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Effect of aftertreatments on direct dyed jute fabrics

S N Pandey, A Day, S N Chattopadhyay, N C Pan & M D Mathew
Department of Chemical Technology & Engineering, Jute Technological Research Laboratories, 12 Regent Park, Calcutta 700 040, India

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The effect of aftertreatments with copper sulphate-potassium dichromate and two dye-fixing agents, viz. Lyofix 2776 and Sandofix WEI liquid, on direct dyed jute fabrics has been studied. It is observed that copper sulphate-potassium dichromate treated fabrics show improved light fastness whereas dye-fixing agent treated fabrics show improved colour strength.

Keywords: Aftertreatment, Colour strength, Dyeing, Direct dyes, Jute fabric, Light fastness

1 Introduction

Bleaching of jute fabric to produce a creamy white shade is an important operation in the manufacture of jute decoratives. On exposure to light, creamy white shade turns to the brownish yellow which gives inferior look to the decoratives. Dyeing of the fabric may overcome this problem to some extent. But the dyed shade also fades after prolong exposure to light. Some studies[1-4] have been reported on the effect of dyeing on jute fabric with acid and basic dyes. But very little work has been reported on direct dyeing of jute fabric.

Farouqui and Hossain[5] studied the colour fastness property of direct dyed jute fabric on exposure to sunlight. Bag *et al.*[6] observed that maximum discolouration (yellowing effect) is caused by UV radiation in the range of 330-370 nm. The radiations in the range of 290-320 and 380-420 nm also contribute some degree of yellowing. Banerjee *et al.*[7] observed that the presence of certain chromophores in dyes can cause absorption of near UV radiation of sunlight and prevent discolouration.

In the present work, the effect of aftertreatments on direct dyed jute fabrics has been studied to select some dyes and aftertreatments which can give better light fastness and colour strength property.

2 Materials and Methods

2.1 Materials

2.1.1 Fabric

A plain weave jute fabric having the following specifications was used:

Warp	: 60 ends/dcm (count, 294 tex)
Weft	: 59 ends/dcm (count, 315 tex)
Fabric mass	: 292 g/m^2.

(at 65% RH and 20°C)

2.1.2 Chemicals

Hydrogen peroxide (30%) was used as a bleaching agent and sodium dihydrogen orthophosphate, sodium silicate, sodium carbonate, trisodium phosphate and Ultravon JU were used as bleaching bath assistants.

Seven Chlorantine dyes (Ciba-Geigy) and two Solar dyes (Sandoz) were used for dyeing. Sodium sulphate and trisodium phosphate were used as dye bath assistants.

Copper sulphate, potassium dichromate, acetic acid, Lyofix 2776 (dye-fixing agent from Ciba-Geigy) and Sandofix WEI liquid (dye-fixing agent from Sandoz) were used for aftertreatment of direct dyed fabrics.

All the chemicals used were of AR grade.

2.2 Methods

2.2.1 Bleaching

Bleaching of grey jute fabric was carried out in 'ROACHES' dyeing machine (2-bath standard model 'S' MK II, I.D.) for 90 min at 80°C, keeping the material-to-liquor ratio at 1:20, with hydrogen peroxide (2 vol.), trisodium phosphate (5 g/l), sodium silicate (10 g/l), sodium dihydrogen orthophosphate (2 g/l), sodium carbonate (4 g/l) and Ultravon JU (5 g/l). The pH of the solution was maintained at 10-11.

2.2.2 Dyeing

Bleached fabrics were dyed with direct dyes in ROACHES' dyeing machine at 90-100°C for 1 h, keeping the material-to-liquor ratio at 1:20. The dye bath contained dyes (2% owf), trisodium phosphate (5 g/l) and sodium sulphate (10 g/l) and the pH of the dye bath was maintained at around 8.0. The dyed fabrics were washed with cold water, soaped (5 g/l detergent) at 40°C for 30 min, washed with water and dried.

The dyes used for the fabric samples A-I and their λ_{max} values are given in Table 1.

