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# Clever Strategies: Salt Free Dyeing Design with Acidic (Neucleophilic Dyeing Method) and Alkaline (Electrophilic Dyeing Method) Process on Pure Cotton Fabric by Using Reactive Dye

# Kunal S1\*, Arijit DV<sup>2</sup>, Dhalwinder S<sup>2</sup>, Joshika G<sup>2</sup>, Shanti K<sup>3</sup>, Satyajit B3, Chakraborty<sup>3</sup> and Raja M<sup>3</sup>

<sup>1</sup>Assistant Professor, Department of Textile Engineering, Panipat Institute of Engineering & Technology, Harayana, India <sup>2</sup>Department of Textile Engineering, Panipat Institute of Engineering & Technology, Harayana, India <sup>3</sup>Department of Textile Technology, Govt. College of Engineering and Textile Technology, West Bengal, India

### Abstract

The reactive dye produce a lot of effluent problems in terms of % AOX, BOD, COD, TDS etc. in spite of its capability of produce wide range of colours and varieties of gamut in hue. In addition the use of salt as electrolytes provides higher chances of eco-hazardous impact problems and end-users comfort related properties. The % dye fixation is being always a problem to reactive dyeing on cotton due to the higher degree of dye hydrolyzation inside the dye bath. In this current work we had tried to develop an unconventional reactive process in both like salt free acidic medium reactive dyeing and salt free alkaline dyeing on pure cotton fabric. Results of the current study shows that alkaline medium salt free reactive dyeing on cotton shows higher colour strength (K/S value), good mechanical properties-bending length modulus, flexural modulus, less generation of the % AOX etc. It also can be concluded that acidic medium salt free reactive dyeing is also better in terms of quality than the conventional reactive dyeing method in the industries.

Keywords: % AOX; BOD; COD; TDS; Salt free acidic; Alkaline dyeing

### Materials and Methods

### Cotton fabric material

100% cotton knitted fabric (single jersey) was procured from Nahar Industries Ltd. Ludhiana, Punjab, India. Combed cotton yarns with linear densities of 29.53 tex (20S Ne) and with a twist factors (33.5), 44 mm staple cotton length was chosen as the raw materials (single jersey knitted 100% cotton fabric with a wpi of 28 and cpi 24).

### Dyes and chemicals

We had used Reactive Red HE8B dye (CI Reactive Red 152, Clariant, India) dye for dyeing of material in a 0.5%, 1% and 3% of shade were used for this study. A nonionic detergent (Felosan RGN-S; CHT) was used for washing off. Deionised water was used for pad-steam dyeing method.

### Pad-stream dyeing method

Fabric samples were dyed by 0.5%, 1%, 3% shade with Reactive Red HE8B dye and the relevant amounts of inorganic electrolyte and alkali or organic salt) by padding (two dip-two nip, 70% liquor pickup, Benz laboratory padder, Germany). The padded fabrics were then steamed for 60 sec (Figure 5). The whole experiment was divided into three parts;

• Normal reactive dyeing method on cotton-used as the reference value experiment

· Salt free reactive dyeing on cotton in acidic medium with a pH of 2.5-3.5

• Salt free alkaline dyeing in a alkaline medium with a pH of 11.0-12.0

After completion of the all the dyeing method (Figure 1) we had compared those method to each other in terms of its superiority with respect to some of the properties like; rubbing fastness, bending length and modulus, flexural modulus, % effluent produces (% AOX i.e. absorbable organic halides) etc.

% shade	Soda ash	Salt	
0.5%	10 gpl	30 gpl	
1%	15 gpl	45 gpl	
3%	20 gpl	70 gpl	

Table 1: Recipe for normal reactive dyeing on cotton.



Figure 1: The role of salt in commercial dyeing process.

\*Corresponding author: Kunal S, Assistant Professor, Department of Textile Engineering, Panipat Institute of Engineering & Technology, Harayana, India, E-mail: kunalsingha28@gmail.com

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The normal cotton dyeing method with reactive dye has been shown as below (MLR=1:10) (Table 1).

# Color yield and fixation

Color strength (K/S) was measured using a Premier Colorscan Spectrophotometer SS 5100A (Premier Colorscan Instrument Pvt. Ltd.) with the specific arrangement of light source-Pulsed Xenon, dual beam, wavelength-10 nm, larger area view -25.4 mm diameter, smaller area view-12.0 mm diameter at the maximum absorption.

% of exhaustion=% E=[1/ {1+(r/K}]×100

(1)

Where r=MLR, K=partition coefficient between the material and the dye liquor.

