Development of Sustainable Leather Finishing Technology Using Natural Rubber

Conference: 13th AICLST, Kolkata, 6–8 March 2026

Paper reference: TI-54/O

Printed pages: 173–176

Source: *Leather 2050: Challenges & Opportunities*, ILTA (2026)

Development of Sustainable Leather Finishing Technology

Technical Support Center for Leather Industries, Hyogo Prefectural Institute of Technology

Ref. No. TI-54/O

Using Natural Rubber

Hirohiko Washiya, Ryosuke Izumi

Abstract

In the finishing process for grain corrected leather, a common technique involves buffing the grain side with buffing paper, then impregnating it with synthetic resin to tighten the surface. Conventionally used synthetic resins have leaned heavily toward components forming rigid structures, such as urethane and acrylic, many of which are derived from fossil fuels. Against this background, the leather industry cannot ignore the trend toward Sustainable Development Goals (SDGs), needing the development of new materials aimed at reducing environmental impact. Therefore, this study focuses on carbon-neutral natural rubber, sourced from the Hevea brasiliensis tree, as a natural material alternative to conventional synthetic resins. Just as leather is a sustainable material, natural rubber also has sustainability. Combining the two is expected to yield synergistic effects. Furthermore, natural rubber supplied as an emulsion can undergo chemical modification. It has recently garnered renewed attention, and application development is progressing. Natural rubber also combines flexibility with excellent mechanical properties and has the characteristic of allowing elastic modulus control through vulcanization, making it promising as a leather finishing material. This study aimed to develop a leather finishing technology using natural rubber. We conducted solid viscoelasticity measurements, evaluated the permeability and coating properties of natural rubber formulations, and produced prototype leather samples. The results showed that the prototype leather showed higher tear strength compared to

Raw hides used as materials for leather production vary individually. Raw hides with minimal damage, such as scratches and pinholes, are used as grain leather with thin coatings that preserve the grain surface, which is the surface of the dermis after removing hair and epidermis, and greatly affects the product value of leather. Conversely, raw hides with considerable damage cannot use the grain surface and are processed into buffed leather by sanding the grain with sandpaper. Buffed leather is characterized using coatings containing pigments, which conceal grain damage to some extent and result in a uniform appearance and high yield. In Japan, the volume and quality of imported raw hides have been declining annually, making finishing technology for buffed leather increasingly important. In the finishing process of buffed leather, after buffing the grain surface with sandpaper, synthetic resin is impregnated to tighten the grain. The synthetic resins used in the leather industry are mainly hard-structured resins such as urethane and acrylic, most of which are derived from fossil fuels. The leather industry cannot ignore the trend toward SDGs, and proactive efforts toward sustainable development goals are required. Here, we focused on carbon-neutral natural rubber harvested from the Para rubber tree as a natural alternative to these synthetic resins. Natural rubber is soft and has strong Corresponding author email : washiya@lyogo-kg.jp

conventional products, suggesting the potential applicability of natural rubber.

Keywords: natural rubber, leather finishing, sustainable materials, emulsion, mechanical properties, viscoelasticity

1. Introduction

mechanical properties. This study aims to develop leather finishing technology using natural rubber, conducting solid viscoelasticity measurements, evaluating the permeability and coating properties of natural rubber compound solutions, and producing prototype leather.

2. Experimental Methods

2.1 Samples and Reagents

The base leather used was chrome-tanned cowhide with the grain surface buffed with sandpaper. Natural rubber included natural rubber emulsion (NR75) with a viscosity of 75 mPa·s and total solids of 62%, and natural rubber emulsion (NR19) with a viscosity of 19 mPa·s and total solids of 51%. Synthetic resins used were urethane resin (Lized) and acrylic resin (same). 2- Ethoxyethanol and 2Propanol were used as special grade reagents without further purification.

2.2 Solid Viscoelasticity Measurement of Natural Rubber and Resins

Solid viscoelasticity was measured for three types: natural rubber (NR75), urethane resin, and acrylic resin, using Rheogel-E4000 (UBM Co., Ltd.) at a frequency of 10 Hz, heating rate of 2 °C/min, and temperature range from -40 °C to 60 °C. Since all samples were solution, sheet samples (width 2.6 mm, length 15 mm) were prepared by casting.

2.3 Stability and Permeability Evaluation of Natural Rubber Compound Solution

After preparing natural rubber compound solutions by mixing NR75 and solvents at specified volume ratios, the solutions were placed in 100 mL sample bottles, and the aggregation of natural rubber after two days was visually observed to evaluate stability. Permeability evaluation of the compound solution into base leather was performed using a contact angle meter CA-X150 (Kyowa Interface Science Co., Ltd.), recording the time from droplet contact to absorption into the leather. All mixing ratios were by

volume. Disposable polypropylene syringes and 22G Catelan needles were used. The leather surface after dropping the compound solution was observed with a digital microscope YDZ-3F (Yashima Engineering Co., Ltd.).

2.4 Coating Property Evaluation of Standard Compound Solution

A tabletop coater TC-3S (Mitsui Electric Machinery Co., Ltd.) was used to coat the base leather with the standard compound solution determined in 2.3. The wireless bar coater OSP-25 (same) was used. Coating speed was 10 mm/sec, solution volume about 3 mL, and coating area 150 mm × 150 mm.

