agents include: **chrome-free metal** tanning agents, **vegetable** tanning agents, **organic synthetic** tanning agents.

However, these alternatives generally suffer from issues:

high costs,
unstable performance,
release of free formaldehyde.

Thus, developing **greener chrome-free tanning agents with excellent comprehensive performance** is one of the research directions in the leather sustainable processing.

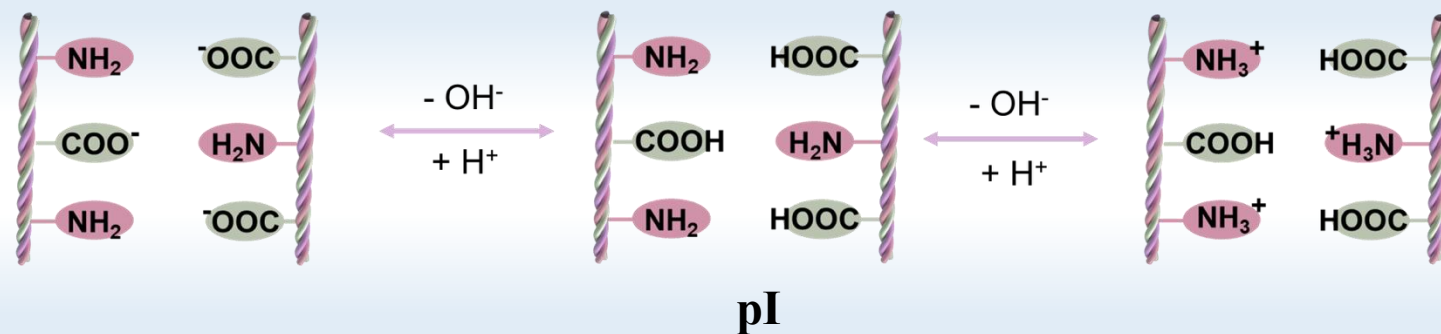
Biomass-based tanning agent



- ✓ Broad raw material
- ✓ environmentally friendly
- ✓ Abundant functional groups



