Comparative Study on Dyeing Behavior of Crabyon and Viscose Rayon Fibres

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Abstract

The crabyon and viscose rayon fibres were dyed using four reactive dyes. The crabyon fibre showed better dye exhaustion and dye up take than viscose rayon fibre. The concentration of dyes in the spent dye bath of crabyon was found to be lower than viscose fibre. The increase in holding time of dyeing up to 60 minutes increases dye exhaustion and dye pick up. The dyed crabyon showed higher K/S value than viscose rayon fibre. The colour fastness to washing, perspiration and light properties of the dyed fibres were also evaluated.

1. Introduction

Crabyon, composite fibre of chitin/chitosan and cellulose, is manufactured by uniformly blending chitin/chitosan and cellulose viscose molecules and extruding the blended viscose into the spin bath. The idea behind the development of Crabyon is the fact that chemical structure of Chitin/Chitosan is quite similar to that of cellulose [1,2]. Chitosan is a linear polysaccharide, composed of randomly distributed β-(1-4)-linked D-glucosamine (deacetylated unit) and N-acetyl-D-glucosamine (acetylated unit). It is made by treating shrimp and other crustacean shells with the alkali sodium hydroxide [3]. As the structure of carbyon is similar to cellulose, it is expected that it will be dyed with all the cellulose class of dyes like direct, azo, and basic and reactive dyes [4]. In this paper an attempt has been made to compare the dyeing behavior of crabyon with viscose fibres using reactive dyes

2.0 Material and Methods

2.1 Fibre properties

Crabyon and viscose rayon fibre were procured from reputed manufacturers. The fibre properties of both the fibres are shown in the Table 1. From the table it can be seen that crabyon is quite comparable with viscose in terms of fibre denier,fibre strength and elongation. However the fibre length of crabyon found to be lower than viscose. It was also explicit from the Table 1 that the moisture regain of crabyon is higher than the viscose rayon.

Table-1 Fibre properties

S. No.	Test parameters	Test results	
		Viscose rayon	Crabyon
1.	Fibre denier (ASTM D 1577)	1.56	1.55
2.	Fibre length, mm (ASTM D 5867)	45	39
3.	Breaking strength, gm (ASTM D 3822)	4.25	4.55
4.	Tenacity, g/denier (ASTM D 3822)	2.73	2.92
5.	Elongation at break, % (ASTM D 3822)	18.21	18.91
6.	Moisture regain, % (ASTM D 2495)	11.00	11.39

2.2 Dyeing

Four reactive dyes such as Drimarene Red S RB, Drimarene Yellow HE6G, Drimarene Orange F2RI and Drimarene Black GRI were procured from M/s Clariant (India) Ltd. Fibres were dyed at 0.5% shade using various reactive dyes without pretreatment in the IR dyeing machine. For dyeing, dye bath was prepared using reactive dye, sodium chloride salt (40 g/L) and sodium carbonate (20 g/L). The material to liquor ratio (MLR) was maintained at 1:30.

The exhaust dyeing method was used for dyeing. Dyeing process began at 30^{o}C in dye baths containing 40 g/L sodium chloride, dye, fibre samples, and distilled water and dyeing was continued during 10 minutes at this temperature. The temperature of the bath was raised at the rate of 2^{0}C/min up to 60^{o}C. At this temperature four dyeing studies were carried out by changing dyeing holding times from 30 to 75 minutes. The sodium carbonate was added in two installments as shown in the Figures 1, 2, 3 and 4. After dyeing, the dye bath was cooled down in 10 minutes to 50^{o}C followed by soaping, rinsing with cold water and then dried.

