INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2001/03–1–95–98
http://www.ijab.org

Influence of Salt, Alkali and Dye Concentration on Washing, Light and Perspiration Fastness of Reactive Dyed Cotton Knitted Fabric

MUHAMMAD IFTIKHAR, NISAR AHMAD JAMIL AND BABAR SHAHBAZ
Department of Fibre Technology, University of Agriculture, Faisalabad-38040, Pakistan

ABSTRACT

This study was conducted to determine the effect of salt, alkali and dye concentration on washing, light and perspiration fastness of reactive dyed cotton knitted fabrics. The results revealed that excellent fastness for washing and light were achieved at minimum concentration of salt, alkali and dye; but excellent perspiration fastness was achieved at maximum concentration of alkali.

Key Words: Fabric; Dye; Salt; Alkali

INTRODUCTION

Colored fabrics are felt not only pleasant to human eyes, but also prove to be a source of satisfaction for human beings. Fabric is often not attractive when it comes directly from the looms, knitting machines, felting machines, etc. It needs many treatments like scouring, bleaching and mercerization before dyeing and printing processes. Reactive dyes are the only textile colorants designed to bond covalently with the substrate on application. Alkali is an essential ingredient of the recipe for reactive dyes. Reactive dyes have low molecular weight. If large quantity of salt is added, unlevelness in dyeing may appear as a result of quick exhaustion of the dyestuff. The achievement of level dyeing of correct shade is the main objective of the dyer. Textile dyers can control the cost and get even shades by using good quality dyes, proper quality control and concentration of various additives. This paper describes the influence of salt, alkali and dye concentration on washing, light and perspiration fastness of reactive dyed cotton knitted fabric.

MATERIALS AND METHODS

Single jersey fabric from 24^s combed yarn having knitting construction as 47 courses and 38 wales per inch was selected from the running material at the Masood Textile Mill (Pvt.) Ltd. Faisalabad. The fabric was given necessary pre-treatments for further dyeing process in the dye house of the same mill. The pre-treatments given to the gray cotton knitted fabric include scouring and bleaching processes, exhaust method was used in this treatment.

Cotton knitted fabric was put into the scouring bath at about 50°C and then raising the temperature of bath up to 90°C (at boiling) and maintained the temperature for one hour. The bath was then allowed to cool at low temperature the fabric was taken out, rinsed in hot and cold water, respectively. Finally, the sample was hydro extracted and dried (Anonymous, 1990). The scoured dry samples were put into the bleaching machine bath at about 40°C and then raised the temperature of bath up to 90°C for about one hour. The bath was allowed to cool and at low temperature the sample was taken out, rinsed first in hot and then in cold water. Finally, the sample was hydro extracted and dried as reported by Anonymous (1990). Cotton samples were dyed with exhaust method using three basic colors of dyes. The machine consists of three pots having red, blue and yellow reactive dye solutions i.e. D_1 1%, D_2 2% and D_3 3%. The dyeing process was started at 40°C and raised to 60°C. After about 10 minutes, NaCl was added to each pot or bath of the machine (concentrations of salt S_1 30%, S_2 40% and S_3 50%) and the automatic stirring was continued. After 30 minutes, alkali (Na_2CO_3) was added to each bath and process was continued for further 30 minutes in varying concentrations of alkali i.e. A_1 20%, A_2 30% and A_3 40%. The temperature was brought to 40°C and fabric were taken out of the dye bath, rinsed in hot water and boiled in soap solution for two minutes having 0.5% sandopan LFW at 60-70°C. Finally, the samples were washed in cold water and dried at room temperature (Anonymous, 1990). The tests of dyed fabric for washing, light and perspiration fastness were performed according to International Organization for Standardization (ISO) rating.

