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Comparative study on dyeing conventional polyester and microfibre polyester with disperse dye and evaluate different dyeing effects

Abstract

In this study, an attempt was taken to dye conventional and microfibre polyester filaments with disperse dye and evaluate their different dyeing effects in similar dyeing condition. The main attention was given to find out K/S values, color difference and different color fastness properties (light and wash fastness) and also the amount of dyes addition required for microfibre polyester filaments to get the same depth of shade as conventional one's. There were three different hues (Red, Navy and Green) of 5 different shades (0.5%, 1.5%, 3%, 4% and 6%) were used. The result shows that, microfibre polyester requires higher amount of dyes due to more surface area and greater absorbing capability of it. Almost similar light fastness was found in both conventional and microfibre polyester filaments and lower wash fastness properties of microfibre filaments when compared to those of conventional polyester.

Keywords: polyester, microfiber polyester, disperse dyes, k/s, fastness

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Introduction

The textile industry is searching for new solutions these days and is moving toward using innovative, eco-friendly, and efficient technologies while maintaining competitiveness and quality. Enhancing the performance of textiles in terms of permeability, biodegradability, resilience, elastic recovery, and other areas has been the main focus of a lot of recent research.[1,2] In this situation, traditional fibers are unable to satisfy the ever-expanding and changing demands of the textile market. In response to these commercial demands, a number of recent studies have been able to create bicomponent, tricomponent, and even more fibers or filaments by combining multiple polymers into a single filament. Two or more polymers extruded from the same spinneret combine to form these fibers.[3,4] Their physical and chemical characteristics, such as molecular weight, strength, melting temperature, and crystallinity, set them apart from one another.[5]

Polyester, chemically known as Polyethylene terephthalate is one of the most commercially valuable polymers.[6] The polymer chain of polyester contains ester group as an integral part, at least 85% of a polymeric ester of a substituted aromatic carboxylic acid, including but not restricted to terephthalic acid and p-hydroxybenzoic acid. Apart from becoming popular as textile fiber, polyester is also commonly used in fibers for industrial purposes, automobile textiles, reinforcement materials etc. as it is versatile and can be blended in different types of textile and other materials.[7,8] Microfiber can be defined as a fiber which is finer than 1 denier or 1 dtex. Their diameter commonly ranges between 0.25 and 1 denier.[9–11] Microfiber can be produced by direct spinning and conjugate spinning process.[12] Microfiber possesses the comfortability of natural fibers having the advantages of synthetic fibers. Microfiber is commonly used for fabrics with a new hand and smooth drape, weather protective clothing, cleaning and filtration purpose, and also for medical applications.[12–14] As there are more filaments present in the cross section of the yarn, it results in more surface area and compact structure.[15] Microfiber also exhibits higher strength due to that reason. As there is more specific surface areas present in microfiber, higher concentration of dye is required to produce a given depth of shade when compared to the conventional filament.[16–18] In comparison to conventional fibers, polyester microfibres absorb disperse dyes at a faster rate and to a greater extent. Microfibres can absorb up to 2-3 or even 4-5 times as much disperse dye, with the amount of this differential dye uptake varying depending on the dye structure, fiber fineness, and cross-sectional shape. This behavior has also been explained by a distinction between the amorphous zones of polyester microfibres and ordinary fibers.[19] On microfibres, the leveling behavior of the colors is frequently worse. Microfiber dyeing sometimes starts at a lower temperature than that used for conventional fibers in order to improve leveling. Moreover, it is typically done so at a slower rate until the temperature reaches the required level. Disperse dyes are used for dyeing both microfiber and conventional polyester. Though same dye is used, dyeing of microfiber creates some difficulties during dyeing and also in color fastness.

In this study, we measured the color strength and color differences between conventional and microfiber polyester filament dyed with disperse dyes in a similar dyeing condition to calculate the additional amount of dyes required for microfiber polyester. Also, the wash and light fastness differences were measured.

Experimental

Materials

In this study, 75D/36F (conventional) and 75D/72F (microfiber) 100% polyester filaments were collected from Knit Concern Yarn Dyeing Limited, Narayanganj, Bangladesh. All the chemicals were commercial grade and used without any prior purification including Felosan NOF (Detergent), CHT; Univadine TOP (Levelling agent), Huntsman; Kappatex R 98 (Reducing agent), Kappa Chem. Caustic soda and Acetic acid were collected from local supplier. The source of all the disperse dyes was Huntsman, Bangladesh.

