# Compatibility of Disperse Dyes on PLA Fiber

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## 1. INTRODUCTION

Since the dawn of synthetic fiber technology, three polymers, PET, nylon, and PP, have found widespread acceptance across a broad spectrum of applications, in woven, knit, and nonwoven forms, and in both apparel and industrial end-uses. Recently, introduction of poly (lactic acid) (PLA) as a commercial polymer presents textile manufacturers with biodegradable sustainability, resilience, dyeability, comfort, softness, strength, low flammability, and UV durability. However PLA has some disadvantages in textile finishing process. PLA has poor alkali resistance causes strength loss in conventional disperse dye process. Low crystalline melt temperature leads to low ironing and setting temperature. And dyeing temperature is lower(110℃) than PET(130℃) with disperse dyes.

Generally, 3-combination dyes(yellow,red,blue) are used to obtain any color in dyeing process. In this report, we studied adsorption compatibility of 3-combination disperse dye on PLA and PET fibers. And we studied compatibility on PLA of conventional 3-combination disperse dye sets using PET, acetate dyeing.

## 2. EXPERIMENTAL

PLA fiber was used Terramac®(Unitika,Japan) spun yarn and PET fiber was used 100,150 denier flat filament yarn(Hyosung). Pre-treatments were performed with sodium carbonate 2g/l solution for 10min at 60℃. To comparing with dye adsorption compatibility on PLA and PET fibers, combination dyeing were performed in 3 groups. The dyeing conditions of 3 groups are listed in Table 1. And another 3 groups of commercial disperse dyes were performed to compare with adsorption compatibility on PLA of conventional 3-combination disperse dye sets using PET, acetate dyeing. The 3-combination recipes are listed in Table 2. The commercial dyes and auxiliaries employed in this study were provided by M.Dohmen Korea.

**Table 1.** Dyeing conditions of 3-combination dyes on PLA and PET fibers.

| | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| C.I. Disperse Yellow 42 | 0.4%o.w.f | 0.5%o.w.f | 2.0%o.w.f |
| C.I. Disperse Red 54 | 0.9%o.w.f | 2.0%o.w.f | 1.8%o.w.f |
| C.I. Disperse Blue 56 | 4.0%o.w.f | 4.2%o.w.f | 1.0%o.w.f |
| Liquor ratio | 1:10 | | |
| Dispersion agent | Doregal SFD New 1g/l | | |
| pH of dye bath | 5.0-5.5(by acetic acid) | | |

**Table 2.** Dyeing conditions of conventional 3-combination disperse dye sets using PET, acetate dyeing on PLA fibers.

| | Group 4 | Group 5 | Group 6 |
|---|---|---|---|
| Lumacel Yellow H-EF | 0.3%o.w.f. | - | - |
| Lumacel Red H-EF | 0.3%o.w.f | - | - |
| Lumacel Blue H-EF | 0.3%o.w.f | - | - |
| Lumacron Yellow ERD | - | 0.3%o.w.f | - |
| Lumacronl Red ERD | - | 0.3%o.w.f | - |
| Lumacron Blue ERD | - | 0.3%o.w.f | - |
| Lumacronl Yellow E3G | - | - | 0.3%o.w.f |
| Lumacron Red EFBB | - | - | 0.3%o.w.f |
| Lumacron Blue EFB | - | - | 0.3%o.w.f |
| Liquor ratio | 1:10 | | |
| Dispersion agent | Doregal SFD New 1g/l | | |
| pH of dye bath | 5.0-5.5(by acetic acid) | | |

These were dyed by IR Dyeing machine (Mathis, Swiss) for 40min at 110℃ and rinsed with cold water. Then dyed fibers were immersed in solution of Doxalin MSA (reduction agent, M.Dohmen Korea) for 20min at 60℃ and rinsed with cold water and dried. The colorimetric properties of the dyed fibers

were determined by a spectrophotometer (Datacolor, SF600) using D65 illuminant.

## 3. RESULTS AND DISCUSSION

Table 3. shows colorimetric data by spectrophotometer of 3-combination dyed PLA and PET fibers. When PLA and PET fibers dye with 3-combination dyes of different concentration (group1,2,3), $L^*$, $a^*$, $b^*$ values of PLA show big gap with PET 100D, 150D fibers. This gap is visibly different (Fig. 1).

**Table 3.** The colorimetric data by spectro-photometer of 3-combination dyed PLA and PET fibers.

| Dye | Substrate | $L^*$ | $a^*$ | $b^*$ |
|---|---|---|---|---|
| Group 1 | PLA | 22.81 | 22.10 | 20.67 |
| | PET 100D | 16.85 | 9.90 | 6.93 |
| | PET 150D | 20.39 | 12.90 | 10.62 |
| Group 2 | PLA | 16.65 | 13.06 | 10.71 |
| | PET 100D | 14.01 | 0.04 | -2.00 |
| | PET 150D | 15.06 | -0.08 | -2.27 |
| Group 3 | PLA | 19.23 | 8.53 | 9.75 |
| | PET 100D | 12.72 | 1.47 | -0.70 |
| | PET 150D | 14.26 | 1.90 | -0.61 |

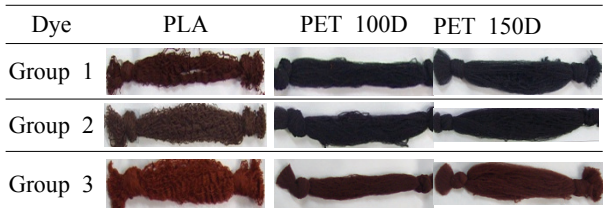


**Fig. 1.** Comparison of 3-combination dye adsorption compatibility on PLA and PET fibers.

Table 4. shows colorimetric data by spectrophotometer on PLA fibers dyed with conventional 3-combination dye sets. The combination of group 4,5 dyes show different $a^*$, $b^*$ values with group 6. This gap was visibly different (Fig. 2). In general the colors of group 4,5,6 dyes on PET look like that of PLA fiber dyed with group 6 combination.

**Table 4.** The colorimetric data by spectro-photometer of PLA fibers dyed conventional 3-combination disperse dye sets using PET, acetate dyeing.

| | Group 4 | Group 5 | Group 6 |
|---|---|---|---|
| $L^*$ | 49.37 | 41.99 | 37.51 |
| $a^*$ | 0.20 | 3.04 | 6.65 |
| $b^*$ | 3.57 | 1.50 | 9.73 |


**Fig. 2.** Comparison of 3-combination dye adsorption compatibility on PLA with conventional disperse dye sets using PET, acetate dyeing.

This result means that any dyes of 3-combination sets could be disturbed exhaustion in PLA 3-combination dyeing. This leads to poor compatibility. Then dyeing engineers will not be achieved color wanted. Apart from the conventional dyeing recipe used PET dyeing, it is necessary to find compatible 3-combination dyes and to research concentration for PLA dyeing with disperse dyes.

Furthermore, we will study compatibility of many dyes for different dye makers.