Polysaccharide-based tanning agent

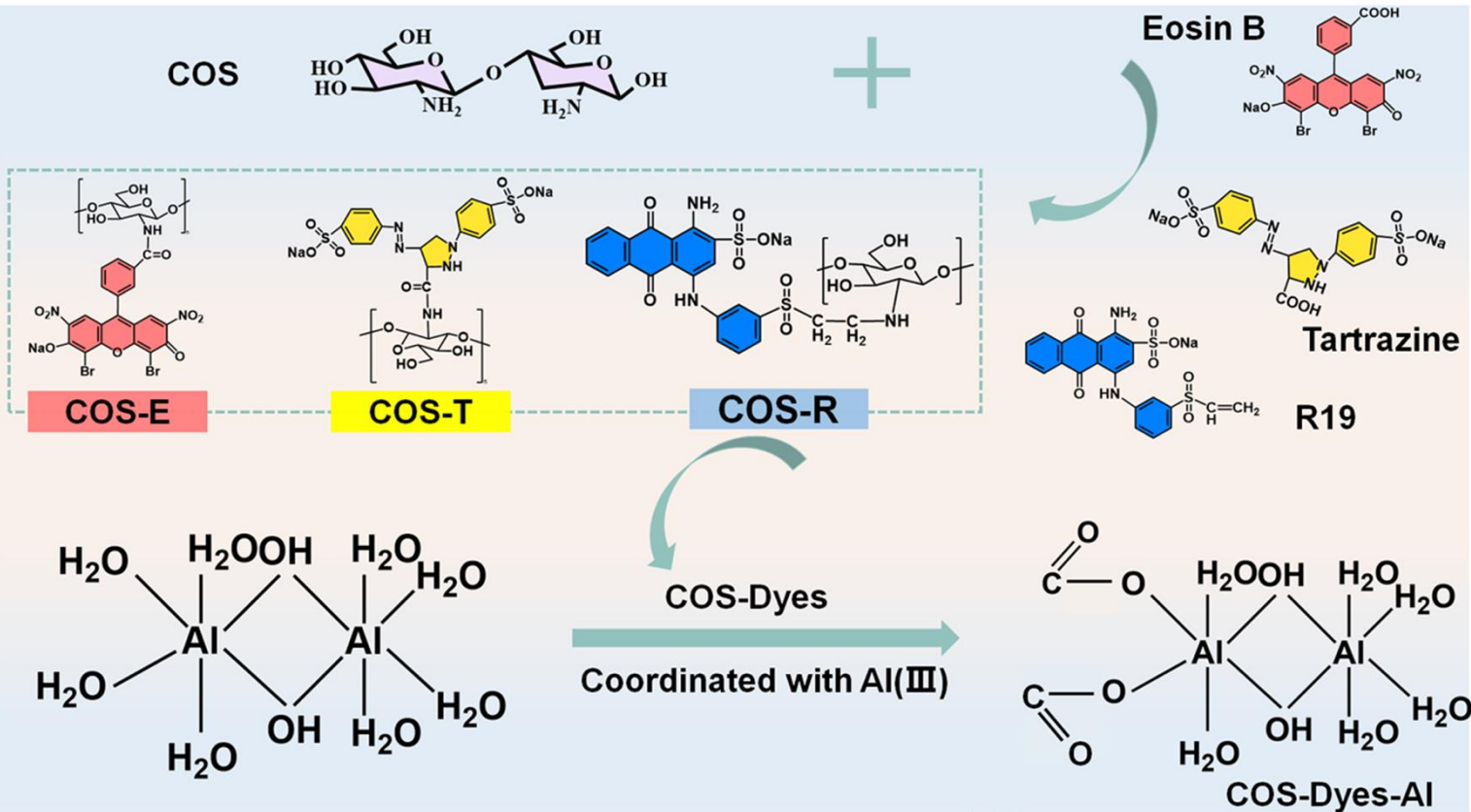


Natural biomass resources: (Starch, Cellulose, chitosan, Gelatin)

Advantages: abundant resources, low cost and easy availability, processibility, biocompatibility, biodegradability...etc.

Biomass-based chrome-free tanning agents have boast advantages like wide availability and environmental friendliness, which gradually become a research hotspot.

