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COMPARATIVE STUDY BETWEEN PIGMENT DYEING AND REACTIVE/DISPERSE DYEING ON POLYESTER/COTTON BLEND FABRIC

S. ISLAM AND N. AKTER

Department of Textile Engineering, Ahsanullah University of Science and Technology, 141-142 Love Road, Tejgaon I/A, Dhaka 1208. Bangladesh.

Corresponding author & address: Shaima Islam, E-mail: shimuu14@yahoo.com
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ABSTRACT

Islam S, Akter N (2012) Comparative study between pigment dyeing and reactive/disperse dyeing on polyester/cotton blend fabric. ***J. Innov. Dev. Strategy.*** 6(1), 40-48.

Polyester/cotton blended fabrics dyed with disperse/reactive dyes require a large amount of dyes, salt and chemicals which pollutes fresh watercourses. Due to the hydrolysis of the dye, the dyeing effluent consists of a large amount of hydrolyzed dye in a wash off process. The present study utilizes pigment which would not contribute to environmental pollution and undertaken to explore promising approach to reduce costs of dyeing process. In this work the polyester/cotton fabrics dyed with pigment was compared with disperse/reactive dyed polyester/cotton fabrics. For this a shade of three different concentrations; light, medium and deep were taken, dyed with disperse/reactive dye in conventional one bath two step processes and matched with pigment. The quality parameters like colour fastness to wash, rubbing, light and dry cleaning were assessed and compared with disperse/reactive dyed sample. The dyed sample showed good wash and light fastness properties within the range of colour change. In case of rubbing fastness light and medium shade showed good result but deep shade the result deteriorates and dry rubbing is better than wet rubbing. Pigment dyed sample showed unsatisfactory result of colour fastness to dry cleaning. The experimental data demonstrate that one bath pigment dyeing can be a suitable alternative dyeing process for polyester/cotton fabric against conventional dyeing.

Key words: *reactive dye, disperse dye, pigment dye, binder, polyester/cotton blend fabric*

INTRODUCTION

Fibres may be mixed together to generate a fabric with improved properties or to blend a less expensive fibre with a more expensive one to obtain a compromise between price and performance. When more than two or more different fibres are mixed intimately in a yarn and that yarn is used to make a fabric, the resulting mixture is referred to as a blend. Blends of polyester and cotton fibres have become very popular to the textile industry. Cotton gives the aesthetic and comfort properties demanded by consumers, while the polyester component adds to performance properties (www.ifc.net.au). Polyester cotton blend can be dyed in many traditional systems. In this article a comparative study between reactive/disperse dyeing and pigment dyeing on blend fabric was carried out and also different fastness properties determined.

To carry out this work Dianix CC dyes from Dianix series were used for dyeing polyester fibre. Dianix CC dyes are compatible and economical medium energy disperse dyes for rapid and reliable dyeing of polyester and polyester blends. Pad dry thermosol pad steam process was used to dye the sample by using disperse/reactive dye. The "Thermosol" process for dyeing polyester was developed by the DuPont Company in 1949 for the continuous dyeing of polyester fabrics (Arthur 2001). The process involves padding on the disperse dye together with auxiliaries that minimize migration, drying, then fixing the dye in the polyester by dry heating to a high temperatures about 190°C–205°C. During this process the fibre molecular chains open up at these elevated temperatures and the dispersed dyes vaporize and diffuse into the polymer. On cooling, the dyes are trapped within the fibre yielding coloured fibres that have good fastness properties (www.ifc.net.au).

Reactive dyes comprise a chromophore and a reactive group. They differ fundamentally from other dye-classes in the fact they chemically react with the textile fibre forming covalent bonds (Choudhury 2006). In this paper work reactive dye was applied on blend fabric with disperse dye on same bath by padding method. The reaction between the cellulosic fibre and the reactive dye takes place in the presence of water and alkali in a short time at elevated temperature. The rate of reaction is further increased at high pH values (Shenai 1980). Among the various classes of reactive dyes, Levafix CA dyes from Levafix series were used for dyeing cotton fibre. In the original Levafix dyes the reactive group was $–SO_2.NH.CH_2.CH_2.O.\ SO_2H$ (Tortman 1975). Effective washing after reactive dyeing is crucially important. At this stage the substrate contains unfixed hydrolysed dyes and usually some residual active dyes. The dyeing does not show optimal wet fastness properties until this loose colour is removed or rendered insignificant in amount (Shore 1995).

