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Dyeing of Polyester/Cotton Blended Woven Fabric in One Bath

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Abstract
In this work polyester/cotton (4:1) woven fabric is dyed in one-bath one-step process and two bath process with the equal amount of dyes and chemicals and comparison is done between two process in terms of shade and the dyeing performances such as wash, rubbing fastness and spectrophotometric evaluation. It is observed that the depth of color of two bath dyed sample is more than one bath one step dyed fabric sample. Wash and rubbing fastness was very good.

Keywords: *One-bath one-step dyeing, two bath, Polyester/Cotton blends, Disperse/Reactive dyes, shade difference, color fastness.*

I. Introduction

Blending cotton/polyester fibers is common practice in the textile industry. In comparison with 100% cotton, cotton/ polyester blends have higher breaking and abrasion strength, crease resistance, are more comfortable to wear, and display better easy-care properties (Baykal *et al.* 2006). However, the P/C blends posses some challenges to dyer as polyester shows a hydrophobic character while cotton shows a hydrophilic character making it inevitable to dye them with chemically different class of dyes (Meena *et al.* 2013, Najafi *et al.* 2009).

Commercially polyester/cotton blended fabrics are dyed by two-bath or one-bath two-step dyeing method employing suitable dyes and chemicals for each fiber. Two bath dyeing methods are relatively long and complicated. The one-bath two-step dyeing procedure is shorter as compared to two-bath method, but the drawbacks are lower dyeability and poor reproducibility. Many research works (Muralidharan and Laya 2011, Blus *et al.* 2005, Youssef *et al.* 2008, Ibrahim *et al.* 2003) have been carried out to dye polyester/cotton blends in one-bath dyeing method using conventional dispersed dyes and newly developed reactive dyes which can be dyed at acidic or neutral conditions around 100–130°C and are added simultaneously to the same bath (Muralidharan and Laya, 2011).

But one-bath one-step dyeing method is a new experience for polyester/cotton blended fabric. Generally, this process is done to get the light and medium shade of P/C blended fabric in a shorter possible time than any other process as like two bath process. The present work involves one-bath one-step dyeing and two bath process of P/C blend fabric using same amount of dyes and comparison is done between two methods.

II. Materials and methods

Dyes and chemicals

Dyes for polyester part dyeing Foron Brown S 2RFL, Foron Rubine S 2RFL and Foron Blue S2R and dyes for cotton part Drimarine Yellow HFCD, Drimarine Red HFCD and Drimarine Blue HFCD of Archroma have been used for this work.

One bath one step dyeing method

10g scoured and bleached PC blended woven fabric was taken. The required disperses dyes for polyester &reactive dyes for cotton part were weighted and taken into the pot and stirred it for required solution. The fabric was immersed in to the solution for 5 seconds. The fabric was padded in a sample padding machine with required pressure and passed through a sample stenter machine at 130 C. The fabric was then cured at 180°C. A hot wash and a cold wash were given to the fabric. Table 1 shows the required amount of dyes and chemicals for one bath one step dyeing.

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Table 1: Recipe for one bath one step dyeing

Dyes for Polyester	Volume (g/L)	Dyes for cotton	Volume	Chemicals	Volume(g/L)
Foron Brown S2RFL	2.867	Dri Yellow HFCD	2.624g/l	Sodium Bi Carbonate	20
ForonRubine S2RFL	5.36	Dri Red HFCD	1.749g/l	Flolux AM	10
Foron Blue S2R	2.624	Dri Blue HFCD	1.295g/l	Cinsper CH20	10
				Urea	100

Two bath dyeing method

10g scoured and bleached PC blended woven fabric was taken. 200ml boiled water was taken in a pot. At first, disperse dyes and chemicals were taken in the pot and stirred it for perfect solution. The fabric was immersed in the dyeing solution for 5 seconds. Then the fabric was padded in the sample padding machine. Then it was passed through a sample stenter machine at 130°C. The it was then cured at 200°C and reduction cleaned. Again it was passed through sample stenter machine at 130°C. 200ml boiled (80°C) water was taken in another pot. Then reactive dyes and chemicals were taken into the pot. The fabric was immersed into the solution for 5 seconds. Then the fabric was padded in sample padding machine. The fabric was then passed through sample stenter machine at 130°C. After that the fabric was cured at 180°C. Table 2 shows the required dyes and chemicals for two bath dyeing.

Spectrophotometric evaluation

The color depth of the dyed fabrics was analyzed by measuring the K/S values of samples. Color measuring instrument Spectrophotometer (Data color) determines the K/S value of fabrics through Kubelka Munk equation as follows:

$$K/S = (1-R)2 /2R$$

where R = reflectance percentage, K = absorption co-efficient and S = scattering co-efficient of dyes. This value represents the attenuation ratio of light due to absorption and scattering is found based on reflectance.