RESULTS AND DISCUSSION

Washing fastness. Overall gray scale rating for both change of shade and staining ranged from 4-5 (very good to excellent) to 5 (excellent; Table I). Previously De-Giorgi and Cerniani (1985) reported excellent washing fastness for reactive dyed samples. On the other hand, Bernard (1980) recorded good washing fastness of reactive dyed samples. Excellent washing fastness (gray scale rating 5) obtained with D_1 at 10% alkali indicates that the pH level must be

Table I. Effect of salt alkali and dye concentration on the washing fastness of reactive dyed cotton knitted fabric

Variables			Red		Blue		Yellow	
Salt	Alk	Dye	CS	ST	CS	ST	CS	ST
		D_1	5	5	5	5	5	5
	A_1	D_2	4-5	4-5	4-5	4-5	4-5	4-5
		D_3	4-5	4-5	4-5	4-5	4-5	4-5
		D_1	4-5	4-5	4-5	4-5	4-5	4-5
S_1	A_2	D_2	5	5	5	5	5	5
		D_3	4-5	4-5	4-5	4-5	4-5	4-5
		D_1	4-5	4-5	4-5	4-5	4-5	4-5
	A_3	D_2	4-5	4-5	4-5	4-5	4-5	4-5
		D_3	5	5	5	5	5	5
		D_1	5	5	5	5	5	5
	A_1	D_2	4-5	4-5	4-5	4-5	4-5	4-5
		D_3	4-5	4-5	4-5	4-5	4-5	4-5
		D_1	4-5	4-5	4-5	4-5	4-5	4-5
S_2	A_2	D_2	5	5	5	5	5	5
		D_3	4-5	4-5	4-5	4-5	4-5	4-5
		D_1	4-5	4-5	4-5	4-5	4-5	4-5
	A_3	D_2	4-5	4-5	4-5	4-5	4-5	4-5
		D_3	5	5	5	5	5	5
		D_1	5	5	5	5	5	5
	A_1	D_2	4-5	4-5	4-5	4-5	4-5	4-5
		D_3	4-5	4-5	4-5	4-5	4-5	4-5
		D_1	4-5	4-5	4-5	4-5	4-5	4-5
S_3	A_2	D_2	5	5	5	5	5	5
		D_3	4-5	4-5	4-5	4-5	4-5	4-5
		D_1	4-5	4-5	4-5	4-5	4-5	4-5
	A_3	D_2	4-5	4-5	4-5	4-5	4-5	4-5
		D_3	5	5	5	5	5	5

Alk=alkali; CS=Change of shade; ST= Staining;
Standard gray scale rating; 5= Excellent; 4= Very good;
3= Good; 2= Moderate; 1= Poor;
Salt concentrations: S_1= 30%, S_2= 40%, S_3= 50%;
Alkali concentrations: A_1= 10%, A_2= 20%, A_3= 30%;
Dye concentrations: D_1= 1%, D_2= 2%, D_3= 3%

kept as low as possible in order to minimize the consumption of dyes and to achieve better washing fastness. This evidence gets some favor from Anonymous (1999) who mentioned that increasing quantities of alkali would favor maximum reaction between dye and fiber, but in practice an optimum level of alkali rather than the maximum has to be sought.

Previously, Kamel *et al*. (1992) reported that sodium carbonate is added for the constant control of pH value to neutralize the liberated HCl during the reaction. While Trotman (1964) stated that before alkali treatment, the color of the reactive dyed fabric can be washed out with repeated extraction with water, but afterwards, it was fast to boiling soap solution. The gray scale rating for both change of shade and staining is 5 (excellent; Table I) for D_1 (1%), for red, blue and yellow samples. However, at D_2 (2%) and D_3 (3%), the rating was 4-5 (very good to excellent) for all samples. By increasing the concentration of dye (at minimum pH value), the washing fastness of the reactive dyed cotton samples was reduced. However, 2% dye concentration gave excellent results (gray sale rating 5) at A_2 and at 3%, the excellent result for washing fastness are achieved at A_3 for red blue and yellow samples. The gray scale rating remained very good to excellent for the washing fastness of reactive dyed cotton samples.

Previously, Imada *et al*. (1994) endorsed that in the cotton fabrics dyed with reactive dyes, the washing treatment showed very little color change. While Lidyard *et al.* (1992) stated that from the exhaust application of reactive dyes, the reduction in the use of chemical, electrolyte, alkali and water bring economic consideration. Sheikh (2000) reported that alkali is an essential ingredient of the recipe for reactive dyes. It ionizes cellulosic fibres and activates reactive dyes. Similarly, Warner (1955) reported that the washing fastness of a cotton dyed fabric is not entirely a function of the coloring material used. The processing methods have also same influence on the fastness properties of any given dye stuff.

