Disperse Dyeing of PET Fabric in Black Shade

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1. INTRODUCTION

In black dyeing of PET, it is an interesting and important issue how to obtain a deep black-colored fabric. Many efforts have been made and they can be categorized into three approaches. First one is to make surface of fiber to be rough, which reduce reflectance of incident light. For this, PET polymer is mixed with inorganic particles in the fiber spinning tank, and then spun into fiber yarn. Once fabric is made from the yarn, the inorganic particles are removed by alkali treatment forming micro crater on the surface of fiber. Low temperature plasma treatment or sputter etching of fabric is also the methods for roughness of fiber [1-4]. Second approach is to coat fabric surface with low refractive compounds [5-6]. Third one involves selection of high performance dye or process optimization in dyeing so that more amounts of dyes can be exhausted into the fiber.

Many studies reported are related to surface treatments which are first or second approaches. However, efforts to investigate dye or dyeing process for deep black color have not been studied much. In commercial black dyeing of PET fabric, high concentrations of disperse dyes of three primary color or black dye where the three dyes are already mixed are generally used. But this leads low exhaustion level of dyes and discharge of unfixed dye into dyehouse effluent. Therefore, it is needed to obtain black color of required quality using dyes as less as possible. Technically, disperse dye can be classified as high energy level range or S-type, medium energy level range or SE-type, and low energy level range or E type dyes. S-type disperse dyes have big size of dye molecule and are usually used for deep shade of dyeing while E-type dyes are small size and used for pale shade. SE-type dyes have properties between S and E type.

In this study, the effect of combination ratio of dye concentration and energy type of disperse dye on dyeing and color property of black dyed PET fabric was investigated. Dyeing compatibility of disperse dyes of three primary color on PET was evaluated by comparison of their dyeing rates. Wash fastness and light fastness were also investigated.

2. EXPERIMENTAL

Materials

Scoured and bleached PET woven fabric (plain, 107×97 tpi, weight 70±5 g/m^2) was used. Six disperse dyes were provided from Kyung-in Synthetic Co. Energy types and chemical structures of the dyes are shown in Table 1.

Table 1. Disperse dyes used in this study

Energy type	Commercial name	C.I. Generic name
S	Synolon Yellow Brown K-2RS	C.I. Disperse Orange 30
	Synolon Rubine K-GFL	C.I. Disperse Red 167:1
	Synolon Navy Blue K-GLS	C.I. Disperse Blue 79:1
SE	Synolon Yellow K-4G	C.I. Disperse Yellow 211
	Synolon Red K-F3BS	C.I. Disperse Red 343
	Synolon Blue K-BR	C.I. Disperse Blue 183:1

PET Dyeing

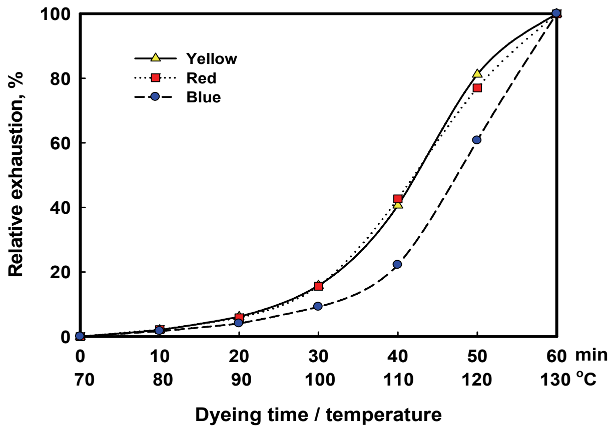
PET fabric was dyed in an IR dyeing machine at a liquor ratio of 10:1. Dye mixture was used with disperse dyes of three primary color (yellow, red, and blue). Total concentration of dye mixture was fixed to 10% owf while combination ratio of dye concentration was varied. Commercial dispersing agent (1 g/l) was used during dyeing. Dyebath pH was buffered as pH 5 with sodium acetate (0.05M)/acetic acid.