### **Color fastness**

For color fastness testing, the dyed samples were soaped with 2 gpl nonionic detergent at boil for 30 min. After dyeing we had used Crockmeter (PARAMOUNT, ISO 9001-2000 group) to analyze rubbing fastness and then after rubbing fastness all the samples are tested by PARAMOUNT GRADING SCALE NO.2 (Grey scale for evaluating staining IOS, AO3, AATCC). Then the bending rigidity of all samples were calculated by stiffness tester ISO 9001-2000 with angle of inclination=41.5°. The light fastness has also checked by the and light (BS 1006: 1990 UKTN).

### **Effluent treatment**

% AOX (% absorbable organic halides) in the dye liquor at the

% AOX=C×(100-E) 
$$35.5 \times H/10VM$$
 (2)

Where; C= concentration of the dye (gpl), E=% exhaustion of dye (calculated by the help of eqn.1), H=theoretical halogen content%, V=dye bath volume (lit), M=molecular weight of halogen (Figures 2-8) and (Tables 2-5).

# **Results and Discussions**

# **Mechanical properties**

Mechanical properties are improving in case of saltfree basic







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% shade	Soda ash	NaOH	Acetic acid	Salt
0.50%	10 gpl	2 gpl	10 gpl	-
1%	10 gpl	2 gpl	10 gpl	-
3%	2 apl	2 apl	10 apl	-

Table 2: Recipe for reactive dye in acidic pH on cotton.

% shade	Soda ash	NaOH	Acetic acid	Salt
0.50%	14 gpl	2 gpl	1.5-2 gpl	-
1%	14 gpl	2 gpl	1.5-2 gpl	-
3%	14 gpl	2 gpl	1.5-2 gpl	-

Table 3: Recipe for reactive dye in basic pH on cotton.

Wavelength, nm	K/S Value (Acid)	K/S Value (Alkaline)	K/S Value (Standard)	K/S Value (Acid- Standard)	K/S Value (Alkaline- Standard)
650	0.153	0.156	0.150	0.003	0.006
660	0.145	0.147	0.135	0.010	0.012
670	0.140	0.144	0.127	0.013	0.017
680	0.137	0.145	0.123	0.014	0.022
690	0.134	0.145	0.118	0.016	0.027
700	0.131	0.144	0.114	0.017	0.030

Table 4: Comparisons between the K/S value under all category of dyeing at 0.5% shade.

Sample	R (=MLR)	K (gm/lit)	%Е	%AOX, mg/lit
Standard reactive dyeing method	10	0.114	53.27	5.81
Acid medium-nucleophile method	10	0.131	56.81	5.39
Basic medium-electrophile method	10	0.144	59.17	5.10

Table 5a: The comparisons between the effluent % AOX content over the various process.

Sample	Grey scale reading	Interference
Standard reactive dyeing method	2.5-3.0	Fair
Acid medium-nucleophile method	3.0-4.0	Noticeable good
Basic medium-electrophile method	4.0-4.5	Excellent

Table 5b: Grey scale reading of dyed fabric.

medium reactive dyeing shows more mechanical properties than the standard commercial reactive dyeing process (n=6).

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### Conclusion

Salt free reactive dyed fabric in basic or alkaline medium provide the maximum mechanical properties in the fabric and also salt free alkaline medium reactive dyed fabric provides enhanced stiffness in the fabric than the salt free acidic medium reactive dyeing method or even superior than normal reactive dyeing on cotton. Rubbing fastness salt free alkaline medium reactive dyed fabric is higher than others categories of the dyeing process. In case of salt less acidic medium excessive acetic acid or for the case of salt less basic medium excess base sodium carbonate Na<sub>2</sub>CO<sub>2</sub> in dye bath will cause generation of nucleophiles (shifting of cell-O-charges due to bathochromic shift from the liquor to the substrates) and electrophiles respectively. In the subsequent step the nucleophiles will attach to cellulose molecule and electrophiles will attach to dye molecule [1]. Hence larger will be the interbonding and interfolding of dye segments (dye molecules) between cellulose (substrates) and the dye molecules will occurs in the dye bath liquor. As a results the ratio of the dye % in the fiber [Df] and dye in the liquor [DS] i.e. partition coefficient (k= [Df] / [DS] and k is equivalent to color strength, K found by the UV-visible spectrophometer instrument used here for the experiment) will always remain at a higher value which actually facilitates to the better dye penetration and dye absorption on to the fabric at a given thermodynamically plot. The other reason of these may be the cotton is more stable in the basic medium than the acidic medium due to the stability of the -CHO group inside the cotton in acidic medium (-CHO+H<sub>2</sub>-CH<sub>2</sub>-+[O]) and the dissociation will occurs due to the nascent oxygen but in basic medium the cotton will more stable (-CHO+[O]-COOH, and the -COOH group) is more dimer stable group in basic medium. As a consequence higher will be the color soaked, the effective mass-momentum inertia of the fabric also will increase and these will leads to results as higher stiffness and other properties like bending rigidity, flexural modulus etc [2].

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