Light fastness. Overall blue scale rating for red and yellow samples ranges from 3-4 to 4-5 (moderate to good) and for blue samples 4-5 (good) to 6-7 (very good) as shown in Table II. Previously, De-Giorgi and Cerniani (1985) reported that reactive dyes had excellent light fastness. Minimum salt concentration (S_1) achieved good results (blue scale rating 4-5) at the concentration A_1 and D_1 for red and yellow samples while very good results (blue scale rating 6-7) were recorded for blue samples at the same concentrations. However, at higher concentrations of alkali (A_2 and A_3) and the same concentration of salt (S_1) and dye (D_1) slightly inferior rating i.e. 4 for red and yellow, 5-6 for blue samples was recorded. Similar trend was observed for other concentration of dye (D_2 and D_3). Like salt concentrations (S_2 and S_3), the deterioration in the light fastness was also evident at higher alkali concentration (A_1 and A_2).

It is, therefore, concluded that for achieving better light fastness, the pH level must be kept as low as possible. Previously, Imada and Harada (1992) observed that the pH value of the dye bath affects both the degree and rate of fixation of reactive dyes on cotton. The optimum pH range will depend on the nature of dye employed.

Likewise, Warner (1955) narrated that the factor which affect the degree to which color will run or bleed are temperature and pH of the solution. It is evident from the results that by increasing the dye concentration, the fastness to light decreased. For D_1, the blue scale rating 4 to 4-5 for red and yellow samples while 5-6 to 6-7 for blue sample was recorded. However, at D_2 the rating becomes 3 to 4 for red and yellow samples and 5-6 for blue samples. Further increase in dye concentration (D_3) resulted in 3 to 4 rating for red and yellow and 4-5 to 6 for blue samples.

Table II. Effect of salt alkali and dye concentration on the light fastness of reactive dyed cotton knitted fabric

Variables			Colour		
Salt	Alkali	Dye	Red	Blue	Yellow
		D_1	4-5	6-7	4-5
	A_1	D_2	4	6	4
		D_3	4	6	4
		D_1	4	6	4
S_1	A_2	D_2	4	5-6	4
		D_3	3-4	5-6	3-4
		D_1	4	5-6	4
	A_3	D_2	3-4	5-6	3-4
		D_3	3-4	5	3-4
		D_1	4	6	4
	A_1	D_2	4	6	4
		D_3	3-4	5-6	3-4
		D_1	4	6	4
S_2	A_2	D_2	3-4	5-6	3-4
		D_3	3-4	5-6	3-4
		D_1	4	5-6	4
	A_3	D_2	3-4	5-6	3-4
		D_3	3-4	5	3-4
		D_1	4	5-6	4
	A_1	D_2	3-4	5-6	3-4
		D_3	3-4	5	3-4
		D_1	4	5-6	4
S_3	A_2	D_2	3	5	3
		D_3	3	5	3
		D_1	3-4	5	3-4
	A_3	D_2	3	4-5	3
		D_3	3	4-5	3

Standard blue scale rating: 8= Excellent, 6-7= Very good, 4-5= Good, 3= Moderate, 2= Poor, 1= Very poor
Salt concentrations: S_1= 30%, S_2= 40%, S_3= 50%
Alkali concentrations: A_1= 10%, A_2= 20%, A_3= 30%
Dye concentrations: D_1= 1%, D_2= 2%, D_3= 3%

For different amounts of salt (S_1, S_2, S_3), the range of gray scale rating for S_1 and S_2 remained 4 to 4-5 (good) and for S_3, rating was 3 to 3-4 (moderate to good) for the light fastness of red and yellow reactive dyed cotton knitted samples. While for blue samples the gray scale rating was 5 to 6-7 for S_1 5 to 6 for S_2, 4-5 to 5-6 for S_3. It is evident from the results that by increasing the concentration of salt the fabric showed relatively poor performance for light fastness. The results get confirmation from the findings of Anonymous (1994) who stated that at higher concentration of salt un-levelled and spotty dyeing resulted. It happens due to aggregation of dye molecules, precipitation of the heavy metal sulphate and chlorides. Likewise, Sheikh (2000) expressed that reactive dyes have low molecular weight if large quantities of salt is added, unlevelness in dyeing may appear as a result of quick exhaustion. Sometimes, high quantity of salt reduces solubility of dyes. Woodcock *et al.* (1992) also reported that the substantiality of reactive dye can be controlled by altering the electrolyte concentration. When the electrolyte concentration is reduced, a greater repulsion exists between the anionic dye and the ionized secondary hydroxyl group of cellulose and a reduction in the substantivity equilibrium is achieved. On the other hand, Shad (1987) endorsed that for dye stuff fixation a proper amount of alkali was added to color paste.

