New Insight & Prospects for the Application of Nanotechnology in Leather Processing Materials and Products

Mulatu Kassie Birhanu[1, 3], Wondimu Wolde[2], Wondwosen Mamuye[2]

[1]*Leather Industry Development Institute, Addis Ababa, Ethiopia*
[2]*Leather Industry Development Institute, Addis Ababa, Ethiopia*
[3]*National Taiwan University of Science and Technology, Taipei, Taiwan, 106*

Abstract

Now a day, the application of nanotechnology in leather production is one of the emerging technology in the world. Its role in the manufacturing area is accelerating with a positive momentum through this time. Recently, increasing interests have been directed towards the incorporation of nanotechnologies into leather manufacturing, which offers cost-effective and improvements in leather performances, as well as enabling the industry to meet legislation regarding environmental safety. Nano-level research is paving the way for leather producers to make it higher quality by improving its property and resistivity from a harsh environment. This article revealed the scenarios of nanotechnology in manufacturing sectors especially in leather and related disciplines. It also points out how scientists explore the properties of materials at the nanoscale level, which is applicable in leather or related products, and its processing until the finishing stage. Finally, it summarizes the application of nanoscale materials with properties in leather manufacturing processes, including its finishing and effluent treatments of the entire process.

Introduction

What is Nanotechnology?

- Nanotechnology is the new frontier of science and technology.
- Now a day, nanotechnology is **basic research** & **development** all over the world.
- Nano-product improve products by creating smaller components & better performance materials, all at a lower cost.
- Use of **nanotechnology** is to control the internal structure of a material at nanoscale is considered to lead the materials with **fewer defects** & hence **higher quality.**
- Dimensions b/n ~ 1 - 100 nm are known as the nanoscale.
- Technology is making, usage & knowledge of tools, machine & techniques, in order to solve a problem or perform a specific function.
- The ability to build using atoms as building blocks
- The manufacture of novel materials with novel properties
- Nanostructure: Structure with at least one dimension < 100 nm

Nanotechnology vs Nanoscience

Nanotechnology:

- ➢The application of nano-structures into useful devices.
- ➢It is the study of manipulating matter on an atomic scale
- ➢*Design*, *characterization*, *production*, and *application* of structures, devices, and systems by manipulation of size & shape at the nm scale (*atomic, molecular & macromolecular scale*).

Nanoscience:

- ➢ The study of phenomena & manipulation of materials at nm scales, where properties differ significantly from those at a larger scale.
- ➢ Study of fundamental principles of nanostructures b/n bulk & atomic properties or knowing nanomaterials and their properties.
- ➢ Both nanotechnology & nanoscience are concerned with materials that are very small.

Nanomaterials

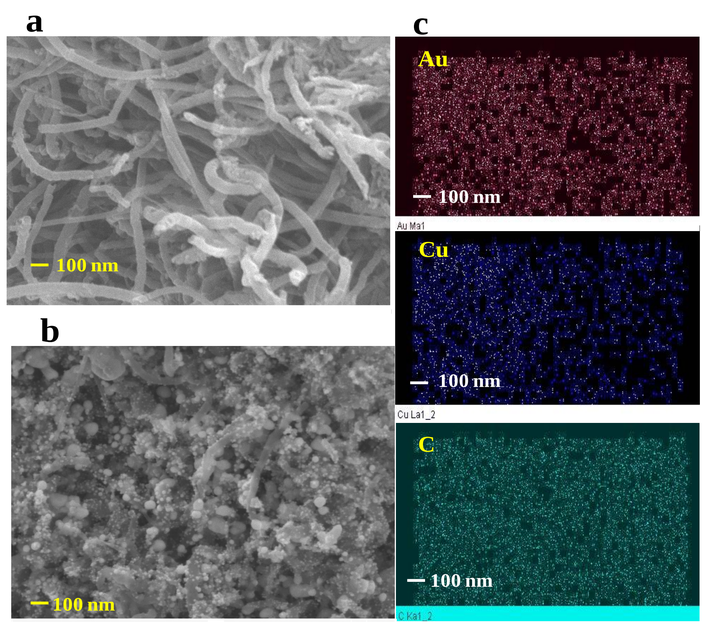
- Materials change their properties at nanoscale impossible to achieve at the macro level.
- Properties of materials can be different at the nanoscale for two main reasons:
- ➢First, nanomaterials have a relatively larger surface area compared to the same mass of material in a larger/bulk form.
- ➢This make chemically reactive (*in some cases materials that are inert in their larger form are reactive in their nanoscale form*), and affect their strength or electrical properties.
- ➢Second, quantum effects can begin to dominate the behavior of matter at nanoscale particularly at the lower end affecting the optical, electrical, magnetic, etc. behavior of materials.