Wash fastness test method

The color fastness to wash of the both samples was done by ISO 105 C03 method. The fastness result was evaluated with the Grey Scale and staining of color in the adjacent multi-fiber fabric with the Staining Grey Scale. This assessment was done in a color matching cabinet under standard lighting of D_{65} (Artificial Daylight).

Rubbing fastness test method

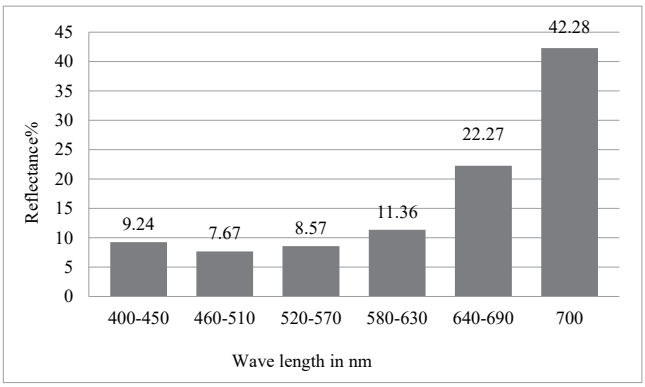
The color fastness to dry and wet rubbing of the both samples was done by ISO105x12:1993 method. The comparison between the untreated and treated white rubbing cloth with the staining Grey Scale and rating was done from 1 to 5 and changing in the tested specimen with changing Grey Scale. This visual assessment was done in a color matching cabinet under standard light source D_{65}.

III. Results and Discussion

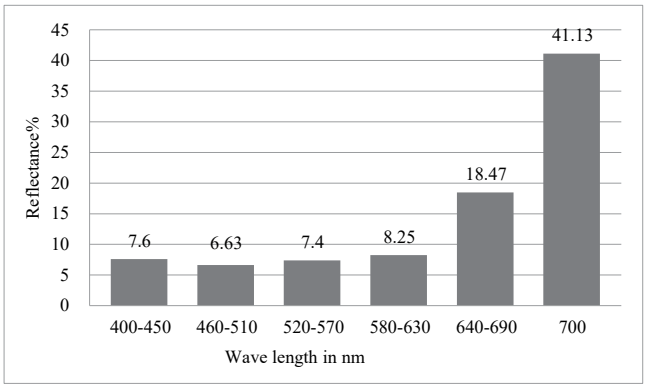
Spectrophotometric evaluation

Table 2: Recipe for two bath dyeing

Dyes for Polyester	Vol. (g/l)	Chemicals for polyester dyeing	Vol. (g/l)	Reduction cleaning	Vol. (g/l)	Dyes for cotton	Vol. (g/l)	Chemicals for cotton dyeing	Vol (g/l)
Foron Brown S2RFL	2.867	Acetic Acid	10	Hydroze	50	Dri Yellow HFCD	2.624	Sodium Bi Carbonate	20
ForonRubine S2RFL	5.36	Flolux AM	10	Caustic	50-60	Dri Red HFCD	1.749	Flolux AM	10
Foron Blue S2FL	2.624	Cinsper CH20	10			Dri Blue HFCD	1.295	Cinsper CH20	10
		Urea	100					Urea	100



Two bath process



One bath process

Figure 1: Comparison on reflectance% of two bath and one bath dyed P/C fabric

Table 3 shows that the comparison on spectrophotometric evaluation of two baths and one bath dyed fabric by light sources D_{65}, TL_{83} and TL_{84}. The lightness (DL*),saturation (DC*), Hue (DH), CIE lab value for references (Da* and Db*), Total color deviations (DE) were evaluated between the samples of two bath and one bath dyed fabric samples. From the table it is seen that the value of DL*, Da*, Db* and Dc* are negative values in all the light sources which indicates that two bath dyed sample is darker than one bath one step dyed sample. The value of Da* is negative, so two bath dyed sample is less red than one bath one step dyed sample. The value of Db* is negative, so two bath dyed sample is bluer than one bath one step dyed sample. The value of DC* is negative, so two bath dyed sample is weaker in chroma difference than one bath one step dyed sample. DH and DE are positive values. The color difference DE value is more than 1 which means that the color difference is out of tolerance. It is required to adjust the dyeing recipe according to spectrophotometric evaluation to match the shade difference.

