Spectrophotometric Evaluation of Re-dyed Polyester Yarn

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Abstract: The aim of this work is to evaluate the re-dyed polyester yarn. In this work four samples of available dyed polyester yarns are selected and re-dyed to match the standard samples then the spectrophotometric evaluation under three different illuminants such as F11, D_{65}, and A are done and compared to the standard samples. The depth of shade of redyed polyester yarns are evaluated by Datacolor (reflectance spectrophotometer) to get the difference in color spaces (DL*, Da*, Db*, DC* and DH) is focused on this work. This work has been done at Win thread Ltd. Tejgaon, Dhaka and Epyllion Fabrics Ltd. Gazipur during the time period of April 2017 to October 2017.

Keywords: *DL*, Da*, Db*, DC*, DH and DE.*

I. Introduction

Poly Ethylene Terephthalate (PET) is one of the most common fiber forming polyesters. The hydrophobic nature of polyester fiber is difficult to wet process. Its dyeing is always carried out more than the glass transitional temperature and after that the dye molecules are uncut chemical bond with fiber molecules. Disperse dyes are used for dyeing of polyester fiber from a stable aqueous dye dispersion at dyeing temperatures ($100\text{-}130^{o}C$) under acidic condition. Many faults that may be raised in earlier stages of processing become clearly visible for the first time after dyeing. Some of the common dyeing problems including dye migration, uneven dyeing, staining, off shade colors, poor hand feel and poor fastness etc. (Chinta *et al*. 2012).

However, Color is a characteristic of a surface but its sensation varies from observer to observer, illuminant to illuminant. The CIE L*a*b* color system is the most complete color space defined by the International Commission on Illumination which describes all the colors visible to the human eye and was shaped to provide as a device independent model to be used as a reference. It has introduced several illuminants such as D65 (average day light; correlated color temperature of 6500K and power of 18 W), TL 84/F11 (Warm white Fluorescent, American Standard; correlated color temperature of 4000K and power of 18 W) and A (Incandescent light with a correlated color temperature of 2856K, power 40W) etc. The spectral data for these illuminants are stored in

color measurement instruments to compute the object's color (Shimo 2015; Khatri *et al* 2011, Shanbeh *et al* 2014; Etaibi *et al* 2016).
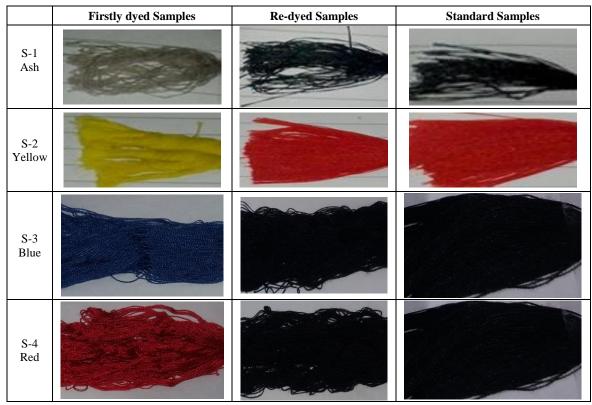
In this work, the values of the lightness (DL*), saturation (DC*), Hue (DH), the CIE reference values (Da* and Db*), Total color deviations (DE) of the redyed polyester samples are determined by different illuminants. The obtained results are evaluated.

II. Methodology

The color differences of the samples are measured by CIE L*a*b* color system which is used to evaluate color deviations by means of ΔE or DE values. The unit DE is taken as a unit of measure of color deviations. Color deviation in the above-mentioned system is represented the shortest distance in the CIE L*a*b* co-ordinate space from the position of the standard color which it is compared with. The comparison is done on spectrophotometric evaluation of re-dyed and standard shade dyed yarn by light sources F11, D_{65} and A. The lightness (DL*), saturation (DC*), Hue (DH), CIE lab value for references (Da* and Db*), Total color deviations (DE) are evaluated between the samples of re-dyed and standard dyed yarn samples. The three coordinates of CIELAB represent the lightness of the color (**L*** = 0 yields black and **L*** = 100 indicates diffuse white, **a*** negative values indicate green while positive values indicate red and **b*** negative values indicate blue and positive values indicate yellow.

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Table 1: Comparison on shades of firstly dyed, re-dyed and standard samples

	Firstly dyed Samples	**Re-dyed Samples**	**Standard Samples**
S-1 Ash			
S-2 Yellow			
S-3 Blue			
S-4 Red			

III. Results and Discussions
Comparison on shade

Table 1 shows the samples S-1, S-2, S-3 and S-4 which were firstly dyed as ash, yellow, blue and red coloured respectively. But the samples were faulty in shade. Therefore, the samples were redyed to match with the standard samples.

Spectrophotometric evaluation

From the table 2 it is seen that the DL* values of sample S-1, S-2 and S-3 are positive in all the light sources which indicates that the re-dyed samples are lighter in shade corresponding to the standard samples but the sample S-4 shows

negative value indicate the re-dyed sample is deeper than the corresponding to standard sample. Likewise, by comparing the values of Da*, it is seen that all the values are positive which indicates the samples are more red than the standard samples. The Db* values of sample S-1 and S-2 are positive which means that the samples are more yellow than the standard samples. Again, S-3 and S-4 samples are bluer than the standard samples. In DE comparison it is found that the DE value of the sample S-1 is less than 1 which indicates the sample S-1 is passed with the standard and for the other samples the DE values are more than 1.