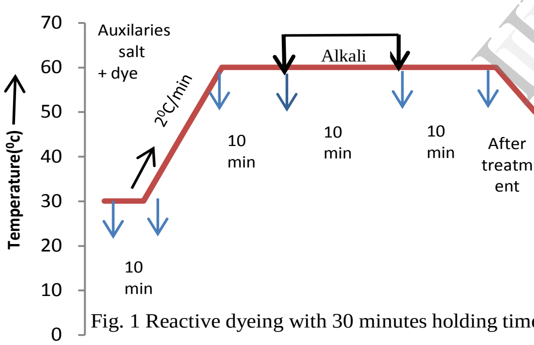

Fig. 1 Reactive dyeing with 30 minutes holding time

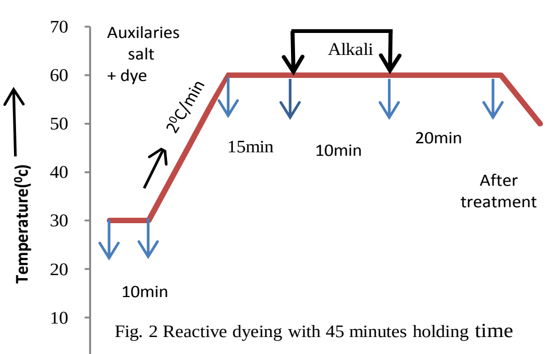

Fig. 2 Reactive dyeing with 45 minutes holding time

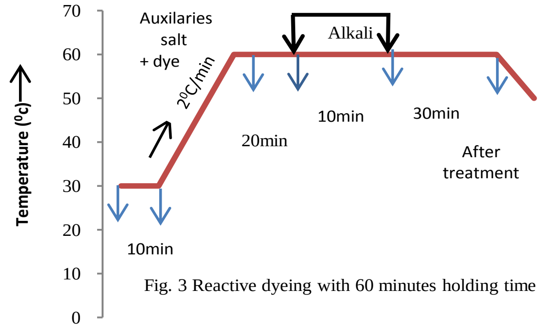

Fig. 3 Reactive dyeing with 60 minutes holding time

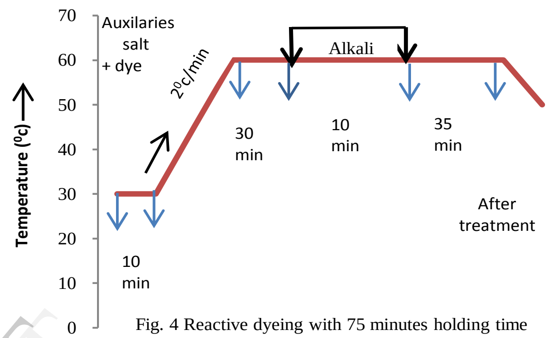

Fig. 4 Reactive dyeing with 75 minutes holding time

2.3 Dye Exhaustion and Spent Dye Bath Analysis

The extent of dye exhaustion for dyeing of crabyon and viscose rayon fibres at the end of the dyeing was estimated indirectly from absorption of the dye solutions measured at the wavelength of maximum absorption (Drimarene Red S RB : λ_{max} - 525, Drimarene Yellow HE6G : λ_{max} - 450nm, Drimarene Orange F2RI : λ_{max} - 490nm, Drimarene Black GRI : λ_{max} - 600nm) based on Beer-Lambert Law in the UV-Vis spectrophotometer of Shimadzu (U.V-160 A), Japan and from a calibration curve. Distilled water was used as a solvent during these measurements. The different absorbance values of the dye bath before and after dyeing were calculated. The dye exhaustion percentage (E) was measured using the following equation:

$$E(\%) = \{(A_o - A_i)/A_o\} X\ 100$$

Where A_o and A_i are the absorbance of the dye bath before and after dyeing [5].

The spent dye bath was analyzed to determine the concentrations of left over dye in the dye bath after dyeing using UV-Vis spectrophotometer. For this study, stock solution of each dyes were prepared and diluted to get different concentrations of dye solution. The absorbance of each of the dye solutions of known concentration were analyzed using spectrophotometer at λ_{max} and calibration curve were drawn and slop and intercept were determined. With the help of these, concentrations of dye in the spent dye bath quantified.