2 Results and Discussion



Synthesis scheme of COS-Dyes-Al

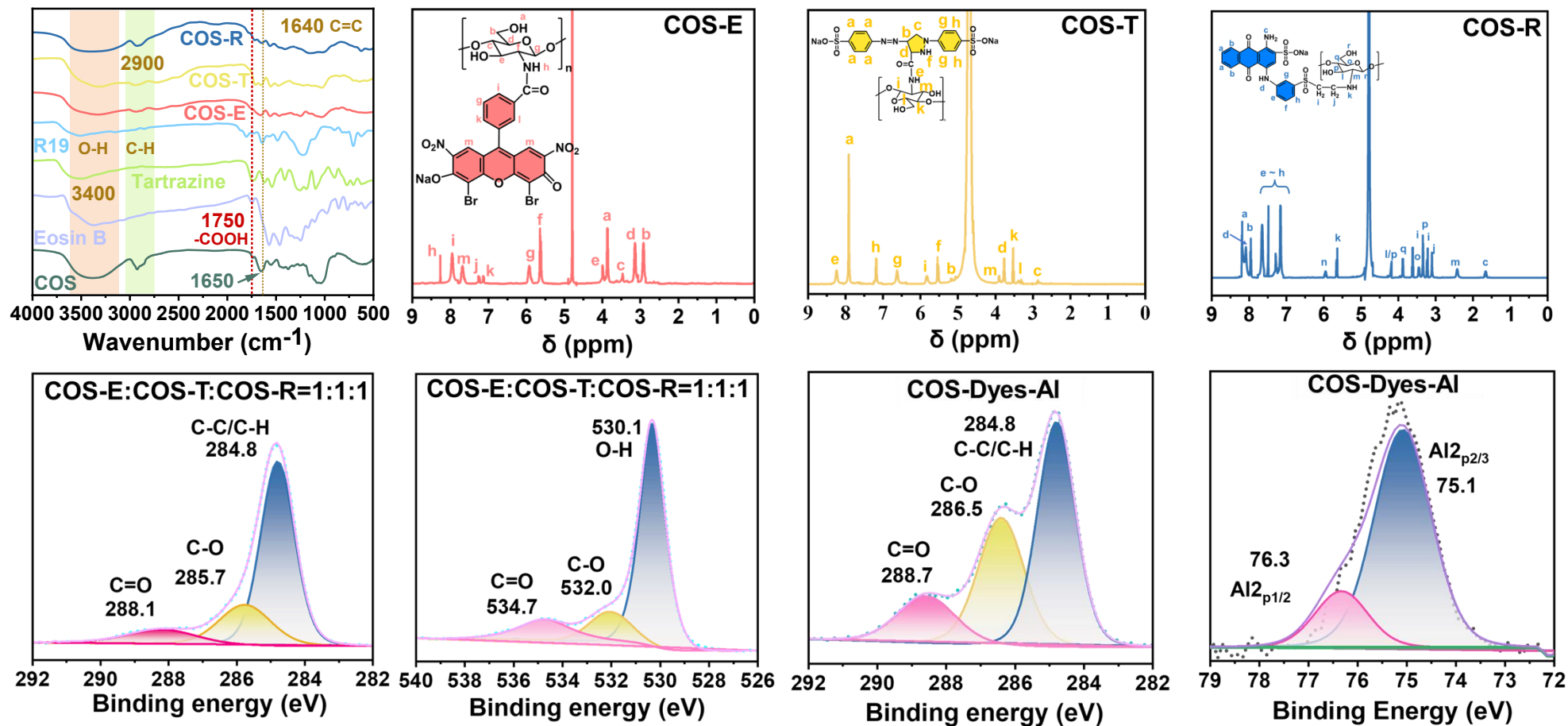
Baed on this, we conducted the following research:

We prepared **three types of chrome-free tanning agents** using *chitosan*, *three types of dyes* (red, yellow, and blue colors) , and *aluminum sulfate* as raw materials.

