



Evaluating Mechanical Properties of Environmentally Friendly Leather Substitute (Eco-Leather)

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Leather and pleather (plastic leather, mainly polyurethane and polyvinyl chloride PVC) are widely used materials in apparel and footwear products. According to the American Apparel and Footwear Association (AAFA, 2009), in 2008, the US consumption of footwear was 2.2 billion pairs, among which about one third were categorized as leather products and one third as plastic/vinyl products. The chemical processes to convert raw animal hides to leather, especially tanning, cause environmental pollution and human health problems. Chromium salts are used in about 90% of global tanning production (Nair et al., 2012). The oxidizing product of tanning agent Chromium (III) is chromium (VI), a known toxin and carcinogen. PVC causes severe environmental problems and human health hazards through manufacture, use, and disposal. Dioxins, the most important by-products of the PVC lifecycle (Thornton, 2002), are persistent and bioaccumulative endocrine disruptive chemicals (EDCs), which represent a global threat to the health of human beings and wildlife (Bergman et al., 2013). Large quantities of phthalates (may be up to 60% by weight) are added to PVC as plasticizers to make the plastics more flexible (Thornton, 2002). A few phthalates are EDCs. Due to these problems, many nations, industries, and companies are trying to eliminate the use of PVC (Thornton, 2002).

To solve these environmental and human health problems associated with leather and pleather, and provide apparel and footwear industry with environmentally friendly materials, this research team uses renewable bio-based materials to develop environmentally friendly leather substitute (eco-leather). This paper reports the evaluation of stiffness and abrasion resistance of the eco-leather material.

A liquid molding resin, normally viscous and insoluble in water, is a compound which can be hardened after treatment. Acrylated epoxidized soybean oil (AESO) and methacrylated lauric acid (MLAU) were used as the starting chemicals. AESO is synthesized through a reaction of acrylic acid and epoxidized soybean oil. MLAU is derived from palm seed oil. Both AESO and MLAU are renewable resources from plants. Organic cotton fabrics (greige goods) with different weight were used as the fiber reinforcements for the AESO/MLAU (50/50 composition) resin treatment. Peel ply films were used to provide a layer between the reusable mold and the composite. A peel ply film was laid on the mold and half of the resin was evenly spread on the film. Then the cotton fabric was placed on top of the resin and the other half of the resin was spread evenly on top. A second peel ply was placed on top and mold was covered with a lid. The mold was placed in the hot press and cured at room temperature with pressure for 24 hours. After that, the mold was placed in an oven at 120°C for an additional 2 hours of post curing. Totally six eco-leather samples were prepared. These samples are water resistant but permeable to air.

The thickness of the eco-leather samples was measured using a portable thickness gauge made by SDL Atlas Inc. (Rock Hill, SC, model: J100). The stiffness of the eco-leather samples

was measured using a Handle-O-Meter Tester manufactured by Thwing-Albert Instrument Co. (West Berlin, NJ). The specimen sizes were 10 cm x 10 cm, the penetrator was a 1,000 g beam, and the slot width was 20 mm. Abrasion resistance (flexing and abrasion) of the eco-leather samples were measured using a University Wear Tester manufactured by SDL Atlas Inc. (Rock Hill, SC, model: M282) with 2 lbs on back tension weight rack and 0.5 lb on head weight.

The testing results are in Table 1. None of the six specimens ruptured after 3,000 cycles of abrasion. After 3,000 cycles of abrasion, the remaining thickness of eco-leather samples was in the range of 87.5% (No. 2) to 98.3% (No. 4) of original thickness. This indicated the eco-leather samples have good abrasions resistance for apparel and footwear applications. The stiffness measurements of two samples (No. 4 and 5) were out of the testing range (>1,000 g). These two samples were also the thickest. For the other four samples, there existed significant linear relationship between stiffness and thickness (linear regression p-value = 0.006, $R^2 = 0.988$, β_0 (intercept) estimate = -1126.8, β_1 (slope) estimate = 3025.6). Increasing eco-leather thickness would increase the stiffness. The genuine leather from animal hides may be split into top grain and split leather, so their thickness and stiffness could meet different requirements for apparel, footwear, upholstery, and luggage applications. The thickness of eco-leather could be easily controlled by the selection of fabric substrate (thickness and weight) and the amount of resin in the composite. By adjusting these two parameters (fabric substrate and amount of resin) in eco-leather production, appropriate thickness and stiffness for eco-leather can be obtained for different applications.

Table 1. Thickness and stiffness testing results of eco-leather samples

No	Original thickness (mm)	Stiffness (g)	Thickness (mm) after 3000 cycles of abrasion
1	0.480	333.75	0.425
2	0.400	84.50	0.350
3	0.476	294.25	0.455
4	0.665	>1,000	0.654
5	0.733	>1,000	0.681
6	0.481	338.25	0.461

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