2.4 Dye uptake

The quantity of the dye uptake of the fibres (mg/gm) was determined using the following equation [5]:

$Q = C_i - C_f\ V/W$

Where Q = quantity of dye uptake
C_i and C_f = initial and final concentration of the dye in the solution (mg/gm)
V = volume of the dye bath (l)
W = weight of the fibre (g)

2.5 Color Measurement

Colour depth of the dyed fibres was analysed by measuring the K/S values using a Macbeth Color-Eye 3100 spectrophotometer. The K/S value are directly proportional to the concentration of colourant in the substrate. Higher the value of K/S, higher will be the concentration of dye in the substrate. The dyed fibres were combed to make them parallel and then attached neatly on the cardboard. The K/S values of the fibres were determined through Kubelka-Munk equation as given below:

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

Where R=reflectance percentage, K=absorption and S=scattering of dyes [6].

2.6 Color Fastness Properties

For assessment of quality of dyed fibres samples, color fastness to washing, light and perspiration properties were evaluated using ISO 105 C 10 A (1), ISO 105 B02 and ISO 105 E04 standard test methods respectively. Change in colour and staining on adjacent fibre of the dyed fibres were assessed by giving rating of 1(poor) to 5(excellent) by comparing with Grey scale in the case of colour fastness to washing and perspiration. The colour fastness to light was assessed by comparing the exposed fibres and blue wool standard nos 1 to 8.

3. Result and Discussions

3.1 Effect of Dyeing Time on Dye Exhaustion

Dyeing time duration is a very important dyeing parameter. When fibre is dipped into dye solution, equilibrium is established between dye in the fiber and dye in the solution. If the dyeing time duration is inappropriate then either dye will remain in solution or will start to shift from fibre to dye bath again. For selecting appropriate dyeing holding time, different conditions of time were selected. Effect of dyeing holding time on percentage exhaustion is shown in fig. 5 to 8 for all the four reactive dyes. It is clear from the figures that 60 minutes dyeing holding time was found to be appropriate after that hydrolysis decreased the exhaustion. It was also evident from the figures that percentage exhaustion around 75 percent was found to be maximum. If the dyeing beaviour of both the fibres is compared, it was found that crabyon picked up more dye from the dye bath i.e dye exhaustion percentage of crabyon is higher than viscose rayon fibre. The reason behind this is that because crabyon is composite fibre of chitin/chitosan and cellulose. It is well known fact that chitosan treated cellulose fabric contains higher number of dye sites than untreated cellulose fabric [7]. As results, the treated fabric absorbed more dyestuff than the untreated fabric and this absorption has increased the exhaustion percentage of dye in the treated fabric.