2.5 Production and Mechanical Property Testing of Prototype Leather

With the cooperation of a tanner, prototype finished leather was produced by coating base leather with the standard compound solution. The resulting prototype leather was evaluated by tensile and tear tests, following JIS K 65572 and JIS K 6557-3.

3. Results and Discussion

3.1 Results of Solid Viscoelasticity Measurement

The dynamic viscoelasticity of urethane resin, acrylic resin, and natural rubber (NR75) was compared. The elastic modulus (E’) serves as an indicator of elasticity and hardness, with higher values representing greater stiffness. Within the temperature range of -40°C to 60°C, urethane resin exhibited showing of 1.0×109 Pa, while natural rubber showed a much lower E’ of 1.0×106 Pa, indicating that natural rubber is significantly softer in this range. Acrylic resin’s E’ varied considerably from 1.0×109 Pa to 1.0×107 Pa, while the E’ of natural rubber remained relatively constant.

These results suggest that leather finished with natural

rubber will be softer than that finished with urethane resin. Furthermore, while acrylic resin’s hardness is highly dependent on temperature, natural rubber shows minimal change in hardness across the typical usage temperature range. This shows that natural rubber can help keep a soft feel in leather products over a wide range of temperatures.

3.2 Permeability Evaluation of Natural Rubber Compound Solution

The permeability of natural rubber compound solutions into base leather was evaluated by measuring the time required for a droplet to be absorbed into the leather surface. Water alone needed 59 seconds for absorption, but the addition of 2-ethoxyethanol reduced this time to 20 seconds, proving its effectiveness as a permeation agent. When natural rubber NR75 was mixed with water (10:90), the absorption time increased to 109 seconds, while NR19 and water (10:90) took 52 seconds, indicating that higher viscosity leads to longer absorption times. The addition of 2-ethoxyethanol consistently shortened absorption times.

Microscopic observation revealed that before applying the compound solution, pores were visible on the leather surface. Application of NR75 and water (10:90) formed a rubber film covering these pores, while NR19 and water (10:90) showed related results, with NR19 penetrating slightly more due to its lower viscosity. Coating with only

Figure.1: Comparison of Tensile Strength, Elongation, and Tear Strength of Prototype Leather

natural rubber and water left solid rubber on the surface, which could result in poor adhesion during subsequent finishing. The inclusion of 2-ethoxyethanol allowed natural rubber to penetrate the leather more effectively, and NR19 exhibited better permeability than NR75.

Based on these evaluations, two standard compound solutions were formulated:

* Standard Compound Solution A (NR75:NR19:

water:2-ethoxyethanol = 75:25:750:150, absorption time 11 seconds) * Standard Compound Solution B (NR75: water:2-

ethoxyethanol = 100:750:150, absorption time 19 seconds).

3.3 Mechanical Properties of Prototype Leather

With the cooperation of domestic tanner, standard compound solution A and B were applied to the base leather (side). After applying the standard compound solution, the final finished leather was produced by spray coating. The results of tensile and tear tests on the prototype leather are shown in Figure 1. In the figure, “Base_Bend_Parallel” refers to samples taken parallel to the backbone direction from the bend of the base leather. Similarly, “B_Belly_vertical” refers to samples taken perpendicular to the direction of the backbone from the belly of the base leather treated with standard compound solution B.

About tensile strength, the base leather after application of the standard compound solution was stronger than before application, showing a reinforcing effect by natural rubber. Comparing standard compound solution A and B, the base leather treated with standard compound solution B showed higher tensile strength. The natural rubber emulsion used in standard compound solution B had a viscosity of 75 mPa·s, while the natural rubber in standard compound solution A was a blend of 75 mPa·s and 19 mPa·s viscosities. The difference in tensile strength is due to the viscosity of the natural rubber. As for elongation, the difference before and after application of the standard compound solution was small.

Tear strength is an indicator of the entanglement in the fiber structure and is practically important for the lasting process in shoemaking, where tear strength is required. Therefore, improving this property is crucial. Tear strength, like tensile strength, was greater after application of the standard compound solution, and higher for base leather treated with standard compound solution B than with A. Comparing the bend and belly, the reinforcing effect of natural rubber was greater in the belly. Typically, the bend has a higher density of fiber bundles, while the belly has lower density and more gaps. Natural rubber may contribute to improved tear strength by penetrating these

gaps. Notably, the higher tear strength in the belly compared to the bend suggests that natural rubber enables the use of the belly, which was previously unsuitable, for shoe leather. Thus, natural rubber may function as an effective finishing agent for leather.

1. Conclusion

This study aimed to develop leather finishing technology using natural rubber, conducting solid viscoelasticity measurements, permeability and coating property evaluations, and prototype production. Results showed that using natural rubber for leather finishing produces softer leather than urethane resin, with less change in hardness over typical usage temperatures, resulting in a soft touch feel over a wide temperature range. Contact angle measurement was effective for adjusting the permeability of natural rubber compound solutions. Diluting natural rubber emulsion with water alone did not allow penetration into leather; the addition of 2-ethoxyethanol was essential. Adjusting the composition and coating conditions with a tabletop coater promoted penetration into leather. Prototype production at a leather factory showed that impregnation with natural rubber increased tensile and tear strength, especially in the belly part, enabling its use for shoes.