2.2.3 Aftertreatments

Each dyed sample was divided into four parts. One part was kept without any aftertreatment as standard. The rest three parts of each dyed sample were treated as follows:

2.2.3.1 Aftertreatment No. 1 (AT 1)

Dyed samples were treated with 0.25% copper sulphate and 0.25% potassium dichromate at 70°C for 30 min, keeping the material-to-liquor ratio at 1:30. The pH was maintained at 5.0-5.5 using acetic acid.

2.2.3.2 Aftertreatment No. 2 (AT 2)

Dyed samples were treated with 0.5% copper sulphate and 0.5% potassium dichromate at 70°C for 30 min, keeping the material-to-liquor ratio at 1:30. The pH was maintained at 5.0-5.5 using acetic acid.

Table 1—Dyes used for fabric samples A-I and their wavelength at maximum absorption

Fabric sample	Dye	λ_{max} nm
A	Chlorantine Fast Orange TGLL	460
B	Chlorantine Fast Olive GLL	410
C	Chlorantine Fast Blue 3 RLL	590
D	Solar Orange 2 GLI	460
E	Chlorantine Fast Grey RLL	620
F	Chlorantine Fast Turquoise Blue GLL conc.	670
G	Chlorantine Fast Blue GLL	610
H	Solar Blue 2 GLNI	610
I	Chlorantine Fast Red 5B	540

2.2.3.3 Aftertreatment No. 3 (AT 3)

Dyed samples were treated with two dye-fixing agents (2% owf) at 70°C for 30 min, keeping the material-to-liquor ratio at 1:20. Lyofix 2776 and Sandofix WEI liquid were used as dye-fixing agents for Chlorantine and Solar dyed fabrics respectively.

All the treated fabrics were washed and dried in air and conditioned for testing.

2.2.4 Evaluation of Colour Strength, Whiteness Index, Redness Index and Yellowness Index

Colour strength, Whiteness index (WI), Redness index (RI) and Yellowness index (YI) were evaluated using computer colour matching system Jaypak 4801.

2.2.5 Evaluation of *K/S* Value

The *K/S* value was evaluated by computer colour matching system using the following equation:

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

where K is the coefficient of absorption; S, the coefficient of scattering; and R, the reflectance.

2.2.6 Evaluation of Light Fastness

The light fastness was evaluated by XENOTEST-150 S and VARIOLUX using D-65 light source according to IS: 2454-1967.

3 Results and Discussion

Whiteness, yellowness and redness indices at 2° angle of observation for grey and bleached jute fabrics along with light fastness grading are given in Table 2. It is observed from this table that the modified hydrogen peroxide bleaching of jute fabric improved its light fastness to 3 as compared to around 2 in conventional hydrogen peroxide bleaching. Whiteness, yellowness and redness indices of bleached jute are as expected. The bleached jute fabric was used for dyeing and aftertreatments.

Table 2—Light fastness and whiteness, yellowness and redness indices of grey and bleached jute fabrics

Jute fabric	Light fastness	Whiteness index				Yellowness index (ASTM)	Redness index
		Berger	Stensby	CIE 1979	Hunter		
Grey	—	−20.52	27.74	−88.19	14.27	55.07	19.85
Bleached	3	12.64	40.19	−9.61	42.91	30.81	8.04

3.1 Effect of Aftertreatment on Colour Strength

Table 3 shows that aftertreatment with Lyofix 2776 in case of Chlorantine dyed fabrics and with Sandofix WEI liquid in case of Solar dyed fabric improves the colour strength appreciably. Because if we take a dyed cellulose fibre and immerse it in water, the fibre swells and the cellulose chains are allowed much freer movement, resulting in holes through which dye or fixative molecules can readily pass. In general, cellulose chains will behave towards the entering cations as chains carrying negative charges distributed along their length. Since nearly all the dye molecules will be firmly absorbed on the polymer chains, only a very small proportion of the total dye on the fibre will be present in solution in the imbibed water. Without dye-fixing agent treatment, the unfixed dyes inside the fibre will come out from the pores. But in case of fabrics treated with dye-fixing agent, the agent reacts with free dyes inside the pores and the molecular size of the dye increases. So, the dye will not come out from the pores. Hence, the colour strength increases[8]. Aftertreatment with copper sulphate and potassium dichromate tends to decrease the colour strength.