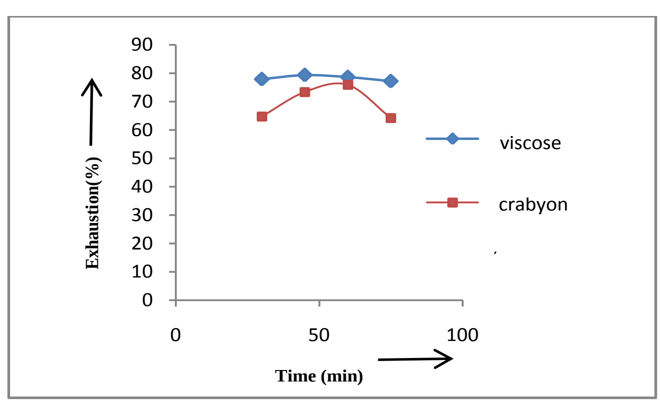

Fig. 5 Dye exhaustion (%) of Drimarene Red –S RB dye versus dyeing time

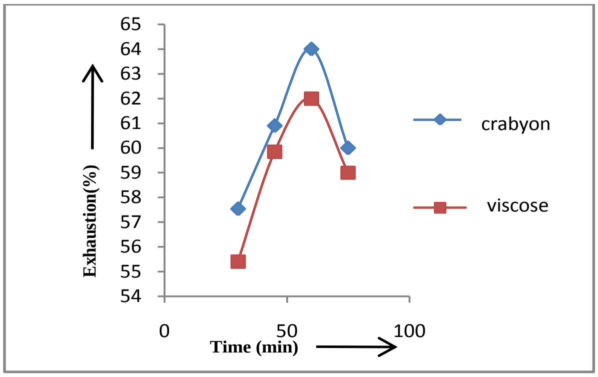

Fig.6 Dye exhaustion(%) versus dyeing time of Drimarene Orange F2RI dye at 60°C

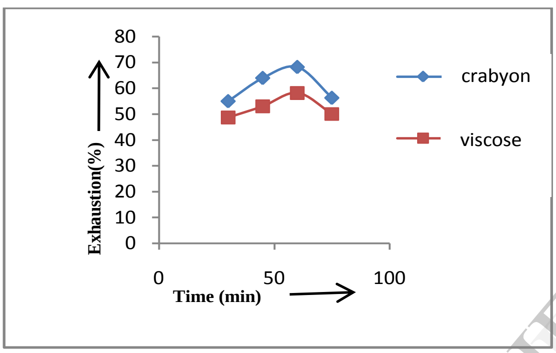

Fig.7 Dye exhaustion (%) versus dyeing time of Drimarene Yellow HE6G dye at 60°C

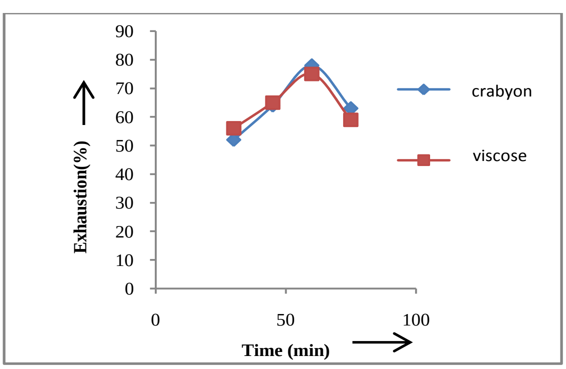

Fig.8 Dye exhaustion (%) versus dyeing time of Drimarene Black dye at 60°C

3.2 Concentration of Dye in the Spent Dye Bath

The left over dye in the spent dye bath was quantified using spectrophotometer at different time duration (holding time) of dyeing. Figures 9 to 12 show the effect of dyeing holding time on concentration of dye in the spent dye bath. From the figures it is clear that with the increase of holding time of dyeing the concentration of dye in the spent dye bath decreases. This decrease in the dye concentration continued up to 60 minutes of holding time after that it started increasing as dye start shifting from fibre to dye bath. The decrease in concentration with time is due to the fact that the dye exhaustion increases with the increase in holding time of dyeing. The decrease in concentration of dye in the spent dye bath is more in crabyon than viscose rayon fibre as it contains higher number of dye sites because it is a composite fibre of chitin/chitosan and cellulose [7]. Due to this the dye exhaustion is more in crabyon than viscose rayon. It is also clear that the increase in dye exhaustion is up to 60 minutes and after that the dye start shifting from fibre to dye bath.

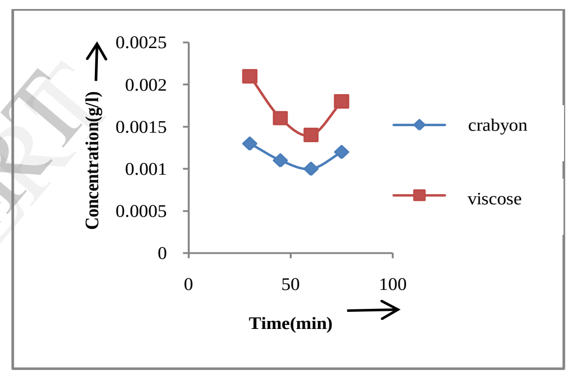

Fig.9 Concentration of dye in the spent dye bath of Drimarene Red –S RB dye versus dyeing time