A pigment colorant is a colored organic substance that is not readily soluble in most common solvents and imparts coloration to textile substrates only when incorporated with an adequate binder system (North Carolina, Technical Bulletin 2007). Pigment dyeing is a process for colouring textiles which uses ground pigments, rather than a true dye. Pigment dyeing only coats the outside of the material, rather than fully penetrating it like a dye would. There are both advantages and disadvantages to pigment dyeing, as is the case with any type of technique colouring (www.wisegeek.com). One bath pigment dyeing offers considerable savings in cost, in equipment, and also in time, energy, and water. Another advantage offered by this process is the possibility of obtaining solid shades on all types of fibrous blends with one class of dye in one operation. An after wash is unnecessary. For this work Helizarin pigments were used. Like all pigments Helizarin are not substantive. The result is that the depth of shade depends on the liquor pick-up as well as the concentration of dye. The reproducibility of the recipe also excellent. The binder fixes the pigment to the fibre. It forms a film that binds the dye mainly physically to the substrate. Thus, the fastness properties of pigment dyeing are dependent mainly on the properties of binder. For this work Helizarin Binder CFF was used. It is a white, aqueous acrylic dispersion. It is miscible with cold water in all proportions and slightly anionic in nature.

MATERIALS AND METHODS

Fabric

The used fabric was 1/1 plain weave polyester/cotton (50:50) blend. The geometrical properties of the fabric are given in Table1.

Table 1. Geometrical properties of polyester/cotton fabric

Fabric	Ends/inch	Picks/inch	Areal Density (GSM)	Warp count(Ne)	Weft count(Ne)
Polyester/cotton	84	68	124	30	30

Dyes & chemicals

The details of the dyes and chemicals used are given in Table 2 and Table 3.

Table 2. Functions of dyes and chemicals used in pigment dyeing

SL No	Dyes and chemicals	Functions
1	Helizarin Red BT Helizarin Yellow FFGR Helizarin Blue	Dyeing
2	Helizarin Binder CFF	Binder
3	Siligen FA	Antimigrating agent
4	Vitexol PFA	Prevents foaming and coating on roller.
5	Kieralon XC-J	Wetting agent
6	Diammonium phosphate	Catalyst

Table 3. Functions of Dyes and chemicals used in reactive/disperse dyeing

SL No	Dyes and chemicals	Functions
1	Dianix Yellow Brown CC Dianix Rubine CC Dianix Blue CC	Dyeing for polyester part.
2	Levafix Amber CA Levafix Rubine CA Levafix Blue CA	Dyeing for cotton part.
3	Sera Wet C-AS	Wetting agent
4	Sera Gal M-IP	Antimigrating agent
5	Ludigol AR	Oxidizing agent
6	Acetic acid	To maintain P^H
7	Glauber salt	Anti bleeding agent
8	Soda ash and caustic soda	Fixing agent

Preparation of fabric: The fabric sample was singed, desized, scoured and bleached but not finished.

Dyeing: The fabric was dyed with reactive and disperse dye by pad dry thermosol pad steam (one bath two step) process. At first a shade was taken in three different concentrations: light (1.73g/l), medium (3.46g/l) and deep (7.25g/l). The process conditions for dyeing were given in Table 4