The prepared tanning agents can display red, yellow, and blue colors respectively.

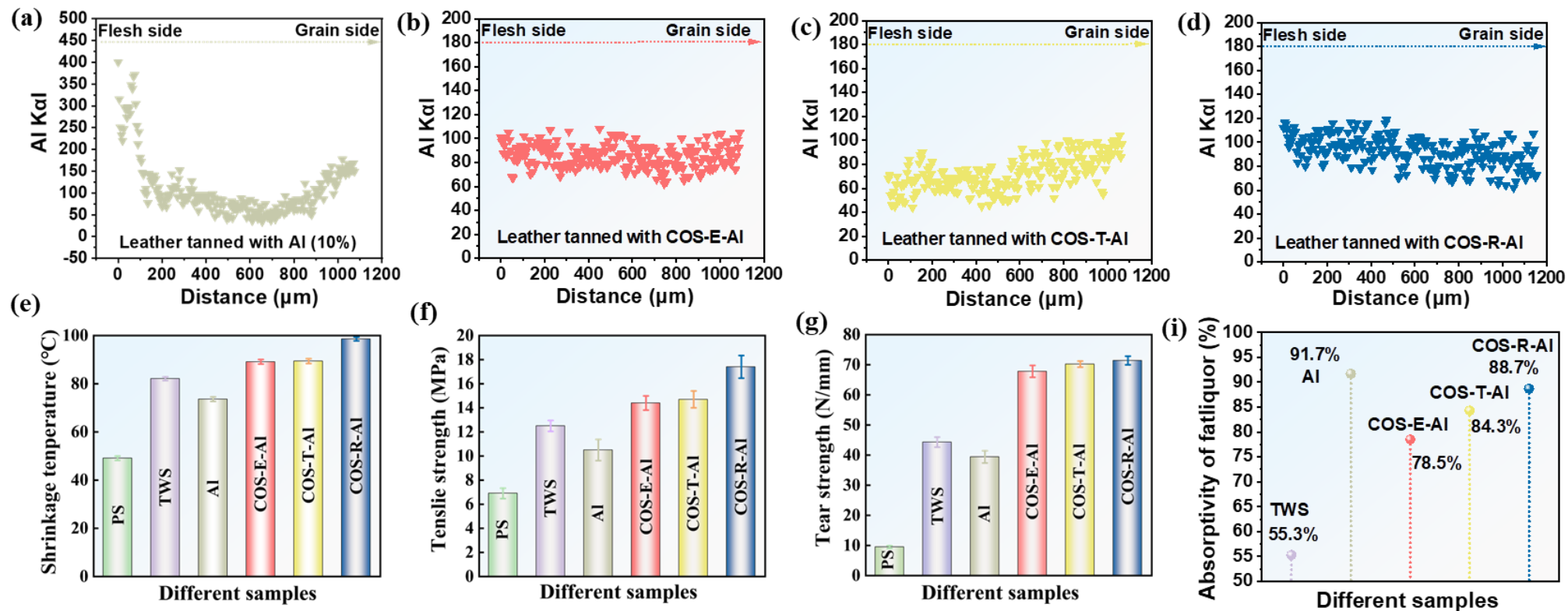
Thus, based on the principle of three-primary-color blending, **we can obtain tanned leather with different colors** by mixing different tanning agents in varying proportions during the tanning process.