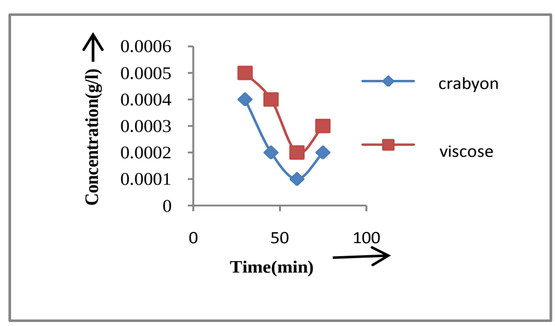

Fig.10 Concentration of dye in the spent dye bath of of Drimarene Orange F2RI dye versus dyeing time

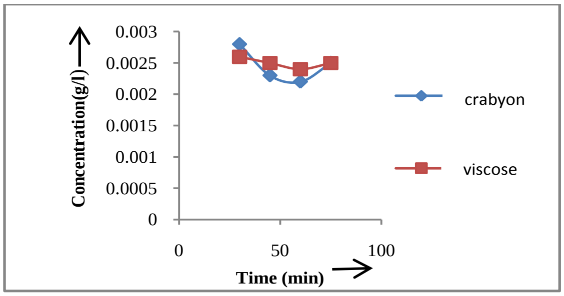

Fig.11 Concentration of dye in the spent dye bath of Drimarene Yellow HE6G dye versus dyeing time

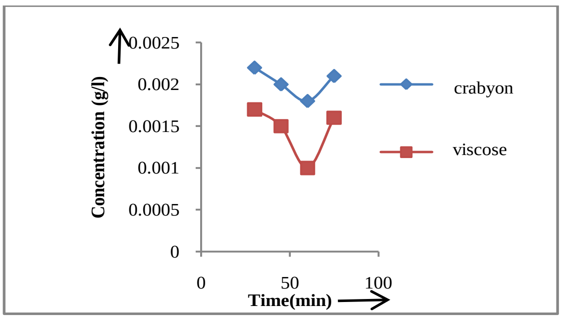

Fig.12 Concentration of dye in the spent dye bath of Drimarene Black GRI dye versus dyeing time

3.3 Effect of Dyeing Holding Time on Dye Uptake by Fibres

Figures 13 to 16 indicate that the dye uptake by the fibres at different holding time of dyeing. With the increase of holding time of dyeing, the dye uptake by fibres increases up to 60 minutes of time duration and after that it start decreasing as the equilibrium between dye in the fiber and dye in the solution shifted toward dye in the solution bath.

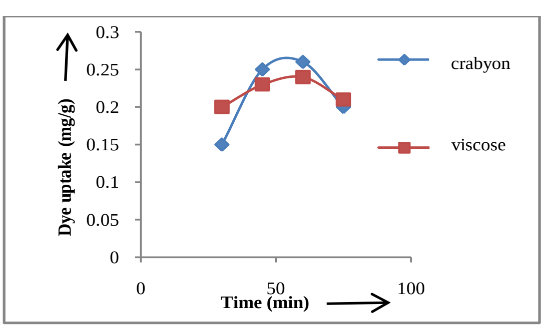

Fig.13 Dye uptake (mg/g) of Drimarene Red –S RB dye versus dyeing time (min)

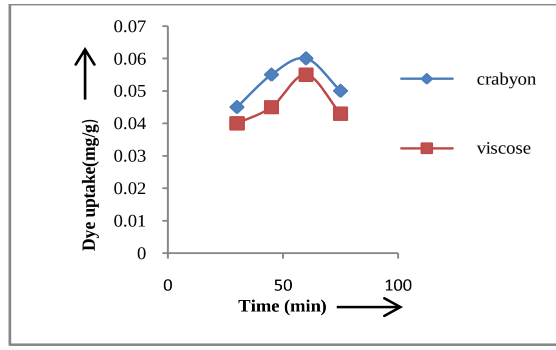

Fig.14 Dye uptake (mg/g) versus dyeing time (min) of Drimarene Orange F2RI

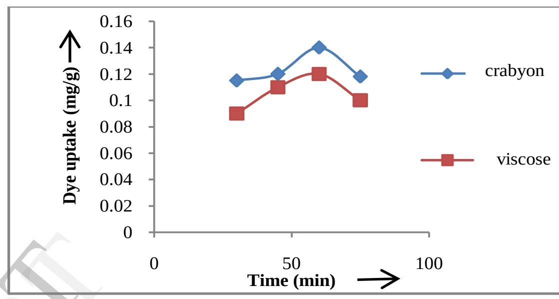

Fig.15 Dye uptake (mg/g) versus dyeing time (min) of Drimarene Yellow HE6G dye at 60°C