Perspiration fastness. The results show that the over all gray scale rating for red, blue and yellow samples are 4 to 5 (very good to excellent) for change of shade and in acidic perspiration and 4 (very good) to 4-5 (very good to excellent) for change of shade in alkaline perspiration. While the range of 4 (very good) to 5 (excellent) for staining in acidic solution and 3-4 to 5 for alkaline solution for red, blue and yellow samples was recorded as shown in Table III. Previously, Bernard (1980) also described that the perspiration and crocking fastness of reactive dyes were good.

At concentrations S_1 and A_3, the gray scale rating for both change of shade and staining was 5 (excellent) in acidic perspiration and 4-5 (very good to excellent) to 5 (excellent) in alkaline perspiration was achieved. So it is obvious that perspiration fastness increases with the increase of alkali concentration. The present results agree with the findings of Anonymous (1994) who pointed out that most of the dye molecules have been physically absorbed on to the surface of the fiber and are thus ideally cited for reaction with alkali, the ready ionization of hydroxyl group on the cellulose molecule sets up and internal pH within the fiber that is primarily maintained by cellulosate anions the resultant change on that fiber surface expelling hydroxide ions from the fiber interior. While Warner (1955) reported that color fastness is complicated and difficult to evaluate; it depends not only upon the nature of the coloring matter, but also on the fiber composition of textile material, the method used in dyeing. On the other hand, it is interesting to note that at S_2 and S_3 the minimum concentration of alkali (A_1) gave very good to excellent (gray scale rating 4-5) results for change of shade and very good (gray scale rating 4) of staining at both acidic and alkaline tests, except for S_3 and A_1 which recorded 4-5 rating for staining at acidic solution. Previously, Imada and Harada (1992) reported that the pH value of dye bath affects both the degree and rate of fixation of reactive dyes on cotton. It is evident from Table III that at A_2 and S_2, both change of shade and staining for both acidic and alkali perspiration was 4 (very good).

Similarly, at higher level of salt and alkali (S_3, A_3), gray scale rating was 4 for change of shade and 3-4 for staining in both acidic and in alkaline perspiration. The present results agree with the findings of Anonymous (1994) reported that at higher concentration of salt un-levelled and spotty dyeing resulted.

Table III. Effect of salt alkali and dye concentration on the perspiration fastness of reactive dyed cotton knitted fabric

Variables			Red				Blue				Yellow			
Salt	Alk	Dye	Acidic		Alkaline		Acidic		Alkaline		Acidic		Alkaline	
			CS	ST	CS	ST	CS	ST	CS	ST	CS	ST	CS	ST
		D_1	5	4-5	4-5	4	5	4-5	4-5	4	5	4-5	4-5	4
	A_1	D_2	5	4-5	4-5	4	5	4-5	4-5	4	5	4-5	4-5	4
		D_3	5	4-5	4-5	4	5	4-5	4-5	4	5	4-5	4-5	4
		D_1	5	4-5	4-5	4	5	4-5	4-5	4	5	4-5	4-5	4
S_1	A_2	D_2	5	4-5	4-5	4	5	4-5	4-5	4	5	4-5	4-5	4
		D_3	5	4-5	4-5	4	5	4-5	4-5	4	5	4-5	4-5	4
		D_1	5	5	4-5	5	5	5	4-5	5	5	5	4-5	5
	A_3	D_2	5	5	4-5	5	5	5	4-5	5	5	5	4-5	5
		D_3	5	5	4-5	5	5	5	4-5	5	5	5	4-5	5
		D_1	4-5	4	4-5	4	4-5	4	4-5	4	4-5	4	4-5	4
	A_1	D_2	4-5	4	4-5	4	4-5	4	4-5	4	4-5	4	4-5	4
		D_3	4-5	4	4-5	4	4-5	4	4-5	4	4-5	4	4-5	4
		D_1	4	4	4	4	4	4	4	4	4	4	4	4
S_2	A_2	D_2	4	4	4	4	4	4	4	4	4	4	4	4
		D_3	4	4	4	4	4	4	4	4	4	4	4	4
		D_1	4	4	4	3-4	4	4	4	4	4	4	4	4
	A_3	D_2	4	4	4	3-4	4	4	4	4	4	4	4	4
		D_3	4	4	4	3-4	4	4	4	4	4	4	4	4
		D_1	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	A_1	D_2	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D_3	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D_1	4	4	4	4	4	4	4	4	4	4	4	4
S_3	A_2	D_2	4	4	4	4	4	4	4	4	4	4	4	4
		D_3	4	4	4	4	4	4	4	4	4	4	4	4
		D_1	4	3-4	4	3-4	4	3-4	4	3-4	4	3-4	4	3-4
	A_3	D_2	4	3-4	4	3-4	4	3-4	4	3-4	4	3-4	4	3-4
		D_3	4	3-4	4	3-4	4	3-4	4	3-4	4	3-4	4	3-4