Table 2: Spectrophotometric evaluation of re-dyed polyester yarn samples

Samples	**Obs.**	**DL***	**Da***	**Db***	**Dc***	**DH**	**DE**
S-1 (Lighter, more red, more yellow)	F11	0.43	0.00	0.01	-0.01	-0.00	0.39
	D65	0.42	0.19	-0.01	-0.05	0.19	0.46
	A	0.45	0.26	0.08	-0.06	0.26	0.55
S-2 (Lighter, more red, more yellow)	F11	2.79	1.92	0.68	1.93	-0.65	1.70
	D65	2.62	1.77	0.38	1.71	-0.61	1.62
	A	2.85	1.68	0.90	1.85	-0.46	1.58
S-3 (lighter, more red, more blue)	F11	0.97	0.85	-1.81	1.76	0.95	3.17
	D65	1.02	0.96	-1.68	1.88	-0.46	3.03
	A	1.01	0.49	-1.50	1.18	-1.04	2.47

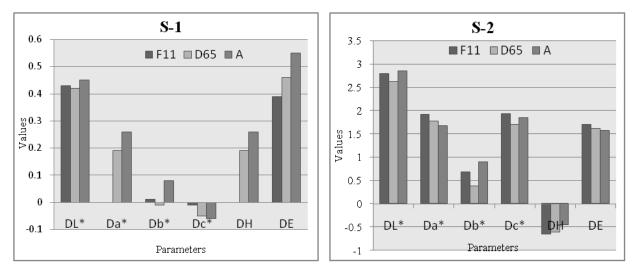| Samples	Obs.	DL*	Da*	Db*	Dc*	DH	DE
S-4 (darker, more red, more blue)	F11	-0.82	1.11	-0.56	0.78	0.96	2.04
	D65	-0.87	1.52	-0.62	1.64	0.14	2.58
	A	-0.74	1.28	-0.19	1.30	-0.07	2.00

Figure 1: CIE color spaces of Sample 1 (S-1) left and Sample 2 (S-2) right influenced by different illuminants

Graphical representation of the Spectrophotometric evaluation

Figure 1 shows that the lightness DL* values of sample S-1(left) and sample S-2 (right) are 0.43, 0.42, 0.45 and 2.79, 2.62, 2.85 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-1 and S-2 are lighter than their corresponding standard samples. Similarly CIE lab value for reference Da* of S-1 and S-2 were 0.00, 0.19, 0.26 and 1.92, 1.77, 1.68 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-1 and S-2 are more red than their corresponding standard samples. Likewise, CIE lab value for reference Db* of S-1 and S-2 were 0.01, -0.01, 0.08 and 0.68, 0.38, 0.90 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-1 and S-2 are more yellow than their corresponding standard samples. The chroma differences Dc* of S-1 and S-2 were -0.01, -0.05, -0.06 and 1.93, 1.71, 1.85 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-2 is more saturated than S-1. The difference in hue DH of S-1 and S-2 are -0.00, 0.19, 0.26 and -0.65,-0.61-0.46 in corresponding illuminants F11, D65 and A respectively. Finally the total color differences DE values of S-1 and S-2 were 0.39, 0.46, 0.55 and 1.70, 1.62, 1.58 in corresponding illuminants F11, D65 and A respectively. It indicates that the total color difference of sample S-1 was in limit with its corresponding standard sample on the other hand the sample S-2 was beyond its limit than its standard sample.

From Fig. 2, it is observed that the lightness DL* values of sample S-3 (left) and sample S-4 (right) were 0.97, 1.02, 1.01 and -0.82, -0.87, -0.74 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-4 is darker and S-3 is lighter than their corresponding standard samples. Similarly CIE lab value for reference Da* of S-3 and S-4 are 0.85, 0.96, 0.49 and 1.11, 1.52, 1.28 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-3 and S-4 are more red than their corresponding standard samples. Likewise, CIE lab value for reference Db* of S-3 and S-4 were -1.81, -1.68, -1.50, and -0.56, -0.62, -0.19 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-3 and S-4 are more blue than their corresponding standard samples.
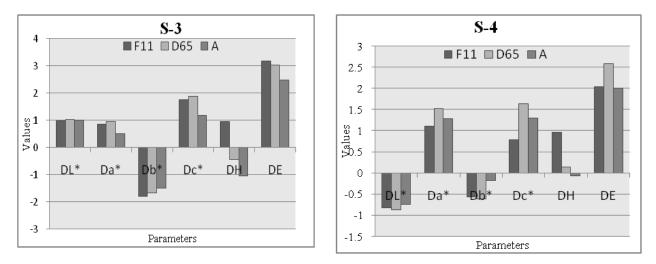
Figure 2: CIE color spaces of Sample 3 (S-3) left and Sample 4 (S-4) right influenced by different illuminants

The chroma differences Dc* of S-3 and S-4 are 1.76, 1.88, 1.18 and 0.78, 1.64, 1.30 in corresponding illuminants F11, D65 and A respectively. It indicates that the sample S-3 and S-4 are more saturated than their corresponding standard samples. The difference in hue DH of S-3 and S-4 were 0.95, -0.46, -1.04 and 0.96, 0.14, -0.07 in corresponding illuminants F11, D65 and A respectively. Finally the total color differences DE values of S-3 and S-4 are 3.17, 3.03, 2.47 and 2.04, 2.58, 2.00 in corresponding illuminants F11, D65 and A respectively. It indicates that the total color differences of both samples are beyond their limit values with the corresponding standard samples.

IV. Conclusion

The results of our investigation allow us to suggest that the CIELAB color spaces are influenced by illuminants. The change of color spaces shows significant differences by viewing under different illuminants. It may be revealed that the Samples S-1, S-2 are lighter, more red and more yellow in shade, S-3 is lighter, more red and more blue, S-4 is darker, more red and more blue than the respective standard samples. Finally, it can be suggested that the re-dyeing recipe ought to be corrected according to the spectrophotometric results to match the color differences within the limit.

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