Dyeing was commenced at 70°C. The dyebath temperature was raised at a rate of 1.5°C/min to 130°C, maintained at the temperature for 60 min and then rapidly cooled to room temperature. The dyed fabrics were rinsed and then reduction cleared in an aqueous solution of 1 g/l sodium hydroxide and 1 g/l sodium hydrosulfite at 80°C for 10 min.

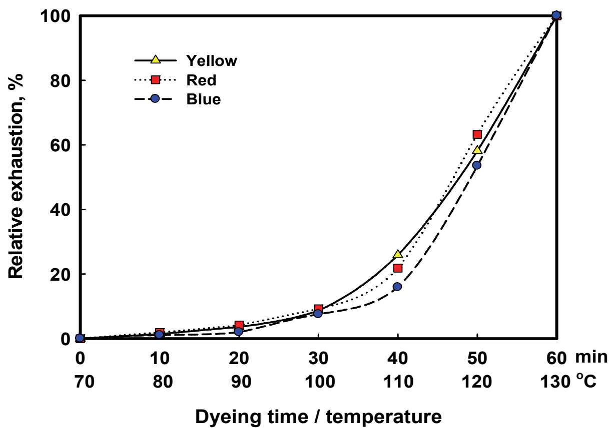
The color parameters of the dyed fabric were determined on a Macbeth coloreye 3100 spectrophotometer. The dyed fabrics were subjected to wash (ISO 105-C06/C1S) and light (ISO 105-B02) fastness tests after heat-set at 180°C for 60s.

3. RESULTS AND DISCUSSION

In Fig. 1, relative dyeing rate of blue dye was slower than that of yellow or red dye when dye concentration is not so high. However, when high concentration (3% owf) of dye was used, relative dyeing rate became similar to one another.



(a)



(b)

Fig. 1. Relative dyeing rate and compatibility of S-type disperse dyes on PET fabric.
(a) dye concentraion : yellow 1%, red 1%, and blue 1% owf; (b) yellow 3%, red 3%, and blue 3% owf.

Table 1 shows the effect of combination ratio of dye concentration on black shade of PET fabric. When the combination ratio was 4:3:3, 3:4:3, and 3:3:4, lightness (L^*) of all the samples were similar (22.0-22.2) and color names were black. Samples for 1:4.5:4.5 and 4.5:1:4.5 were black color showing lower L^* values (21.8-21.9) than those for 4:3:3, 3:4:3, and 3:3:4. On the other hand, sample for 4.5:4.5:1 in which small amount (1% owf) of blue dye was used, showed high L^* value (23.1) and color was not neat black but grayish black. Similar result was obtained for the samples dyed with SE-type dyes.

Table 1. The effect of combination ratio of dye concentration on color properties of PET fabric

Energy type	Combination ratio of dye concentration (owf) [Y:R:B][a]	L^*	a^*	b^*	ISCC-NBS Color name
S	4 : 3 : 3	22.1	0.8	-0.5	Black
	3 : 4 : 3	22.2	0.9	-0.7	Black
	3 : 3 : 4	22.0	0.8	-0.9	Black
	1 : 4.5 : 4.5	21.9	1.3	-1.7	Black
	4.5 : 1 : 4.5	21.8	0.4	-0.9	Black
	4.5 : 4.5 : 1	23.1	4.0	1.1	Grayish black
SE	4 : 3 : 3	22.2	1.6	0.2	Black
	3 : 4 : 3	22.5	2.3	0.0	Black
	3 : 3 : 4	22.5	2.0	0.1	Black
	1 : 4.5 : 4.5	22.7	2.6	-0.3	Black
	4.5 : 1 : 4.5	22.7	0.8	0.7	Black
	4.5 : 4.5 : 1	23.4	5.2	1.4	Grayish black

In washfastness, staining to acetate, nylon, and wool fabric was fair to moderate. Lightfastness was generally moderate.

4. CONCLUSIONS

S- and SE-type disperse dyes showed generally good dyeing compatibility especially at high dye concentration. Lightness of black dyed fabric was found to be dependent upon the combination ratio of dye concentration. Amoung three primary color, blue dye should be used in large amount for black color.

Although washfastness was fair to moderate and lightfastness was moderate, this level can be accepted commercially once the dyed fabric shows deep black color.

5. REFERENCES

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