Nanomaterials can be prepared in different ways:

- Physicochemical methods: Such as emulsification–solvent evaporation, diffusion or reverse salting out, etc.
- Chemical reaction/synthesis: like polymerization reaction, condensation reaction, etc.
- Electrochemical methods: e.g. electrodeposition
- Mechanical methods: e.g. use of high-energy devices like high pressure homogenizers, sonifiers, or high-energy wet mills
- Electrospinning technology
- A "personal" nanofactory: future projection

What are the materials of nanotech?

Nanostructure	*Size*	*Example Material or Application*
Clusters, nanocrystals, quantum dots	Radius: 1-10 nm	Insulators, semiconductors, metals, magnetic materials
Other nanoparticles	Radius: 1-100 nm	Ceramic oxides, Buckyballs
Nanowires	Diameter: 1-100 nm	Metals, semiconductors, oxides, sulfides, nitrides
Nanotubes	Diameter: 1-100 nm	Carbon, including fullerenes, layered chalcogenides



Examples of Au & Cu Np

Fig. 1 SEM images of (a) C-nanotube, (b) AuCu NPs on CNT (c) EDS elemental maps of Au, Cu & C NPs

M.K. Birhanu, et al. /Electrochimica Acta. 356 (2020) 136756

Application of Nanotechnology in Leather Manufacturing

Leather industry is still facing severe pressure from multiple sources.

- ✓Living standards rise, traditional leather products may no longer meet the rigorous expectations of end customers for appearance, quality & even function. Considering the scarcity of raw hides & growing ethical concern over animal rights during the last decade, competitive pressures from leather substitutes, such as polyvinyl chloride, polyurethane & microfiber materials, are becoming tougher than ever, which are racing to capture more market share. Still now many processes for leather manufacturing are still known as environmentally unfriendly.
- ✓ However, despite many technical advantages associated with this tanning method, traditional chrome tannage is being challenged from environmental perspectives, including: A global shortage of chrome source, potential carcinogenicity of hexavalent chrome & a low combination ratio of chrome in the tanned leather.
- ✓ Alternative nanomaterial tanning agents such as: Synthesized acrylic retanning emulsion from methyl methacrylate (MMA), n-butyl acrylate (BA) and methacrylic acid (MAA). Vinyl polymer modified with intercalated or exfoliated nano montmorillonite (MMT) was also demonstrated as an efficient tanning agent. Specific nanomaterials such SiO2 or TiO2 nanoparticles is also considered tanning agent.

Conclusions

- ➢ In order to overcome these challenges, leather technologists and chemists have to break out this old industry through:
- ➢ Multidisciplinary, interdisciplinary & transdisciplinary approaches for sustainable development in the future. An important direction of these extensive efforts involves the utilization of novel nanotechnology. Companies & research institutes need to spend large numbers of manpower, financial resources and materials in this field, in order to re-engineer and add innovations to the leather products.

Reference:

1. *M.K. Birhanu et al. /Electrochimica Acta. 356 (2020) 136756*
2. *M. K. Birhanu et al. Adv. Mater. Interfaces 2018, 1800919*
3. *Y. chen etal. JALCA, VOL. 106, 2011*