3.2 Effect of Dye and Aftertreatment on Light Fastness

The aftertreatment with copper sulphate-potassium dichromate slightly improves the light fastness property but the aftertreatment with dye-fixing agent decreases the light fastness marginally (Table 4). Blue and grey shades (Chlorantine Fast Blue 3 RLL, T-Blue GLL, Blue GLL, Solar Blue GLNI & Chlorantine Fast Grey RLL) having wavelength of maximum absorption (λ_{max}) in the range of 590-670 nm show poor light fastness. Chlorantine Fast Red 5 B having λ_{max} 540 nm shows medium light fastness (4-5) for the sample studied.

Chlorantine Olive GLL, Chlorantine Fast Orange TGLL and Solar Orange 2 GLI having λ_{max} in the range of 410-460 nm show better light fastness.

3.3 Effect of Aftertreatment and Nature of Dye on *K/S* Value

Fig. 1 shows that the *K/S* value varies widely from dye to dye and aftertreatment to aftertreatment. The *K/S* values of the treated samples are in the following order:

Bleach + Dye + AT 3 > Bleach + Dye > Bleach + Dye + AT 2 > Bleach + Dye + AT 1

The colour strength and light fastness depend on the nature of the dye (i.e. its molecular structure, molecular size, configuration, substituent groups, solubility, etc.), aftertreatment and fibre, particularly the lignocellulosics. Light fastness also

Table 4—Effect of dye and aftertreatment on light fastness

Fabric sample	Light fastness[a]			
	Bleach + Dye (Standard)	Bleach + Dye + AT 1	Bleach + Dye + AT 2	Bleach + Dye + AT 3
A	5	5	5	4-5
B	5	5	5	4-5
C	4	4	4	4
D	5	5	5	5
E	3-4	4	4	3-4
F	3-4	4	4	3-4
G	4	4	4	4
H	4	4	4	4
I	4	5	4-5	4

[a]Assessed on rating scale 1-8.

Table 3—Effect of aftertreatment on colour strength

Fabric sample	Colour strength, %			
	Bleach + Dye (Standard)	Bleach + Dye + AT 1	Bleach + Dye + AT 2	Bleach + Dye + AT 3
A	100	59.08	87.94	138.67
B	100	61.05	93.37	138.66
C	100	52.80	87.88	140.06
D	100	50.50	88.16	134.51
E	100	50.22	88.76	115.21
F	100	50.67	74.51	124.40
G	100	60.41	93.87	152.51
H	100	46.67	84.49	122.39
I	100	53.05	85.00	119.60

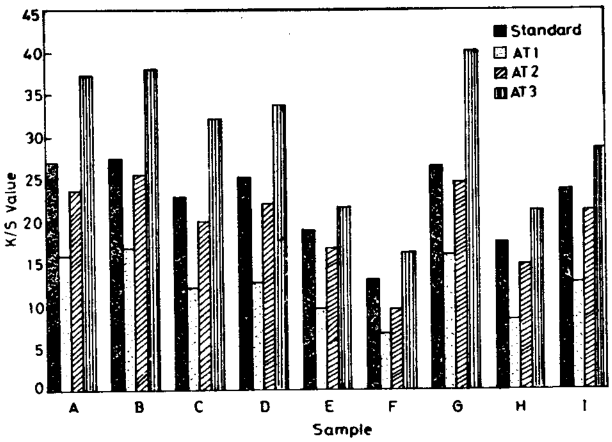

Fig. 1—Effect of aftertreatment and nature of dye on *K/S* value

depends on the wavelength of maximum absorption and chromophoric groups present in the dyes.

4 Conclusions

4.1 Slight improvement in light fastness is observed in the case of potassium dichromate-copper sulphate treated fabric while a marginal decrease in light fastness is observed in the case of dye-fixing agent treated fabric.

4.2 Aftertreatment with dye-fixing agent improves the colour strength appreciably while the aftertreatment with potassium dichromate-copper sulphate decreases the colour strength.

4.3 The dyes having λ_{max} in the range of 590-670 nm result in lower light fastness of dyed jute fabric. Therefore, dyes having λ_{max} below 550 nm should be selected to get higher light fastness of dyed jute fabric.

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