Table 4. Process conditions for reactive/disperse dyeing

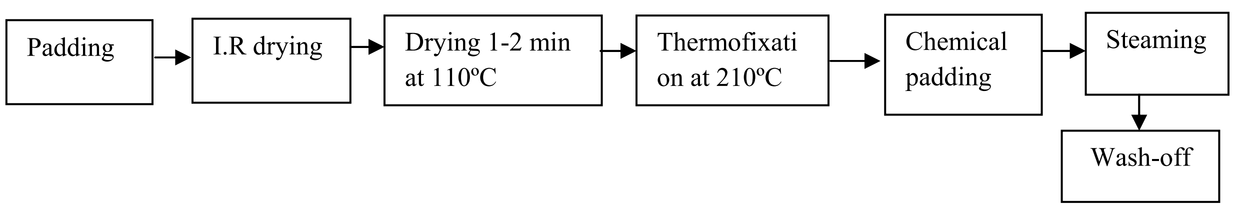
Dyes and chemicals	Light shade	Medium shade	Deep shade
Dianix Yellow Brown CC	0.30	0.60	1.2
Dianix Rubine CC	0.20	0.40	0.8
Dianix Blue CC	0.15	0.30	0.7
Levafix Amber CA	0.33	0.66	1.45
Levafix Rubine CA	0.60	1.2	2.4
Levafix Blue CA	0.15	.30	0.70
Sera Wet C-AS	1.0 g/l		
Sera Gal M-IP	10.0 g/l		
Ludigol AR	5.0 g/l		
Acetic acid	0.5 g/l		
Glauber salt	250 g/l		
Soda ash and caustic soda	20 g/l and 3 g/l		

Recipe for reduction clearing

Caustic soda	5 g/l
Sodium hydrosulphite	3 g/l
Sera wash MSF	1 g/l

Process sequence: The fabric was padded with disperse and reactive dye then the material passes through a pre dryer unit and dried 110ºC for 1/2 mins. The dried material containing the film of padding mixture is then heated to the thermosol unit at 210ºC for 1 min time then padded with Caustic soda and Sodium hydrosulphite. It then passes into a steaming chamber where the reactive dyes fixed and also reduction clearing of polyester part happens and finally washed off.

Process sequence for reactive and disperse dyeing.



After reactive and disperse dyeing the three shades; light, medium and dark were taken as standard and matched with pigment. The correction recipes were taken by Datacolor 650 spectrophotometer. The accepted ΔE values for these three shades were 0.5, 0.56 and 0.75 respectively. For matching light, medium and deep shade 6.118g/l, 14.8 g/l and 28.07 g/l pigments were required respectively. The process conditions for pigment dyeing were given in Table 5.

Table 5. Process conditions for pigment dyeing

Dyes and chemicals	Light shade (6.118 g/l)	Medium shade(14.8 g/l)	Deep shade(28.07 g/l)
Helizarin Red BT	5.49	11.8	21.41
Helizarin Yellow FFGR	0.094	2.07	4.64
Helizarin Blue	0.534	0.93	2.02
Helizarin Binder CFF	100 g/l		
Siligen FA	20 g/l		
Vitexol PFA	5 g/l		
Kieralon XC-J	2 g/l		
Diamonium phosphate	5 g/l		
Liquor P^H	7-6.5		

***Process sequence for pigment dyeing*.**

The fabric padded with dyes and chemicals, and then dried at 120ºC for 5 mins then cured at 180ºC for 45 sec.

Padding → Drying at 120ºC → Curing at 180ºC

Testing

The physical properties of the dyed fabric samples and the instruments used are given in Table 6.

Table 6. Physical properties of polyester/cotton fabric sample

No	Property	Standards	Instrument used
1	Colour fastness to wash	ISO 105 C06(C2S)	Gyrowash
2	Colour fastness to light	ISO 105 B02	Microsol
3	Colour fastness to drycleaning	ISO 105 D01	Launder-Ometer
4	Rubbing fastness	ISO 105 X12	Crockmeter
5	Areal density	BSEN-12127	GSM cutter

RESULT AND DISCUSSION

The results of colour fastness to wash are presented in Table 7 and Table 8.

Table 7. Colour fastness to wash for reactive/disperse and pigment dyed sample

Componenst of multifibre	Reactive/disperse dyed sample			Pigment dyed sample		
	Light shade	Medium shade	Dark shade	Light shade	Medium shade	Dark shade
Di-acetate	4	4	3-4	4	4-5	4-5
Bleached cotton	4	4	3-4	4-5	5	4-5
Polyamide	4-5	4-5	3-4	5	5	5
Polyester	3-4	4-5	4-5	4-5	5	4-5
Acrylic	4-5	5	4-5	4-5	5	5
Wool	5	5	5	5	5	5
Change of colour of the dyed sample	4-5	4-5	3-4	5	5	4-5

The results of rubbing fastness of the dyed samples are given in Table 9 and Table 10.