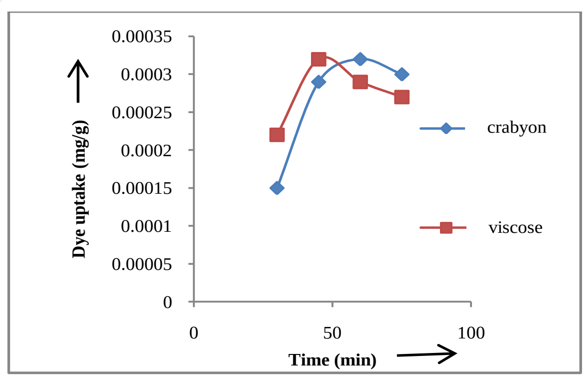

Fig. 16 Dye uptake (mg/g) versus dyeing time of Drimarene Black dye at 60°C

3.4 Color Measurement:

It has been found that the crabyon fibre have absorbed significantly higher amount of dyes than viscose rayon fibre for all the four reactive dyes as indicated by its higher K/S value than viscose rayon (Figures 17 to 20). It is also clear from the figures that with the increase in holding time of dyeing, the K/S value increases up to 60 minutes and then it start decreasing. This study further explained that dye pick up increases with the increase of holding time of dyeing up to 60 minutes and then it start decreasing due to shifting of dye from fibre to dye bath.

