Dyeing Properties of PET Suede with Waterborne Polyurethane as an Impregnation Finishing Agent

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1. INTRODUCTION

A natural leather manifests diverse types of sensitivities brought by differences in a 3-dimensional reticular structure inside fiber and in non-collagen content. It exhibits excellent volume and soft touch as well. The natural leather also has superior resilience and elasticity due to its unique structure. Among the synthetic polymers, PU resins can present similar characteristics. In order to revive the natural sensitivity, an artificial leather consists of ultra fine PET fiber for natural soft touch and impregnates with Polyurethane (PU) resins for the natural sense of volume and elasticity.

Polyurethane is a segmented block copolymer composed of soft segment (SS), consisting of polyol, and hard segment (HS), consisting mainly of isocyanate. It will have a phase-separated structure due to incompatibility of the two segments. The specific characteristic of PU depends upon the structure of hard segment and soft segment which shows the phase separation. Due to its features, PU resins have been generally used as an impregnation finishing agent for the artificial leather.

Traditionally, PU has been manufactured by using organic solvents due to strong hydrophobicity of a polyol. However, concerns on environmental problems have emerged globally, and regulations have been enforced against the use of organic solvents such as DMF and DMAc (which were used for PU), for they cause environmental contamination and inflict critical hazards to human body. Hence, PU is being replaced with waterborne polyurethane (WPU) which uses water as solvent within the extent of not causing pollution.

In this study, Waterborne polyurethanes (WPUs) based on isophorone diisocyanate and mixed polyols of poly(tetramethylene glycol) (PTMG) /polycarbonate diol (PCD) were synthesized. The synthesized WPU solutions were used as impregnating resins for the production of PET artificial leathers. The treatment resulted that the prepared WPU resins improved the color fastness to washing, rubbing, and light of the artificial leather fabrics, and the improvement was greater in increasing PC content within the WPU resin.

2. EXPERIMENTAL

2.1. Materials

Soft segments are polycarbonate diol (PCD) (molecular weight of 2,000 g/mol) and polytetramethylene glycol (PTMG) (molecular weight of 2,000 g/mol), supplied by Asahi Kasei Co. and Dupont respectively. Isophorone diisocyanate (IPDI, Bayer) was used as a hard segment. DMPA, TEA and EDA were also used for syntheses of WPU.

2.2. Synthesis of WPU

Polyurethanes were prepared by using a two-step bulk polymerization procedure. PCD, PTMG and DMBA were weighed and placed in a four-necked flask reactor, which was heated up to 120°C with stirring. When DMBA was completely dissolved, the reactor was cooled down to 70°C, and IPDI was input into the reactor. When the reaction reached theoretical -NCO content, the reactor was cooled down to 60°C and TEA was added to the reactor as a neutralizer for 40 minutes. Distilled water was added into prepolymers, and the dispersion process continued for one hour. After EDA was input into the reactor, the chain extend reaction was proceeded, and WPU was completely synthesized.

2.3. Dyeing of WPU

The prepared WPU film was dyed with a IR dyeing machine by using C. I. Disperse blue 56 (Dystar) with 1% o.w.f. Minolta CM-2600d Spectrophotometer which was used to analyze the dyeing property of the WPU films. The reflection rate in range of 360~700nm was measured. The R value at the maximum absorption wavelength was calculated by using the Kubelka-Munk formula, and the K/S value was achieved.

2.4. Impregnation Finishing and Fastness Analysis

The synthesized WPU solutions were used as impregnating resins for the production of PET artificial leathers with 80% of pick-up ratio and 20% of add-up ratio at 160°C for 70 sec. The color fastness to washing, rubbing, and light of the artificial leather

fabrics were measured by the method of AATCC 61, AATCC 8, and AATCC 16E respectively.

3. RESULT and DISCUSSION

FT-IR spectra were collected to confirm the synthesis of WPU by using the Attenuated Total Reflectance (ATR) method at resolution of 4 cm^{-1}, and 512 scans were signal-averaged at room temperature.