Table 8. Rubbing fastness for reactive/disperse and pigment dyed sample in warp direction

Rubbing fastness	Reactive/disperse dyed sample			Pigment dyed sample		
	Light shade	Medium shade	Dark shade	Light shade	Medium shade	Dark shade
Dry rub	5	5	5	5	4-5	4
Wet rub	5	5	4-5	4-5	4-5	4

Table 9. Rrubbing fastness for reactive/disperse and pigment dyed sample in weft direction

Rubbing fastness	Reactive/disperse dyed sample			Pigment dyed sample		
	Light shade	Medium shade	Dark shade	Light shade	Medium shade	Dark shade
Dry rub	5	5	4-5	4-5	4-5	4
Wet rub	5	5	4-5	5	4-5	4-5

The results for colour fastness to light is presented in table 10.

Table 10. Colour fastness to light for reactive-disperse and pigment dyed sample

Dyed sample	Light shade	Medium shade	Dark shade
Pigment dyed	3-4	4	4
Reactive and disperse dyed	2-3	2-3	2-3

The results for colour fastness to dry cleaning is presented in table 11.

Table 11. Colour fastness to dry cleaning for reactive-disperse and pigment dyed sample.

Change of colour of the dyed sample	Reactive/disperse dyed sample			Pigment dyed sample		
	Light shade	Medium shade	Dark shade	Light shade	Medium shade	Dark shade
	5	5	4-5	4	3-4	3-4

From Table 7, a comparison between, colour fastness to wash between pigment dyed sample and disperse/reactive dyed sample can be observed in the following figures:

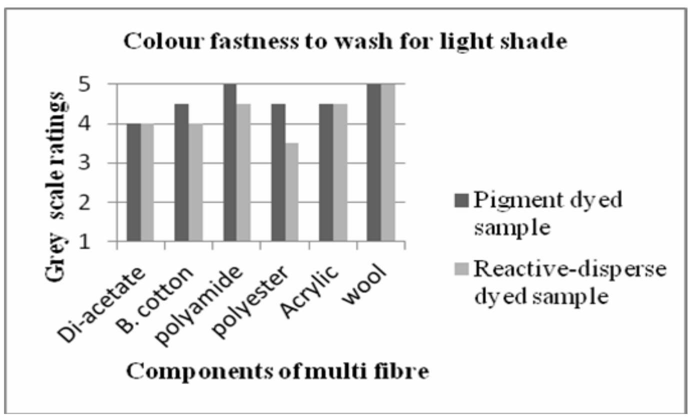


Fig. 1. Comparison of colour fastness to wash in pigment and disperse/reactive dyed sample

In figure-1, it is clearly observed that for light shade the grey scale ratings between pigments and disperse- reactive dyed samples for di-acetate, acrylic and wool are the same. Whereas in case of bleached cotton, polyester and polyamide pigment dyed sample shows better result than that of disperse and reactive dyed sample. This is because pigment being insoluble in water.

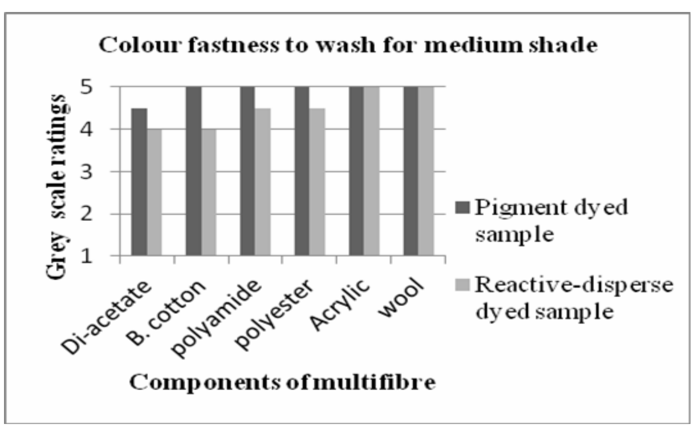


Fig. 2. Comparison of colour fastness to wash in pigment and disperse/reactive dyed sample

From figure-2, it can be found that for medium shade the grey scale ratings between pigments and disperse- reactive dyed samples for acrylic and wool are the same. On the contrary, in case of di-acetate, bleached cotton, polyester and polyamide pigment dyed sample shows better result than that of disperse-reactive dyed sample.

