A Study on Fiber Extraction, Sliver Formation, and Dyeing Processes for the Development of Mobility Seat Covers Based on Upcycled Leather Composite Yarns

Hyejun Kim*, Seonghun Cho*, Heetae Park**
*Korea High Tech Textile Research Institute
**Jigu Co., Ltd.
e-mail: khj0925@koteri.re.kr

폐가죽 복합방적사 기반 모빌리티 시트커버 개발을 위한 섬출·슬라이버 제조 및 염색 공정 연구

김혜준*, 조성훈*, 박희태**
*한국섬유소재연구원
**주식회사 지구

Abstract

Waste leather in Korea amounts to nearly 170,000 tons annually, yet only 13% is recycled. This study explores the upcycling of leather scraps into composite yarns for mobility seat covers. A stable raw material classification protocol was established, and customized opener-garnetter machinery was developed to extract fibers while minimizing damage. Pretreatment and dyeing tests showed alkaline conditions to be unsuitable, whereas a wool-reactive dyeing route under acidic conditions was identified as effective. These results demonstrate the feasibility of producing functional yarns from waste leather and highlight its potential as a sustainable textile resource.

1. Introduction

The accumulation of waste leather presents both an environmental and industrial challenge. Although leather is composed of collagen protein with structural similarities to wool and silk, it remains largely unutilized, with the majority disposed of through incineration or landfill. This study investigates the transformation of waste leather into composite yarns for mobility seat cover applications, focusing on raw material classification, fiber extraction, sliver formation, and dyeing strategies.

2. Materials and Methods

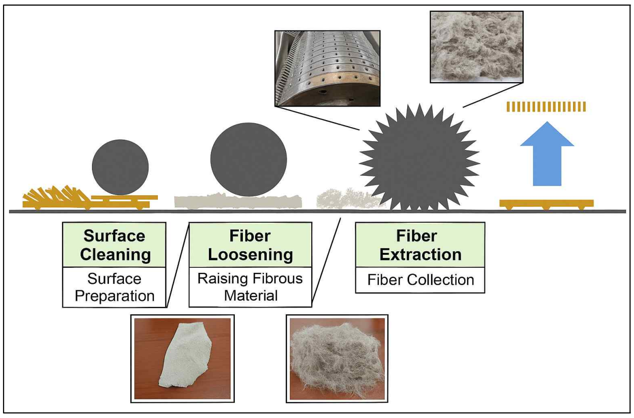
2.1 Raw material classification

Leather scraps were collected from local tanneries and systematically sorted by color, flexibility, and thickness, ensuring consistent quality for spinning and minimizing variability (Fig. 1).

[Fig. 1] Collected and Sorted Waste Leather Scraps

2.2 Fiber extraction system

A prototype opener-garnetter unit was designed with steel wire clothing (5 mm length, 17×17 density, 15° inclination), a pressure-type taker-in, and air suction discharge. More than 50 pilot runs were conducted, revealing issues such as fiber sticking, NEP formation, and poor cohesion. These problems were mitigated through wire-angle adjustments, draft optimization, and a dual-line sliver approach separating leather-rich fibers from carrier fibers (Fig. 2).



[Fig. 2] Opener-garnetter unit for fiber extraction

2.3 Sliver formation

The two-line system consisted of a no-combing track for leather-rich fibers and a combed track for carrier fibers. Blending both streams improved drafting stability and yarn evenness.

2.4 Pretreatment and dyeing

Laboratory pretreatment tests included enzyme-only, sodium hydroxide, and mixed solutions. Protease treatments showed negligible effect, while sodium hydroxide caused fiber swelling, coagulation, and surface melting. These results ruled out alkaline processing as unsuitable for maintaining fiber integrity. Instead, a wool-reactive dyeing strategy under acidic conditions (pH 4-5, 60-80 °C) was identified as a viable alternative, with commercial products from Archroma, Runtu, and Town End considered as candidates (Table. 1).

[Table 1] Pretreated leather scraps

		
NaOH	NaOH+Enzyme	Enzyme

3. Results and Discussion

3.1 Fiber behavior

Collagen-based fibers presented challenges such as sticking, NEP formation, and weak cohesion. Adjustments in the machinery setup and the introduction of the dual-line system improved fiber liberation and sliver uniformity.

3.2 Pretreatment evaluation

Alkaline hydrolysis caused structural collapse of collagen fibers, while enzymatic treatments alone produced minimal changes. These findings emphasized the importance of non-alkaline, protein-compatible approaches.

3.3 Dyeing roadmap

The proposed wool-reactive dyeing strategy under acidic conditions provided higher compatibility with collagen fibers compared to conventional cellulose-reactive dyes. Candidate dye series from Archroma, Runtu, and Town End are under consideration for further application.

3.4 Collaborative framework

Regular meetings among research partners facilitated technical discussions, troubleshooting, and alignment of progress, ensuring efficient collaboration throughout the study.

4. Conclusion

This study demonstrates that waste leather can be transformed into upcycled composite yarns suitable for mobility seat covers. Through systematic classification, optimized fiber extraction, dual-line sliver formation, and an alkali-free wool-reactive dyeing process, leather scraps were shown to be a viable source of sustainable textile materials. The results highlight the potential for scaling up leather-based upcycling technologies to support circular textile innovation.

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