Dyeing properties of PLA/easily dyeable PET union fabric with disperse dyes

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1. INTRODUCTION

Poly(lactic acid) (PLA) is highly versatile, biodegradable, a linear aliphatic thermoplastic polyester derived from 100% renewable sources such as corn. PLA is 100% compostable and its life cycle potentially reduces the Earth's carbon dioxide level. Its importance in the textile field increased from the world that is becoming increasingly sensitive to the need to protect our environment. PLA properties are similar to PET and it can be dyed with disperse dyes. However, the glass transition temperature is typically between 55–65℃. The melting temperature of PLA containing either the L- or D-isomeric form alone, is between 160–170℃ whereas that of PET is approximately 254℃. If PLA is blended with PET, they cannot be dyed at high temperature such as 130℃ due to damage on PLA fiber. To handle the problem, we used easily dyeable PET (EDP) in this study. The advantage of EDP in comparison with regular PET is to be dyed at lower temperatures, which facilitates its application to blends with natural fibers. Disperse dyeing at 10 0℃ without the use of carrier is recommended for EDP fibers. It might suggest that both PLA and EDP are dyed well at the lower temperature than regular PET dyeing.

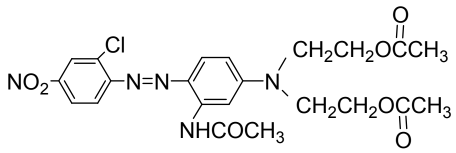
The purpose of this study is to investigate dyeing properties of PLA and EDP with various energy types of disperse dye. Furthermore, the possibility of one bath dyeing of PLA/EDP union fabric is studied by simultaneous dyeing of both fabrics.

2. EXPERIMENTAL

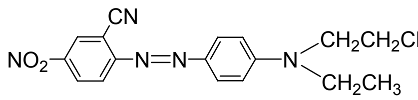
2.1. Materials

100% PLA (75d/72f, circula knit) and 100% EDP (75d/72f, circular knitt) were provided by Huvis (Korea).

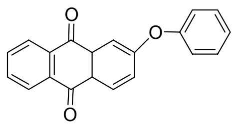
Chemical structures of three disperse dyes are shown in Figure 1. These disperse dyes were selected on the basis of their energy level, as shown in Table 1.



C. I. Disperse Red 167



C. I. Disperse Red 73



C. I. Disperse Blue 60

Fig. 1. Chemical structure of disperse dyes.

Table 1. Energy level of Disperse Dyes

C.I. Generic name	Energy level
Disperse Red 167	High (S type)
Disperse Red 73	Medium (SE type)
Disperse Red 60	Low (E type)

2.2 Dyeing process

Dyeing of PLA and EDP was performed by using Automatic Dyeing machine. The following procedure was applied to all dyeing. PLA and EDP were dyed at a liquor ratio of 1:20, dyeing pH 4.5. The temperature of dye bath was increased to 100℃ at a rate of 1℃/min, holding at this temperature for 30minutes.

2.3 Reduction clearing

After dyeing, the fibers were rinsed in cold water and reduction cleared at 60℃for 20min using a 1:20 liquor ratio with NaOH 0.5g/l and $Na_2S_2O_4$ 0.5 g/l

2.4 Measurement

Depth of shade was assessed in terms of K/S values which were calculated by CCM.

3. RESULTS AND DISCUSSION

Color strength of dyed PLA and EDP fibers were evaluated by K/S value. Figures 2 and 3 show the effect of dye concentration on color strength of both fabrics. The results show that color strength of PLA fiber is less proportional to the concentration of disperse dye than EDP fiber, meaning that build-up property of disperse dye on PLA fiber is worse than EDP fabric.

Generally speaking, EDP fiber possesses better dyeability than PLA fiber. When dyed with medium and high energy classes of disperse dye (Red 167 and Red 73), both PLA and EDP fibers represent high color strength. It turns out that PLA fiber cannot be dyed with low energy dye (Red 60). Color strength of PLA and EDP fibers dyed with the high energy dye is the highest, suggesting that S type disperse dyes is suitable to both fibers.