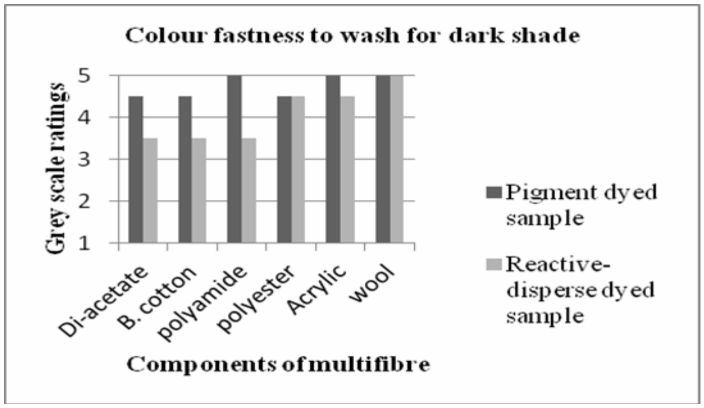


Fig. 3. Comparison of colour fastness to wash in pigment and disperse/reactive dyed sample

From figure-3, it can be found that for deep shade, in case of di-acetate, bleached cotton, polyamide and acrylic, pigment dyed sample shows much better result than that of disperse- reactive dyed sample. On the hand polyester and wool shows the same result.

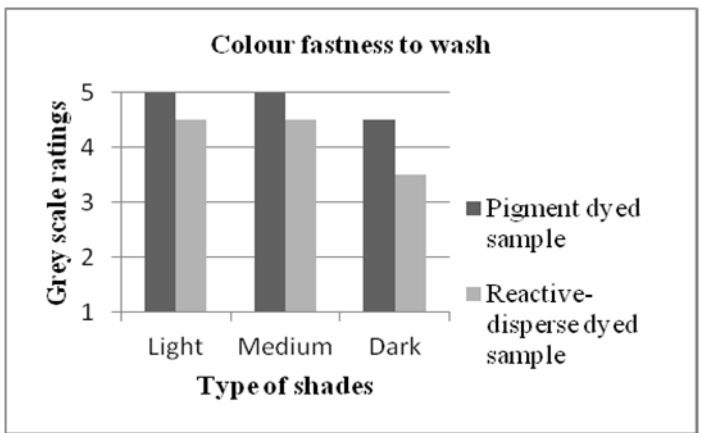


Fig. 4. Comparison of change of colour of the dyed samples

Figure-4 shows change of colour of dyed sample for light, medium and deep shade. The change of colour of the dyed sample is better in case of pigment dyed sample.

From Table 8 a comparison between, colour fastness to rubbing in warp direction between pigment dyed sample and disperse/reactive dyed sample can be observed in the following figures:

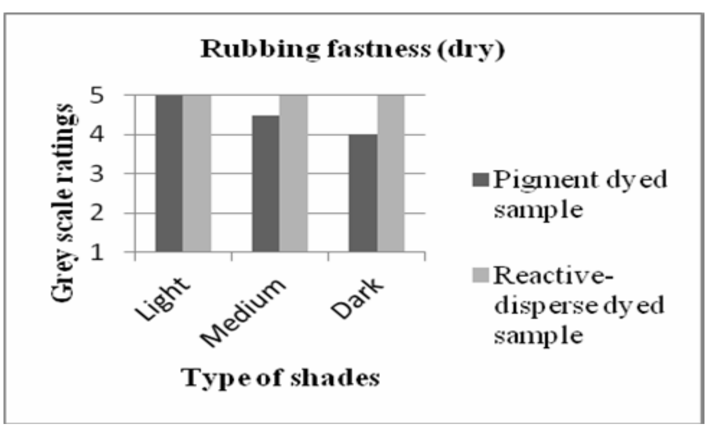


Fig. 5. Comparison of rubbing fastness in pigment and disperse/reactive dyed sample (warp direction)