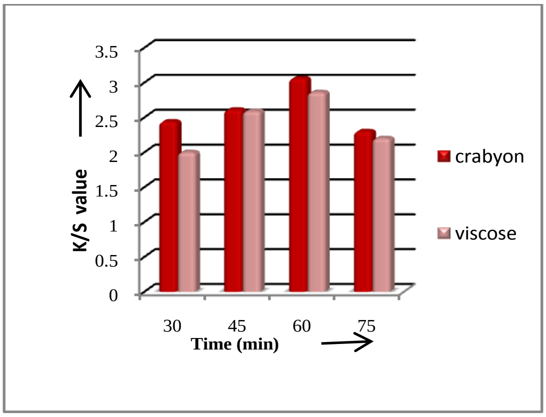

Fig.17 K/S value of Drimarene Red S-RB

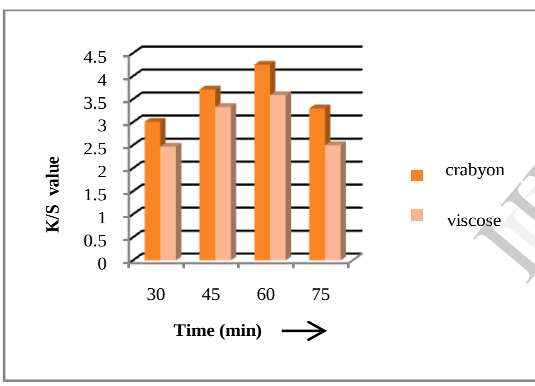

Fig.18 K/S value of Drimarene Orange F2RI

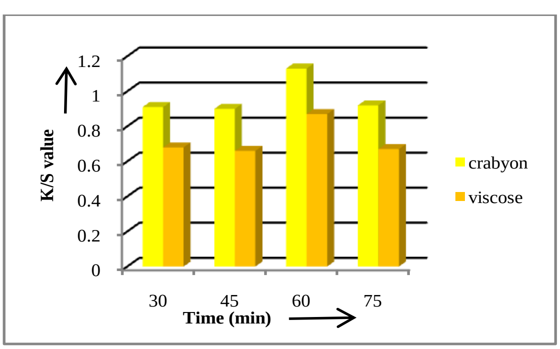

Fig.19 K/S value of Drimarene Yellow HE6G

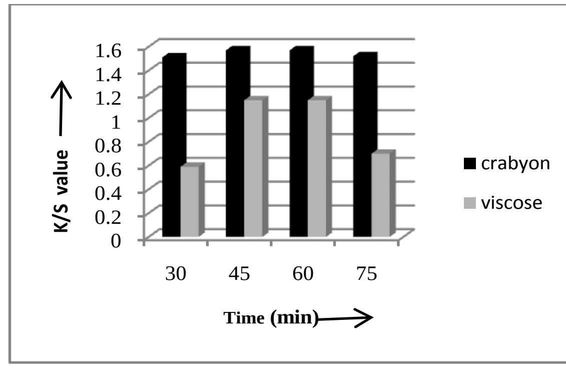

Fig.20 K/S value of Drimarene Black GRI

3.5 Color Fastness Properties:

As all the studies indicated that dye exhaustion is found to be higher at 60 minutes dye holding time, the fibres dyed at this time were taken for evaluating colour fastness to washing, perspiration and light properties. The results are reported in the Tables 2, 3 and 4. Colour fastness to washing was assessed for change in colour and staining on adjacent multifibres while the colour fastness to perspiration was analyzed to understand the effect of acidic and alkaline perspiration. For colour fastness to light, the change in colour of the dyed fibre after exposure to light was assessed by comparing corresponding blue wool standards. The colour fastness to washing results is shown in Table 2. From the table it is clear that change in colour and staining on adjacent fibres for both fibres were found to be 4-5. In the case of colour fastness to perspiration test (Table 4) the change in colour due to acidic and alkaline perspiration were 4-5. All the fibres have shown colour fastness to light grading 4-5 on blue wool as shown in the Table 3.

Table 2 Colour fastness to washing

Dyes Drimarene	CC*	Staining on multi fibre					
		W**	V#	S##	N@	C$	A$$
Crabyon fibre							
Red –S RB	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Yellow HE6G	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Orange F2RI	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Black GRI	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Viscose rayon fibre							
Red –S RB	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Yellow HE6G	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Orange F2RI	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Black GRI	4-5	4-5	4-5	4-5	4-5	4-5	4-5

CC*- colour change, W**- wool, V#-viscose, S##-silk, N@ -nylon
C$ - cotton, A$$-acetate

Table 3 Colour fastness to light

	Crabyon fibre	Viscose fibre
Dyes	**Change in colour, Grade (on blue wool)**	**Change in colour, Grade (on blue wool)**
Red S RB	4-5	4-5
Yellow HE6G	4-5	4-5
Orange F2RI	4-5	4-5
Black GRI	4-5	4-5

Table 4 Colour fastness to perspiration

Dyes	Fibres	CC*	Staining on multi fiber					
			W**	V#	S##	N@	C$	A$$
Alkaline perspiration								
Red -S RB	Crabyon	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Yellow HE6G	Crabyon	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Orange F2RI	Crabyon	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Black GRI	Crabyon	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Acidic Perspiration								
Red S RB	Crabyon	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Yellow HE6G	Crabyon	4-5	4-5	4-5	5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Orange F2RI	Crabyon	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Black GRI	Crabyon	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Viscose	4-5	4-5	4-5	4-5	4-5	4-5	4-5

4. Conclusion

The comparative dyeing study of crabyon and viscose fibres indicated that the dye exhaustion and dye uptake of crabyon fibre was higher than viscose rayon for all the four reactive dyes- Drimarene Red S RB , Drimarene Yellow HE6G , Drimarene Orange F2RI and Drimarene Black GRI. The rating of colorfastness to washing and perspiration for dyed crabyon and viscose fibre were found to be 4-5. The colour fastness to light grade on blue wool standards for all the dyed samples was 4-5.

ISSN: 2278-0181
Vol. 2 Issue 12, December - 2013

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