2 Results and Discussion



Based on the results of FTIR, NMR, and XPS: the tanning agents have been successful prepared.

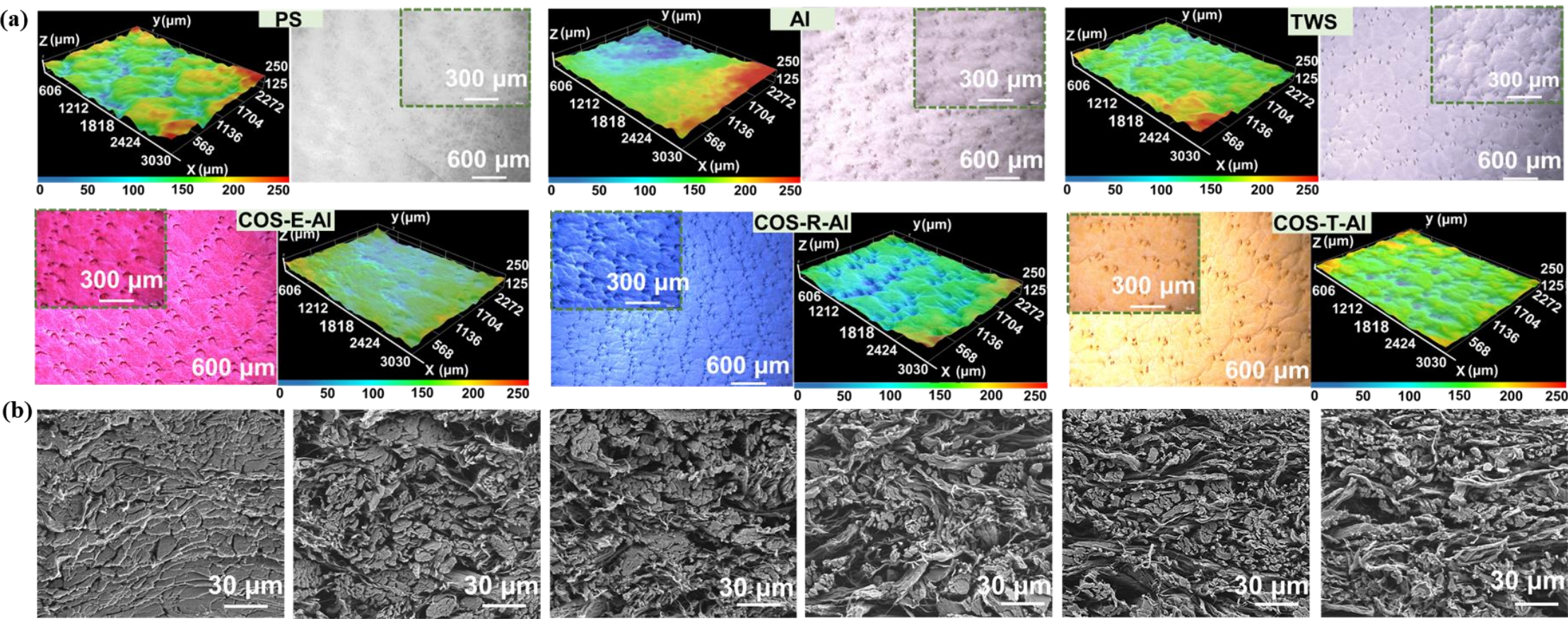
2 Results and Discussion



EDS results showed that compared to leather tanned with aluminum tanning agent alone, the distribution of aluminum in leather tanned with our tanning agents was more uniform.

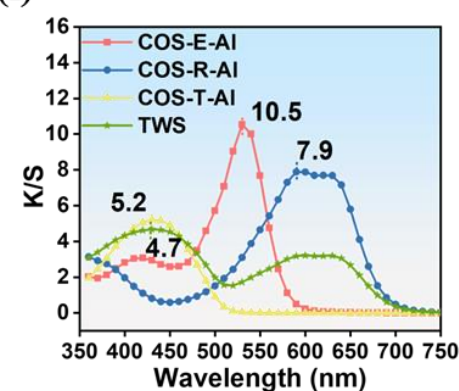
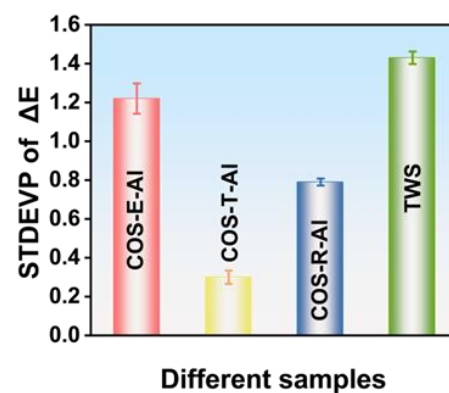
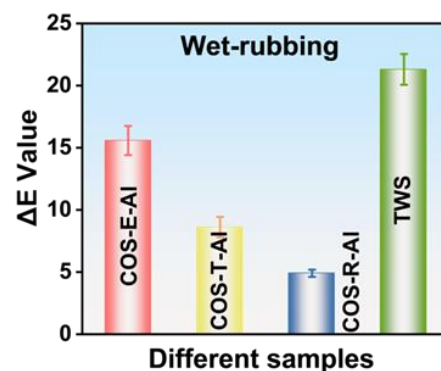
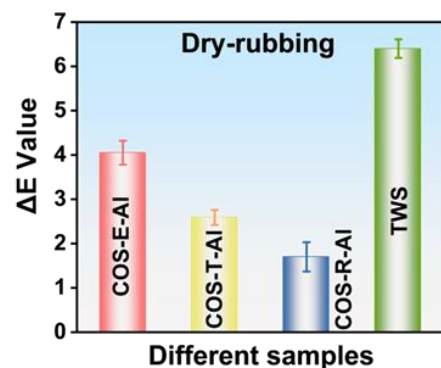
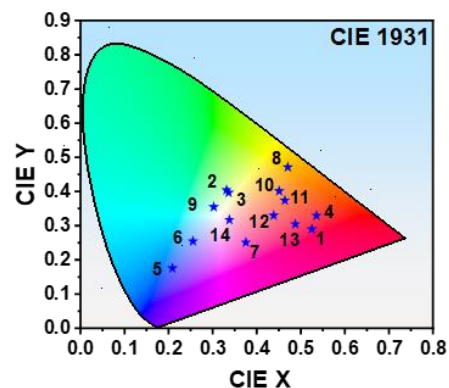
The leather tanned with our tanning agent showed excellent damp-heat stability and physical-mechanical properties.