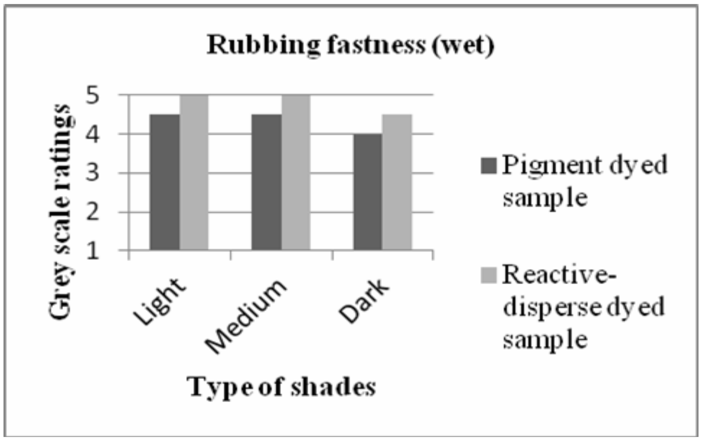


Fig. 6. Comparison of rubbing fastness in pigment and disperse/reactive dyed sample (warp direction)

Figure-5 and 6 Shows, both dry and wet rubbing fastness is slightly better in case of disperse and reactive dyed samples and in case of pigment dyed sample rubbing fastness decreases gradually from light to dark shade.

From Table 9 a comparison between, colour fastness to rubbing in weft direction between pigment dyed sample and disperse/reactive dyed sample can be observed in the following figures:

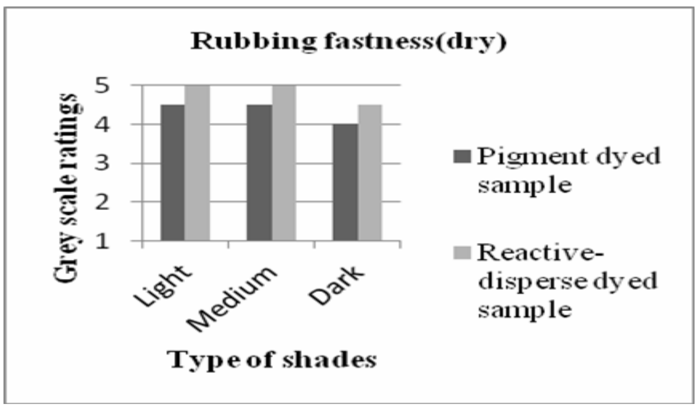


Fig.7. Comparison of rubbing fastness in pigment and disperse/reactive dyed sample (weft direction)

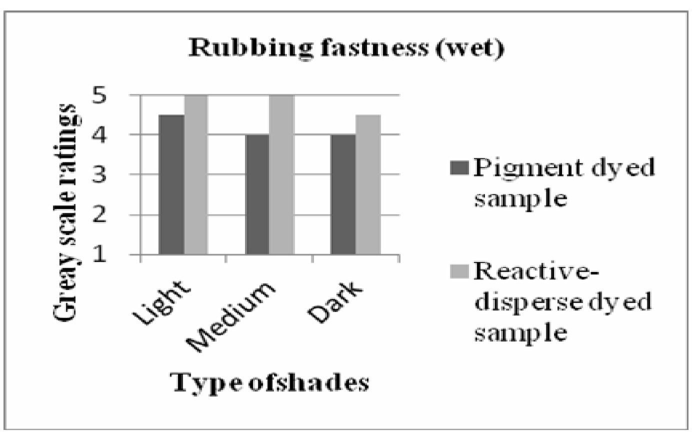


Fig. 8. Comparison of rubbing fastness in pigment and disperse/reactive dyed sample (weft direction)

Figure-7 and 8 also shows the same result for rubbing fastness in weft direction as in warp direction.