Method

Pre-treatment: The pretreatment process was carried out due to remove the spin finishes from the raw polyester filaments. Ahiba IR (Datacolor, USA) laboratory dyeing machine were used to do the pretreatment process by using a detergent (Felosan NOF, 2 g/l) at 80°C for 20 min with a liquor ratio of 1:10. Figure 1 shows the process flow curve of the pretreatment process.

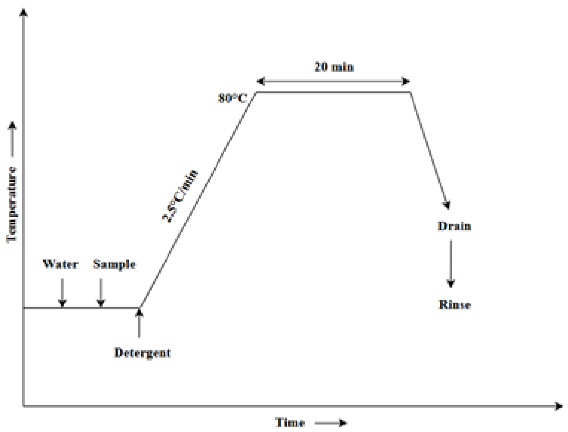

Figure 1 Process diagram of pre-treatment of the filaments.

Once the dying process was finished, a 20-minute hot wash was performed at 80°C. According to literature, for the improving of fatness properties, a reduction clearing treatment was done by using a reducing agent (2g/l) and caustic soda (2 g/l) at 80°C for 20 minutes with a liquor ratio of 1:10. Neutralization process was carried out using acetic acid at a concentration of 1g/l for 20 minutes at 50°C with similar quantity of liquor used in previous steps.

Dyeing

The dyeing procedure was carried out in both polyester filaments (75D/36F and 75D/72F) with combination of red and navy colors (Disperse dyes) in 5 different shades% i.e., 0.5%, 1.5%, 3.0%, 4.0%, and 6.0% in an Ahiba IR (Datacolor, USA) laboratory dyeing machine with a liquor ratio of 1:10 for 45 minutes at 135°C. The dyeing was carried out in acidic conditions by adding into the bath acetic acid (0.5 g/l) and for uniform dyeing a levelling agent (Univadine TOP: 2 g/l) were also used. The following combination of dyes are shown in Table 1 (Figure 2).

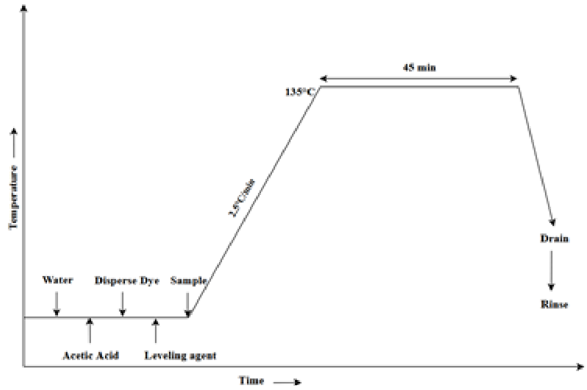

Figure 2 Process diagram of dyeing.

Finally, the conventional polyester (75D/36F) dyed with 3.0% shade of Combination 1 (Terasil Yellow W-6GS, Terasil Red WW-3BS), and 1.5% shade of Combination 2 (Terasil Blue 3RL and also Terasil Yellow W-6GS, Terasil Red WW-3BS, Terasil Navy GRLC) were taken as standard for color matching. The microfiber polyester (75D/72F) were dyed with four predicted recipes to match the color with the conventional one. The predicted recipes are shown in Table 2.