2 Results and Discussion



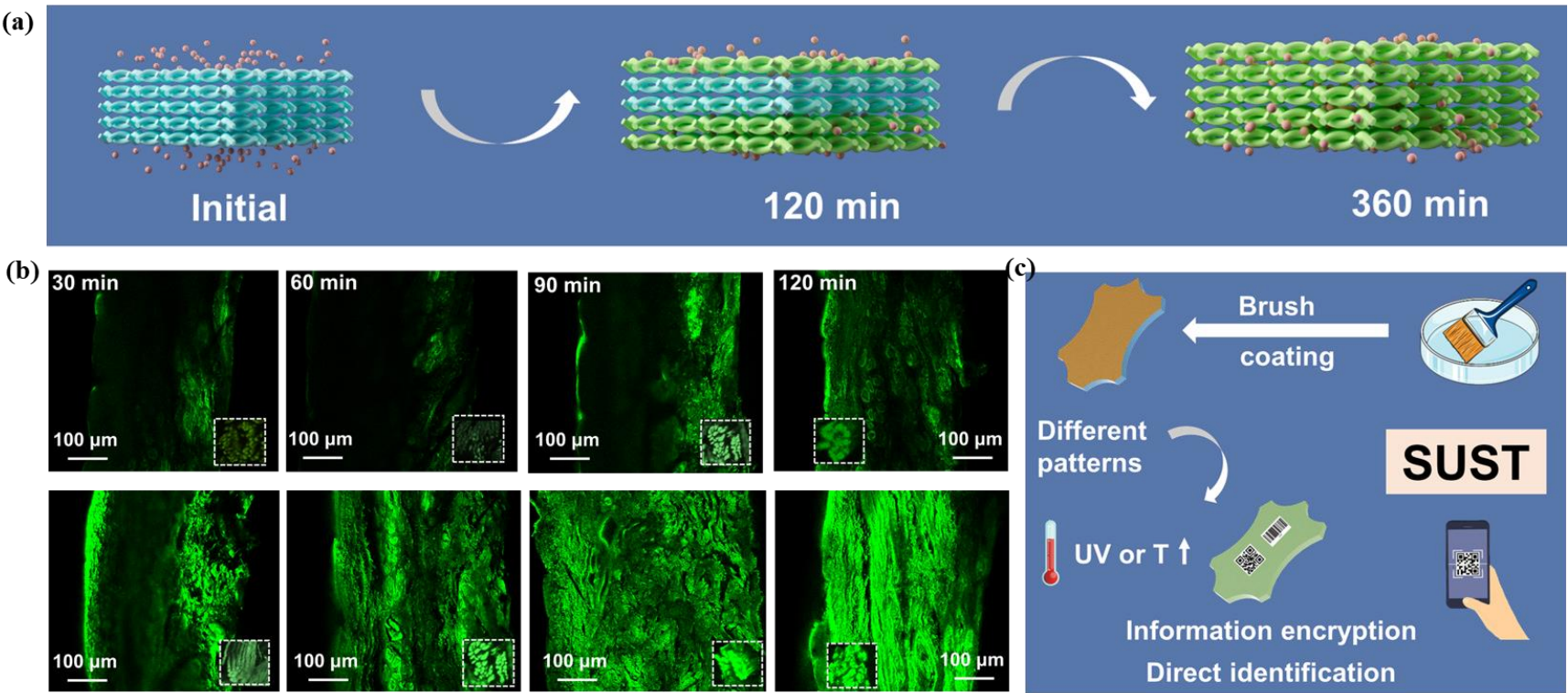
SEM and SDM: The grain surface of the leather tanned with our tanning agents was finer and smoother, the collagen fibers being more dispersed.

(a)



Additionally, the tanned leather showed excellent washing fastness, as well as dry and wet rubbing fastness.