Alk=alkali; CS=Change of shade; ST= Staining; Standard gray scale rating: 5= Excellent, 4= Very good, 3= Good, 2= Moderate, 1= Poor
Alkali concentrations: A_1= 10%, A_2= 20%, A_3= 30%; Salt concentrations: S_1= 30%, S_2= 40%, S_3= 50%; Dye concentrations: D_1= 1%, D_2= 2%, D_3= 3%

CONCLUSIONS

Varying concentrations of alkali, dye and salt influenced the dyeing of cotton fabrics with reactive dyes. Excellent results for washing and light fastness were recorded at 30% salt concentration, 10% alkali and 1% dye concentration. However, perspiration fastness improved at maximum concentration alkali. But with the increase of salt (S_3) the perspiration fastness decreased.

REFERENCES

Anonymous, 1990. *Standard Methods for Determination of Color Fastness of Textiles and Leather.* 5th Ed., The society of dyers and colourists. USA. Pp. 619–30.

Anonymous, 1995. *Pretreatment of Viscose fabrics. Dyeing with Remazol Dyes.* Hoechst Technical Information Manual, F. Hochst (W. Germany): 7.

Anonymous, 1999. Reactive dyes for warm application. *Textile Asia,* 30: 109.

Anonymous, 1994. *Technical Information on Continuous Dyeing of Cellulosics.* CH-3, Soc. of Dyers and Col.

Baxter, G.C., H. Giles, M.M. Mekee and N. Macaulary, 1979. Influence of physical state of dyes on their light fastness. *Text. Res. J.,* 49: 260.

Beckmann, W. and F. Hoffmann, 1977. Exhaust Dyeing Processes. *J.S.D.C.,* 93: 11.

Bernard, P.C., 1980. *Fibre to Fabric.* McGraw-Hill, Inc. Library of Congress Catalog Card No. 66-21868, USA.

De- Giorgi, M.R. and A. Cerniani, 1985. Some dyeing properties of dichlorotriazinyl reactive azo dyes for cotton. *Wrld. Text. Abst.,* 17: 3851

Imada K. and N. Harada, 1992. Recent developments in the optimised dyeing of cellulose using reactive dyes. *J.S.D.C.,* 108: 210–14.

Imada, K., N. Harada and T. Takagishi, 1994. Fading of azo reactive dyes by perspiration and light. *J.S.D.C.,* 110: 231.

Kamel. M.M., M.M. Kamel and M. Kamel, 1992. The addition of reactive compounds to nonreactive dyebaths. Part 5 - procedure for obtaining reactive dyeings on cotton. *J.S.D.C.*, 108: 450–53.

Lidyard, A.M., A. Woodcock and P. Noonet, 1992. Economic considerations from the exhaust application of reactive dyes under ultra-low liquor ratio conditions. *J.S.D.C.*, 108: 501–4.

Shad, M.A., 1987. Printing cotton with reactive dyes. *Textech., Nat. Coll. Text. Engg.,* 57–8.

Sheikh, H.R., 2000. Wet processing: Technology and Processing Part II. *Pakistan Text. J.,* 49: 27–31.

Trotman, E.R., 1964. *The Chemical Technology of Fibrous Material.* Charles Griffin & Co. Ltd., Landon, UK.

Warner, K.R., 1955. Chemistry and Chemical Technology of Cotton. CH.

XII: 617.

(Received 20 November 2000; Accepted 15 December 2000)