The peaks of PCD originating from a carbonyl group were observed at around 1780 cm^{-1} and peak originating from C—O—C stretching was observed around 1260 cm^{-1} while broad peak originating from —OH appeared at 3300-3500cm^{-1}. The broad peak at 3300-3500 cm^{-1} from PTMG was also observed. After the reaction in nitrogen atmosphere at 70°C for 20 minutes, the peaks at 2257 cm^{-1} originated from isocyanate's —NCO was shown. The peaks at 2257 cm^{-1} originated from —NCO and at 3300-3500 cm^{-1} from —OH of PCD and PTMG, had disappeared and declined from prepolymers after the synthesis, whereas 1703 cm^{-1} peak (that is carbonyl group of urethane) and 1640 cm^{-1} peak (that is carbonyl group of urea) were observed. Through the result, the synthesis of WPU had been confirmed.

To check the dyeing stability of WPU resins, WPUs with various ratios of PCD/PTMG contents were synthesized and WPU films were prepared. The film was dyed with the IR dyeing machine by using C. I. Disperse blue 56. To confirm the dyeing property of WPU films, the K/S value of the films was analyzed as shown in Figure 1. In this study, the K/S value decreased as PCD content increased, as shown in figure 1. It means that as PCD content increases, the quantity of non-bonded dyes decrease.

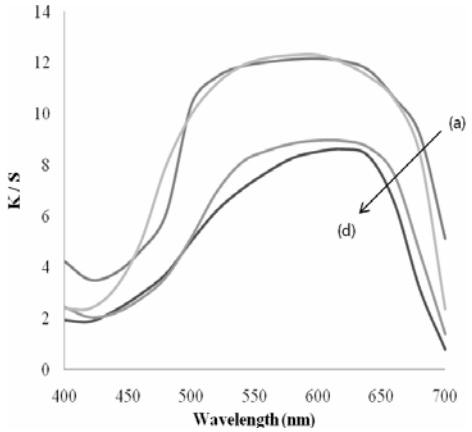

Figure 1. K/S curves of WPU films dyed with C. I. Disperse Blue 56; PCD/PTMG; (a) 0:100, (b) 30:70, (c) 70:30, (d) 100:0

Artificial leather applied to a car seat and headliner generally uses the WPU resin as an impregnation finishing agent. When the WPU resin was used, non-bonded residual dyes were migrated to the surface of the artificial leather, which cause serious deterioration of fastness. In particular, black color is most widely used and its problem of deteriorating color fastness is more serious than that of other colors, so a method to solve the problem is required. Among fastness factors of the black colored artificial leather, the rubbing fastness is the most important factor as it causes difficulty to control during finishing process. To improve the color fastness of WPU, in this study, WPU that had used PCD retaining, good mechanical properties, was synthesized. It was used as an impregnation finishing agent for the artificial leather, which was prepared with durability suitable to its end use. PET artificial leathers were impregnated by using WPU that had been synthesized with various ratios of PCD/PTMG content and dyed with a black disperse dye. Table 1 shows the analysis result of their color fastness. It can be confirmed in the table that as PCD content increases, the color fastness becomes enhanced.

Table 1. Various color fastness of the WPU-impregnated PET fabrics dyed with a black disperse dye

Impregnating WPU resin (PCD:PTMG)	Rubbing fastness		Light fastness	Washing fastness				
	Dry	Wet		Acetate	Cotton	Nylon	PET	Color change
0:100	1	2	2	3-4	4	3	4	3
30:70	1-2	3	2	3-4	4	3-4	4	3-4
70:30	4	3-4	3	4-5	4-5	4	4-5	4-5
100:0	4	3-4	3-4	4-5	5	4	4-5	5
Non-treated*	2-3	3	3	4-5	5	4-5	4-5	4-5

** Without WPU resin impregnation*

4. CONCLUSION

Waterborne polyurethanes based on isophorone diisocyanate and mixed polyols of PTMG/PCD were synthesized. The synthesized WPU solutions were used as impregnating resins for the production of PET artificial leathers. The treatment resulted that the prepared WPU resins improved the color fastness to washing, rubbing, and light of the artificial leather fabrics and that the improvement was greater in increasing PCD content which the WPU resin.

5. REFERENCES

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