2 Results and Discussion



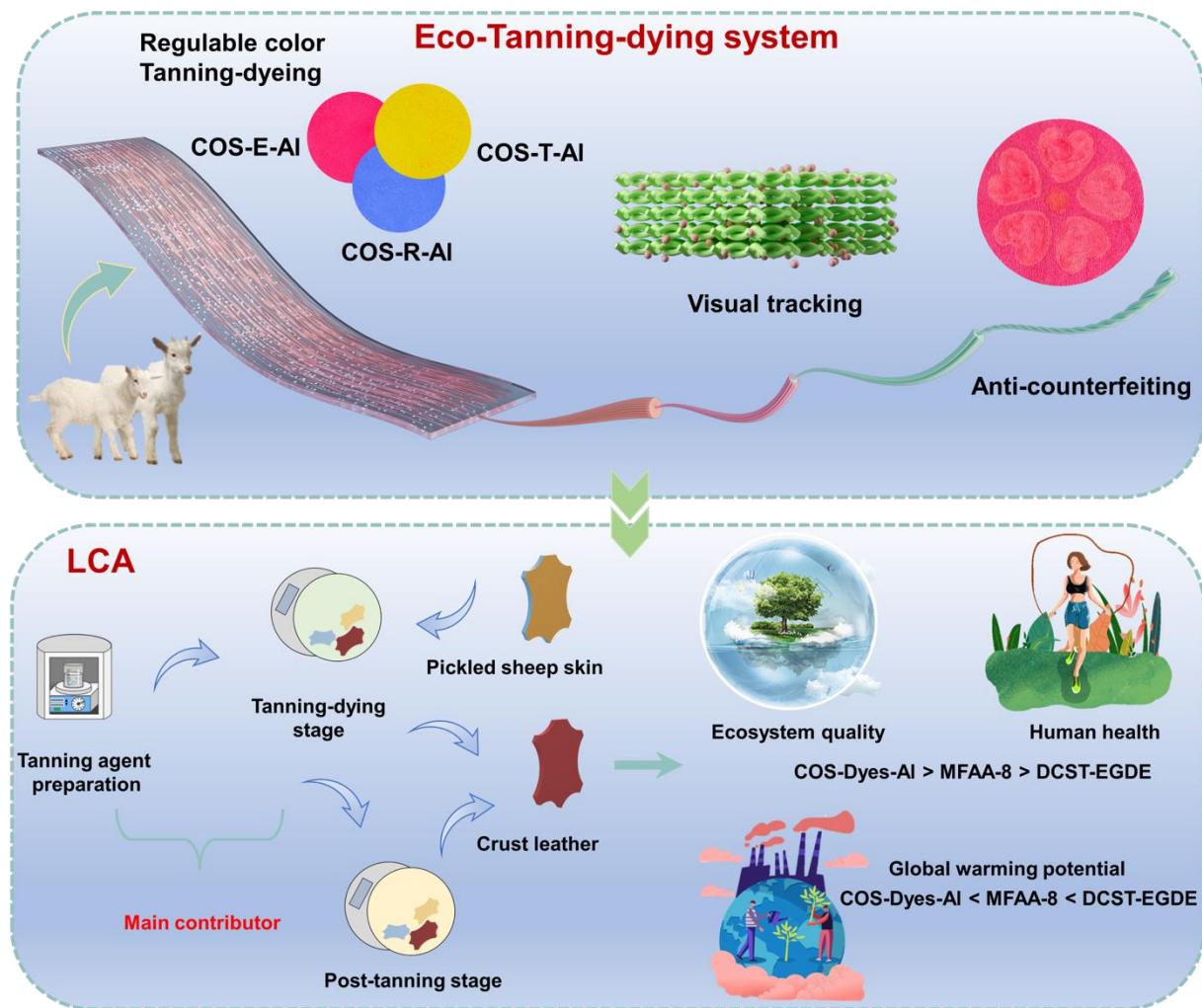
(a) **Penetration process** of COS-Dyes-Al in leather, (b) **fluorescent images** of different penetration times (30, 60, 90, 120, 150, 180, 240 and 360 min) of COS-Dyes-Al in leather, (c) **fluorescent anti-counterfeiting technology**

Based on the fluorescent properties of the tanning agents, we also employed the fluorescence tracing technology to develop the penetration process of our tanning agents within the leather.

The results indicating that **the tanning agent can thoroughly penetrate into the collagen fibers**.

This finding provides valuable insights for optimizing the leather manufacturing process.