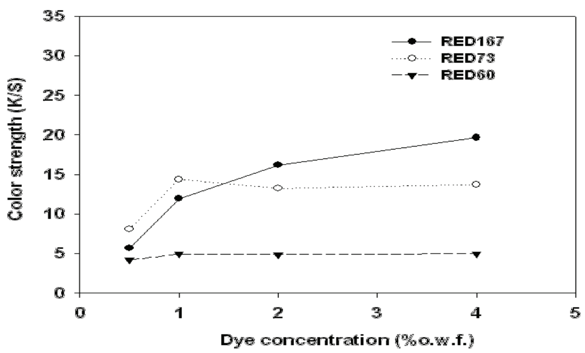


Fig. 2. Build-up profiles of PLA fiber.

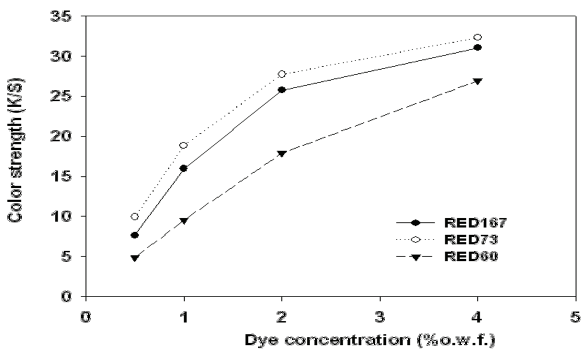


Fig. 3. Build-up profiles of EDP fiber.

Exhaustion curves of 100% PLA and EDP fibers at 1% o.w.f. dyeing are shown in Figure 4. It can be generally said that the disperse dyes exhaust more rapidly on EDP fiber than on PLA fiber. For example, EDP fiber absorbs sharply Red 73 dye in the temperature range 70~90℃ (30~50min) while PLA fiber absorbs the same dye in the temperature range 80~100℃(40~ 60min).

The color strength of simultaneously dyed PLA and EDP fibers in a bath is shown in Figure 5. It represents different results from dyeing of each fiber. When both EDP and PLA fiber are in the same dye bath, EDP fiber dominantly absorbs disperse dye molecules, resulting in higher K/S values of EDP fiber and lower K/S values for PLA fiber. It seems that the same color strength between PLA and EDP fibers cannot be achieved in one bath dyeing of PLA/EDP union fabric.

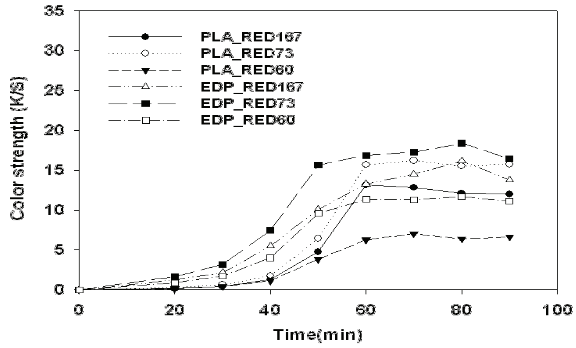


Fig. 4. Exhaustion curves of 100% PLA and EDP fibers.

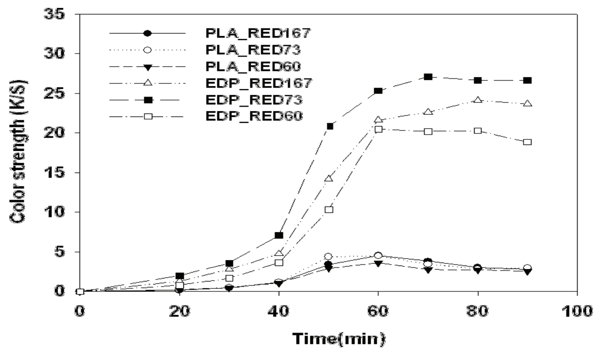


Fig. 5. Exhaustion curves of simultaneous dyeing of PLA and EDP fibers.

4. REFERENCES

[1] H. Tsuji and Y. Ikada, *Polymer Science* **67**, 405,1998

[2] R.E. Drumright, P.R. Gruber and D.E. Henton, *Adv. Mater*, *12* (23), 1841.

[3] D. Karst and Y. Yang, *Polymer Science* **96**, 416-422(2005).