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Utilization of Fleshing Waste from the Leather Industry for the Synthesis

of Wax Esters for Leather Finishing

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Abstract

The leather industry generates large quantities of fleshing waste rich in proteins and lipids, which pose significant environmental challenges when disposed of untreated. This study focuses on the valorization of animal fleshing waste through the synthesis of highvalue waxe esters suitable for leather finishing applications. Fat was first recovered from fleshing waste using a hydrothermal extraction process at 120 °C and 15 psi, yielding oil with ~23.8% fat content. The extracted triglyceride-rich oil was subjected to de-esterification in alkaline tetrahydrofuran to obtain free fatty acids. NMR and mass spectrometric analysis confirmed oleic acid as the predominant constituent.

Subsequently, waxes were synthesized via esterification of the isolated fatty acids with long-chain alcohols such as dodecanol and octadecanol in the presence of a sulphamic acid catalyst. The synthesized waxes displayed appropriate melting characteristics which could make them a suitable replacement for the burnish wax. Additionally, by careful selection of the chain length of the alcohol, the waxes with variable melting points could be synthesized, making this route a versatile method for the synthesis of wax emulsions. For application studies, the waxes were emulsified using SDS and IPA to form stable dispersions and were applied to leather substrates via spray coating. The treated leathers exhibited desirable surface aesthetics, improved polishability, and burnishability, demonstrating performance comparable to commercial waxes.

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This work establishes a sustainable route to convert tannery solid waste into value-added finishing materials, supporting circular economy initiatives in leather manufacturing.

Keywords: Fleshing waste, wax synthesis, esterification, leather finishing, waste valorization.

1. Introduction

The leather industry is under increasing pressure to adopt sustainable processing practices due to stringent environmental regulations and escalating waste disposal costs. Traditional leather processing methods generate significant quantities of solid wastes, including fleshing, trimmings, and shavings, which together account for nearly 30–35% of the raw hide weight. These wastes pose serious environmental challenges when managed through conventional disposal methods such as landfilling and incineration, which are both environmentally undesirable and economically inefficient [1–3]. Consequently, there is a growing emphasis on adopting cleaner production technologies and waste minimization strategies to achieve greener leather processing.

Among the various solid wastes generated during leather manufacture, fleshing waste is particularly significant due to its high content of fat, moisture, and proteinaceous matter. Several studies have highlighted the potential of tannery fleshing waste as a valuable raw material for the recovery of useful components, rather than treating it solely as a disposal burden [3,4]. The recovery and utilization of such waste streams align well with the principles of sustainable development and circular economy in the leather sector [2].

Fleshing waste is especially rich in lipids, making it a promising source for the recovery of fat and oil. Earlier investigations have demonstrated the feasibility of extracting fleshing oil and converting it into biodiesel and other value-added products, thereby reducing environmental load while generating economic benefits [5]. Fat-derived products such as waxes play an important role in leather finishing, where they impart desirable properties including surface smoothness, gloss, and water resistance. However, most commercial waxes used in leather finishing are derived from petroleum-based sources, raising concerns regarding sustainability, biodegradability, and long-term environmental impact [1,2].

In this context, the present study focuses on the extraction of fat from animal fleshing waste, its conversion into wax, and the evaluation of its applicability in leather finishing applications. By valorizing fleshing waste into a functional finishing material, the study aims to provide an eco-friendly and sustainable alternative to conventional petroleumderived waxes, while contributing to waste reduction and resource recovery in the leather industry.

2. Methodology

2.1 Raw Material and Fat Extraction

Mixed animal fleshing waste was collected and analyzed for fat content using the Soxhlet extraction method with petroleum ether as the solvent. The fat content was found to be 23.8% by weight.

For bulk extraction, hydrothermal processing was employed. Animal fleshing (100 g) was treated with water (500 g) at 120 °C under 15 psi pressure. The hydrolysis duration varied from 1 to 4 hours with increments of 1 hour. After completion, the mixture was allowed to cool, and the top oil layer was separated using a separating funnel.

2.2 Wax Synthesis

The extracted fat was subjected to a chemical conversion process to obtain wax through a defined reaction pathway involving the transformation of fatty acids. The reaction scheme was optimized to yield a stable wax suitable for leather applications.

2.3 Characterization of Synthesized Wax

The melting point of the synthesized wax was determined using the slip melting point method, providing an indication of its thermal suitability for leather finishing processes.

2.4 Emulsification of Wax

Since wax is immiscible in water, emulsification was carried out to enable aqueous application. The formulation used was:

- Water: 50 mL
- Sodium dodecyl sulfate (SDS, anionic surfactant): 1.0 g
- Synthesized wax: 7.5 g (15% w/w active content)
- Isopropyl alcohol (IPA): 5.0 g

The mixture was stirred for 2 hours at room temperature to obtain a stable wax emulsion.

2.5 Application on Leather

The wax emulsion was applied onto leather surfaces using a spray coating method under controlled conditions.

2.6 Colour Measurement

The colour characteristics of treated and untreated leathers were evaluated using the CIELAB colour measurement system, measured with a UV–Visible spectrophotometer equipped with a diffuse reflectance spectroscopy (DRS) attachment.

3. Results and Discussion

3.1 Fat Recovery and Wax Formation

The hydrothermal process effectively liberated fat from animal fleshing, with increased extraction efficiency observed at longer hydrolysis durations. The extracted fat exhibited suitable characteristics for conversion into wax, confirming the potential of animal fleshing as a viable raw material.

3.2 Wax Characteristics

The synthesized wax exhibited a defined melting point, indicating good thermal stability for leather surface applications. The melting behavior suggests compatibility with conventional leather finishing operations without risk of surface tackiness or wax migration.

3.3 Emulsion Stability

The anionic surfactant-based formulation resulted in a stable wax emulsion with uniform dispersion. The inclusion of IPA improved emulsification efficiency and sprayability, making the formulation industrially feasible.

3.4 Leather Application and Colour Properties

Spray application of the wax emulsion produced a uniform coating on leather surfaces. CIELAB analysis showed minimal colour deviation, indicating that the bio-based wax does not adversely affect leather shade while enhancing surface aesthetics.

3.5 Sustainability Perspective

The approach converts a high-moisture, high-fat waste into a functional finishing chemical, reducing waste load and dependence on fossil-based waxes. The process aligns with principles of waste valorization, eco-friendly chemistry, and circular economy in leather manufacturing.

4. Conclusion

The study successfully demonstrates the synthesis of a bio-based wax from animal fleshing waste and its effective application in leather finishing. Hydrothermal fat extraction followed by wax synthesis provides a

sustainable pathway for valorizing slaughterhouse waste. The synthesized wax, when emulsified and applied to leather, exhibited good compatibility and had a negligible impact on color characteristics. This technology offers a promising, eco-friendly alternative to conventional petroleum-based waxes, contributing to sustainable leather processing practices.

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