From Table 10,a comparison between, colour fastness to light between pigment dyed samples and disperse-reactive dyed samples can be observed in the following figure.

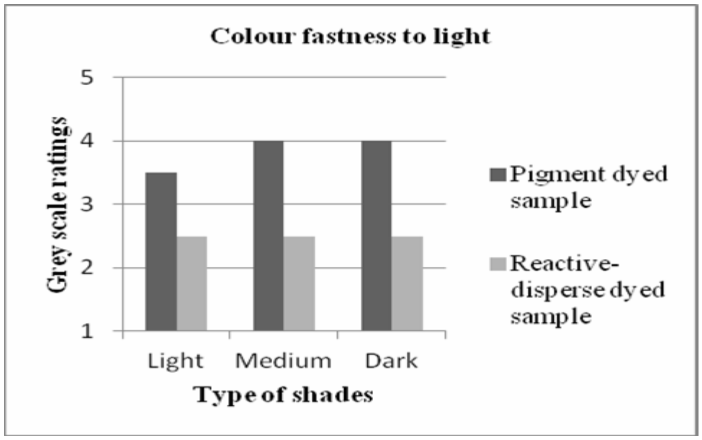


Fig. 9. Comparison of colour fastness to light in pigment and disperse/reactive dyed sample

In figure-9, it is clearly observed that colour fastness to light is much better in case of pigment dyed sample than that of disperse and reactive dyed sample. Moreover medium and deep shade shows better result than that of light shade.

From Table 11 for pigment and disperse/reactive dyed sample, a comparison of colour fastness to dry cleaning can be observed in the following figure:

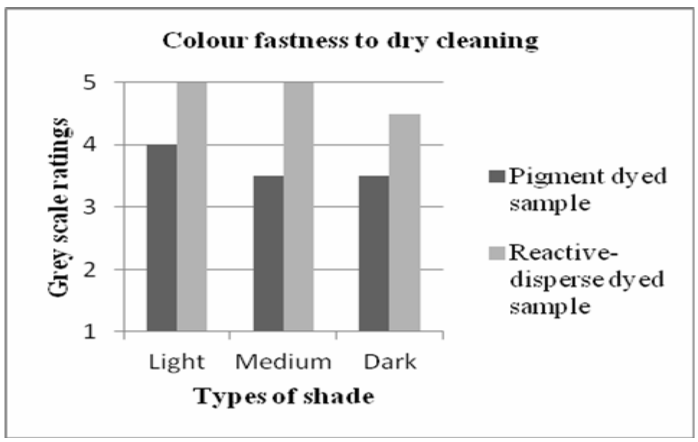


Fig. 10. Comparison of colour fastness to dry cleaning in pigment and disperse/reactive dyed sample

In figure-10, it is clearly observed that colour fastness to dry cleaning is much better in case of disperse and reactive dyed sample than that of pigment dyed sample as chlorinated hydrocarbons swell binder.

CONCLUSION

The analysis upon the evolution of study it is determined that dyeing of polyester/cotton blend fabrics with pigment is a suitable process. From the analysis it was found that pigment dyed sample showed higher wash fastness than that of conventionally dyed sample, moreover the pigment dyed sample showed very good light fastness. In case of colour fastness to dry cleaning disperse-reactive dyed fabric showed better result than pigment dyed sample. There was no significant change in rubbing fastness both warp and weft direction. Dry rubbing fastness is better than wet rubbing fastness. But rubbing fastness deteriorates from light to deep shade. Because to obtain deep shade a large amount of pigment require. For this reason pigment dyeing should be limited to pale and medium shades. Again as large amount of dye used in case of deep shade the hand feel of the fabric become poor. This study also investigate some advantages on pigment dyeing like significant savings in process cost as the process sequence is consists only of dyeing, drying and curing so limited number of equipment and chemicals used. It is therefore a very economic process. It reduces the use of water as wash-off process is not necessary. Finally it can be said that it is eco-friendly as less chemicals used.

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