Table 1 Recipes for dyeing conventional and microfiber polyester

		Shade percentage	0.50%	1.50%	3.00%	4.00%	6.00%
Dyes	Red	Terasil Yellow W-6GS	0.01	0.04	0.1	0.13	0.25
		Terasil Red WW-3BS	0.48	1.42	2.8	3.74	5.5
	Navy	Terasil Blue 3RL	0.01	0.04	0.1	0.13	0.25
		Terasil Yellow W-6GS	0.06	0.16	0.3	0.3	0.57
		Terasil Red WW-3BS	0.16	0.14	0.9	1.32	1.98
		Terasil Navy GRLC	0.28	1.2	1.8	2.38	3.45

Table 2 Predicted recipes for color matching

Dyes		Recipes			
		Recipe 1	Recipe 2	Recipe 3	Recipe 4
Red	Terasil Yellow W-6GS	0.242	0.23	0.19	0.23
	Terasil Red WW-3BS	3.3	4.08	3.75	3.82
Navy	Terasil Blue 3RL	0.158	0.158	0.125	0.144
	Terasil Yellow W-6GS	0.17	0.168	0.169	0.152
	Terasil Red WW-3BS	0.46	0.408	0.42	0.443
	Terasil Navy GRLC	1.76	1.51	1.73	1.73

Testing

K/S values of the dyed polyester filaments

Color strength (K/S) values of the dyed polyester filaments were measured by dual beam DataColor 650 spectrophotometer pulsed xenon filtered to approximate illuminant D65. Diffused illumination and 8° viewing angle were used during measurement. The relevant software used Kubelka-Munk equation for measurement.

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \quad (1)$$

Eq. 1 K is absorption co-efficient; S is scattering co-efficient and R is the sample reflectance value.[17]

Color difference

The differences in color between two dyed samples were measured by ΔE (CMC) with the help of spectrophotometer. The relevant software used following equation during measurement:

$$\Delta E = \sqrt{\left(\Delta L^*\right)^2 + \left(\Delta C^*\right)^2 + \left(\Delta H^*\right)^2} \quad (2)$$

Eq. 2 ΔE is the color difference, ΔL *is* difference in lightness or darkness, ΔC is difference in chroma, and ΔH is difference in hue. CIE lab theory were used for color matching. According to the theory If, $\Delta E \le 1$, Color is matched and $\Delta E > 1$, Color is not matched.[20]

Determination of color fastness

Color fastness to wash of the polyester filaments were determined used ISO 105 C06 (C2S) test method. Gyrowash Machine (James H. Heal Co. Ltd, England). Sample size was 10cm×4cm. DW multifiber fabric (James H. Heal Co. Ltd, England) and grey scale for assessing color change and staining (SDC Enterprise, UK) was used. Color fastness to light were determined using ISO 105-B02 test method. Sample size was 1cm×5cm. Microsol Light Fastness Tester (James H. Heal Co. Ltd, England) and Blue Wool scale (James H. Heal, England) was used for assessment.

Results and discussion

Figure 3 and Figure 4 shows that 36F (conventional) and 72F (microfibre) Polyester both were dyed with same recipe for those of Red and Navy colored samples, there were differences between the color strength of conventional polyester and the microfibre polyester. Microfibre polyester have less color strength than the conventional polyester. It occurs because microfibre polyesters have more surface areas because of having more filaments in the same cross section (as both have same count i.e., 75D) as conventional polyester.

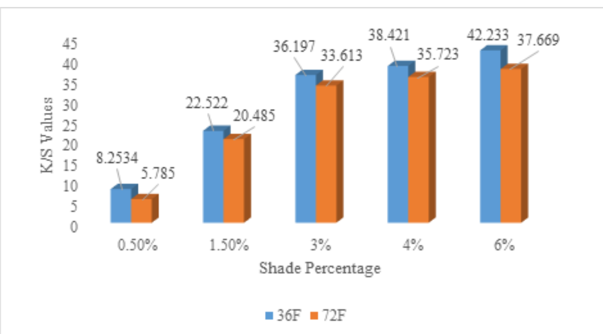

Figure 3 K/S values of 36F and 72F Red samples.

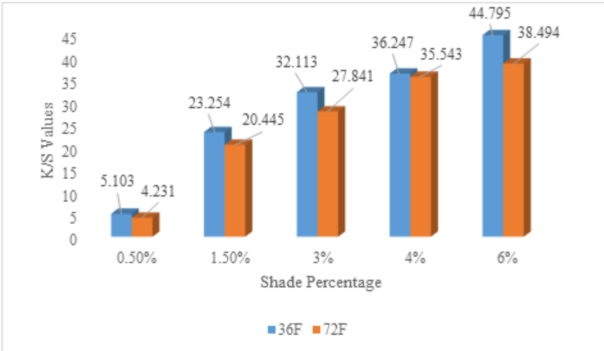

Figure 4 K/S values of 36F and 72F Navy samples.