Table 3: Spectrophotometric evaluation of both dyed samples

Obs.	DL*	Da*	Db*	Dc*	DH	DE
D_{65}	-2.59	-4.35	-0.85	-4.27	1.20	5.13
TL_{83}	-3.06	-4.53	-1.46	-4.45	1.69	5.66
TL_{84}	-2.81	-4.48	-1.15	-4.28	1.75	5.42

Reflectance% evaluation

Figure 1 shows the reflectance (%) of two bath dyed sample and one bath dyed sample fabrics. It is known that, when reflectance is more, absorbance is less and when reflectance is less, absorbance is more. Reflectance (%) was measured in 400-450, 460-510, 520-570, 580-630, 640-690 and 700 nm wave lengths. For two bath dyed sample, the reflectance % was 7.6, 6.63, 7.4, 8.25, 18.47 and 41.13 respectively. For one bath dyed sample, the reflectance % was 9.24, 7.67, 8.57, 11.63, 22.27 and 42.28 respectively. It is clearly observed that the reflectance% of two bath dyed sample is less than one bath one step dyed sample which indicates that the depth of color of one bath sample is less than two bath dyed fabric sample.

K/S evaluation

Figure 2 shows the color strength (K/S) evaluation of two bath and one bath dyed fabric samples. The maximum K/S value was 6.57and 5.55 at 460-510 nm for two bath dyed fabric sample and one bath dyed fabric sample respectively and on the other hand the minimum K/S value was about 0.41and 0.39 at 700 nm. It can be mentioned from the both graph that two bath dyed fabric sample's color strength was 5.55, 5.79, 5.1, 1.79 and one bath dyed sample's color strength was 4.45, 4.87, 3.45, 1.35 respectively at 400-450, 520-570, 580-630 and 640-690 nm wave length. In all the cases the value was more for two bath than the one bath dyed fabric samples.

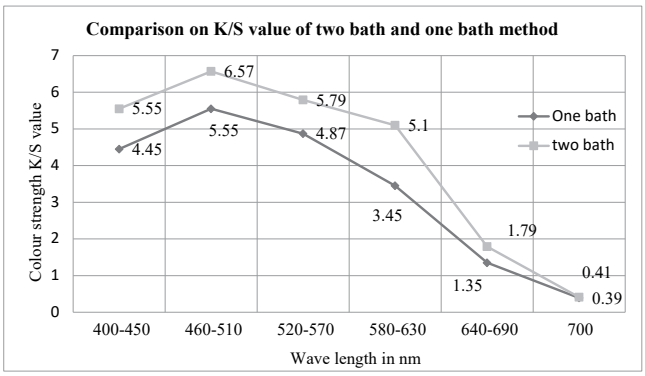


Figure 2: Comparison on K/S value of two bath and one bath dyed P/C fabric

Evaluation of wash fastness

Table 3 shows the results of color fastness to wash of one bath one step dyed sample and two bath dyed sample. In two bath process reduction clearing is done after polyester part dyeing which is not done in one bath process as a result wash fastness is higher of two bath dyed sample compared to one bath dyed sample. The grey scale rating of change in color of one bath dyed sample was 3/4 and for two bath sample was 4. The staining scale rating for acetate, bleached cotton, poly amide, polyester, acrylic, wool was 3, 4, 2/3, 3/4, 4 and 2/3 respectively for one bath and two bath dyed fabric sample. The staining result was good for all fibers.

Table 4: Wash fastness test results of both dyed samples

The changes in fibres	One bath one step method	Two bath method
Change in color	**3/4**	**4**
Staining in Acetate	**3**	**4/5**
Bleached cotton	**4**	**4/5**
Polyamide	**2/3**	**4**
Polyester	**3/4**	**4**
Acrylic	**4**	**4/5**
Wool	**2/3**	**5**

Evaluation of rubbing fastness

The samples of both fabrics were evaluated for rubbing fastness test. Table 4 illustrates the rubbing fastness in dry and wet condition of both dyed fabric samples. In dry rubbing for both fabrics the result was 4/5 which indicates very good and in wet rubbing the result was 4 for one bath process 4/5 for two bath process. Hence, it means that there was not any change in fastness with the change in process during dyeing.

Table 5: Rubbing fastness test results of both dyed samples

Rubbing test	One bath one step dyed sample	Two bath dyed sample
Dry	4/5	4/5
Wet	4	4/5

IV. Conclusion

Two baths dyed fabric sample is relatively darker than one bath single step dyed sample. The dyeing procedure is done in alkali medium, so cotton part of the blended fabric absorbs more dye comparative to polyester part. Two bath dyeing is relatively expensive than one bath single step dyeing process since chemical, water, utilities, cost & time is higher in two bath process. In one bath process production is two times higher than two baths dyeing & dyeing cost is about 50% less than two bath process. The environment friendly advantage of this process is that it reduces the use of chemical & extra water compared to two bath process which reduces extra cost of ETP (Effluent treatment plant) cost. If any light and medium shade is possible in one bath one step dyeing process for polyester/cotton woven fabric, it can be further studied.

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