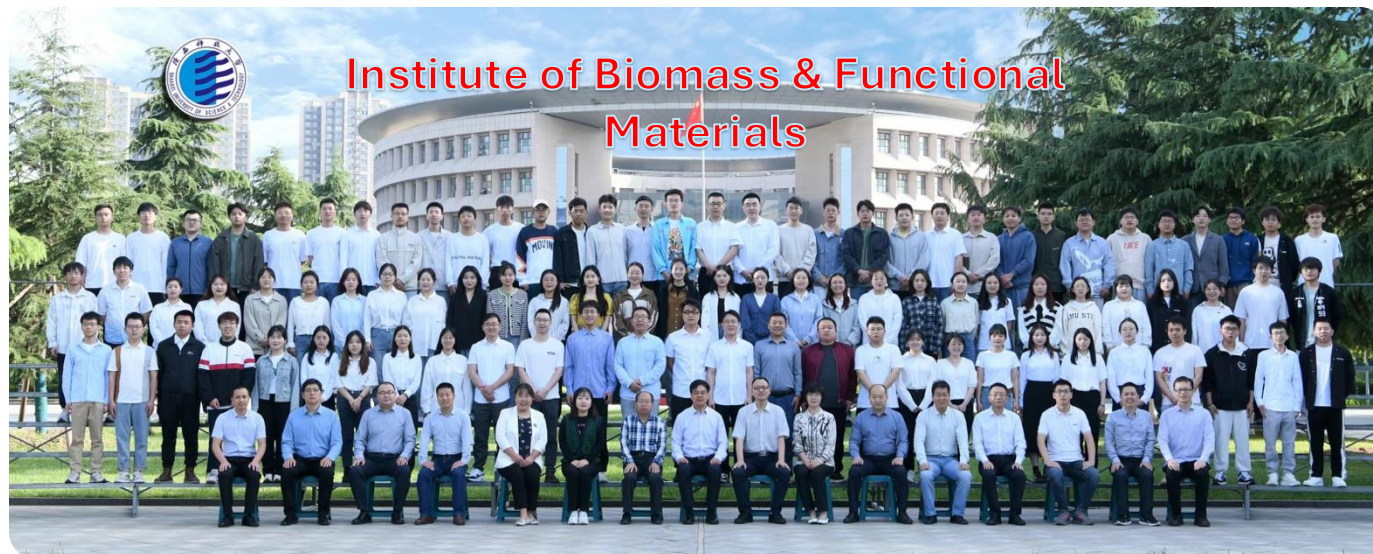
3 Conclusion



- The leather tanned with our tanning agents demonstrated **excellent physical and mechanical properties**;
- Our tanning agent can **give leather with different colors**, and show **good resistance to rubbing and washing**;
- The prepared tanning agents can **reduce the environmental burden** by effectively integrate tanning and regulable color dyeing functionality into the leather;
- It can be used for sustainable leather manufacturing.

Team Introduction

1. Clean leather production technology and theory;
2. Preparation and application collagen-based medical biomaterials;
3. Advanced functional nano-materials and molecular luminescent materials;
4. Structural design and properties of functional polymer materials;
5. Preparation and application of flexible electronic materials.



120 Members

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Team Leader - Xuechuan Wang



- **Former deputy vice-chancellor: Shaanxi University of Science and Technology**
- **Professor of the Second Rank, Doctoral Supervisor**
- **Vice Chairman of the Teaching Steering Committee for Light Industry Specialties of the Ministry of Education**
- **Vice Director of the Eighth Science and Technology Committee of China Leather Industry Association**
- **The Fifth Provincial Government Inspector of Shaanxi Province**
- **Member of the 12th and 13th Central Committee of the China Democratic League**

- "National Model Teacher", enjoying special government allowance from The State Council;
- One National Technological Invention Award, two National Teaching Achievement Awards, ten provincial and ministerial-level science and technology Awards, four provincial and ministerial-level Teaching achievement Awards, etc. have been obtained. More than 150 SCI papers have been published and over 60 domestic and international patents have been authorized.

Thank You!