Also, as there are differences in color strength between conventional and microfibre polyester, no values of ΔE are ≤1. So, according to CIE Lab theory, we can say that color is not matched for every shade of different hues in different light sources.

The rating of fastness shows that color fastness to wash on staining for both conventional polyester and microfibre polyester is excellent or good to excellent. It means that there is no staining or very slight staining to no staining on different multi-fibre fabric. Though both conventional and microfibre polyester filaments shows quite similar ratings, microfibre polyester shows relatively more staining when compared to conventional polyester.

Also, color fastness to wash on shade change for conventional polyester are mostly excellent i.e. no change in color. Only 6% shade shows slight loss in depth to no change in shade. On the other hand, color fastness to wash on shade change for microfibre polyester are mostly good to excellent i.e., slight loss in depth to no change. Only 0.5% shade shows no change in shade. From the ratings, conventional polyester filaments have comparatively better wash fastness on shade change than microfibre polyester. It is possible to explain the reduced wet fastness of dispersed dyes on microfibres by the increased dye uptake within the fiber as well as the increased specific surface area available for dye desorption. The increased dye uptake on microfibres explains why the fastness of dyeing to sublimation on them is lower than on ordinary fibers.[19]

Both conventional and microfibre polyester filament shows very high light fastness (rating 7-8 on blue wool scale). Microfibre polyester shows slightly lower light fastness properties but that may be negligible. From Figure 5, it is evident that the K/S value for Recipe 4 (72F) is closest to the standard (36F Red 3.0%). For the Navy color, Figure 6 shows that the K/S value for Recipe 3(72F) is closest to the standard (36F Navy, 1.5%).

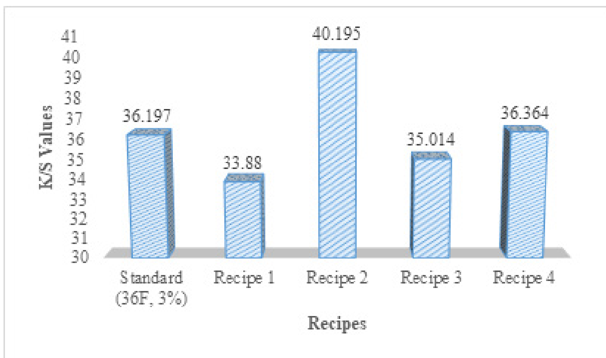

Figure 5 K/S Values for color matching for Red.

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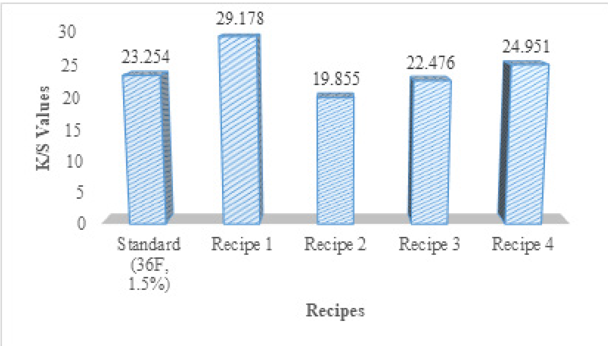

Figure 6 K/S Values for color matching for Navy.

From Table 3, Recipe 3 (4.065%) and Recipe 4 (4.194%) for Red and Recipe 3 (2.319%) and Recipe 4 (2.325%) for Navy shows Δ E value <1, so it can be said that, when microfibre polyester is dyed with recipe 3 and recipe 4 then the color is matched with the standards which showing that, in terms of depth or intensity, the color it gives off is a little closer to the standard.

Table 3 Color differences for addition between standard and 72F Polyester

Hue	Recipe	Color differences between 36F& 72F (		
		D65	TL84	F02
Red	1	1.15	1.36	1.33
	2	1.39	1.71	1.72
	3	0.76	0.67	0.83
	4	0.4	0.34	0.55
Navy	1	1.24	1.3	1.3
	2	1.02	1.22	1.13
	3	0.66	0.69	0.68
	4	0.82	0.9	0.86

Finally, it is found that almost 37% more dye was required for Red and 55% more dye was required for Navy hue to get the same depth of shade in microfibre polyester as conventional one.

Conclusion

Microfiber polyesters show few unique characteristics when it is compared with the properties of conventional polyester but there is difficulties in dyeing it and also higher amount of dyes are required. This study was based on comparison between dyed conventional polyester and microfibre polyester by assessing color strength and difference in color. This study also includes the additional amount of dyes required to produce a given shade (conventional polyester) on polyester microfibre and different fastness properties. Almost 37-55% more dye is required for microfibre polyester and they show poor fastness properties when compared to conventional polyester. When it comes to dyeing, the increase in surface area that results from a decrease in filament linear density serves two purposes: first, it increases the extent of dye adsorption and desorption (which in turn increases dyeing rate and frequently reduces wet and light fastness); and second, it decreases the depth of shade achieved, both visually and instrumentally.

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Conflicts of interest

Author declares that there is no conflict of interest.

References

1. Souissi M, Khiari R, Haddar W, et al. Dyeing of Innovative Bicomponent Filament Fabrics (PET/PTT) by disperse dyestuffs: characterization and optimization process. *Processes.* 2020;8:501.
2. Ahir SV, Tajbakhsh AR, Terentjev EM. Self-assembled shape-memory fibers of triblock liquid-crystal polymers. *Adv Funct Mater*. 2006;16:556–560.
3. Rwei SP, Lin YT, Su YY. Study of self-crimp polyester fibers. *Polym Eng Sci*. 2005;45(6):838–845.
4. Fumei W, Fei G, Bugao X. Elastic strain of PTT/PET self-crimping fibers. *J Eng Fibers Fabr*. 2013;8:50–55.
5. Joon HK, Sung SY, Samuel MH. Comparison of the structure-property relationships for PTT and PET fibers spun at various take-up speeds. *Fiber Polym*. 2011;12:771–777.
6. Kitano Y, Kinoshita Y, Ashida T. Morphology and crystal structure of an a axis oriented, highly crystalline poly (Ethylene Terephthalate). *Polymer*. 1995;36(10):1947–1955.
7. Cook JG. *Handbook of textile fibres: man-made fibres*. Elsevier; 1984.
8. Choudhury AR. *Textile preparation and dyeing*. Science publishers; 2006.
9. Nakamura T, Ohwaki S, Shibusawa T. Dyeing properties of polyester microfibers. *Textile research journal.* 1995;65:113–118.
10. Nakamura T, Bommu RR, Kamshi Y, et al. Dyeing properties of a polyester ultrafine fiber. *Textile Research Journal.* 2000;70:961–968.
11. İçoğlu Hİ, Kaynak HK. Comparison of color values of polyester fabrics woven from conventional and microfilament yarns. Budapest, Hungary, 2018:7–11.
12. Jeon HY. *Woven fabrics*. IntechOpen. 2012. ISBN 978-953-51-0607-4.
13. Purane Sandip V, Panigrahi Narsingh R. Microfibres, microfilaments & their applications. *AUTEX Research Journal.* 2007;7(3):148–158.
14. Chao YC, Chen SS. Dyes for polyester microfibres. *Dyes and pigments.* 1994;24(3):205–222.
15. Al-Etaibi AM, Alnassar HS, El-Apasery MA. Dyeing of polyester with disperse dyes: part 2. synthesis and dyeing characteristics of some azo disperse dyes for polyester fabrics. *Molecules.* 2016;21(7):855.
16. Lallam A, Michalowska J, Schacher L, et al. Diffusion and adsorption of dye by polyester microfibres. *Journal of the Society of Dyers and Colourists*. 1997;113:107–110.
17. Chong CL, Yeung KW, Cui ZY. Parameters influencing the dyeing of polyester microfibres. *Research Journal of Textile and Apparel.* 1997;1:1–9.
18. Uddin MZ, Watanabe M, Shirai H, et al. Dyeing conventional and microfiber polyester with disperse dyes. *Textile research journal.* 2002;72(1):77.
19. Park KH, Casetta M, Koncar V. Diffusion of disperse dyes into microfibres and conventional polyester fibres. *Coloration Technology.* 2002;118:319–324.
20. Ito M, Katoh N. Three-dimensional gamut mapping using various color difference formulae and color spaces. Proceedings of the Color Imaging: Device-Independent Color, Color Hardcopy, and Graphic Arts IV; SPIE. 1998;3648:83–95.

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