Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
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http://ansinet.com

Journal of Applied Sciences 7 (23): 3791-3795, 2007
ISSN 1812-5654

Improvement of Light Fastness Properties of Dyed Jute Fabrics Through Pretreatment

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Abstract: The chemical treatments such as desizing, scouring, caustic soda mercerization, ammonia mercerization at -33°C and bleaching were carried out on jute fabrics. Then dyeing was done with various reactive dyes applying by standard procedure to investigate the change in different properties like light fastness, moisture regain and nitrogen content has been done on undyed and dyed jute products. It was observed that the moisture regain percentage of the jute fabrics increased after different treatments and the moisture regain percentage of dyed fabrics decreased in all the cases. The nitrogen content percentage of the ammonia treated and dyed fabrics were higher than other treated and undyed jute fabrics. Therefore light fastness properties of the ammonia treated and dyed fabrics will be adequate. So, it can be concluded that anhydrous liquid ammonia (-33°C) treatment improves light fastness properties of dyed jute fabrics for the diversification of jute for value addition.

Key words: Jute fabrics, reactive dyes, liquid ammonia, caustic soda, bleaching and light fastness

INTRODUCTION

The technical jute fibre consists of strands i.e., bast bundle fibre assemble in parallel manner with overlapping to produce filaments throughout the length of the stalk. It is also physically coarse, meshy, harsh, irregular in length and diameter. On account of their properties, jute is used for making traditional products such as ropes, cords, hessian, sacking and Carpet Backing Cloth (CBC) etc.

Jute fibre bundle contains cells or ultimate fibres which are joined together with natural cementing materials as lignin and hemi-cellulose etc. Similarly each ultimate fibre is composed of a large number of smaller units known as fibrils and these are arranged in right-handed spirals. The fibrils are again made up of molecular chains, closely held together. These are known as micells. Though lignin and other non-cellulosic materials are abundant in the middle lamella, they are also found in other parts of the cell wall (Kar, 1954; Guha Roy *et al*., 1988).

Chemically jute fibre contains α-cellulose (58-63%), lignin(12-14%), hemicellulose(22-24%), waxes(0.4-0.8%), pectin (0.2-0.5%), protein (0.8-1.5%), mineral matters (0.6-1.2%) and traces of tannin and colouring matters. The hemicellulose portion is a mixture of pentosan (xylan: 12-14%), polyuronide (4-5%) and contains acetyl groups (3.2-3.5%) etc. (Doree, 1947; Das *et al*., 1948; MacMillan, 1957).

The traditional uses of jute materials are gradually decreasing due to keen competition from synthetic fibres or products. So non traditional and value added products are sought in wider scale. So, various wet processes like bleaching, dyeing, printing and finishing are required for diversified uses of jute. Different dyes are used for dyeing of jute and jute products. Reactive dyes formed covalent bond with cellulose of jute/cotton fibre. The chemical formula of some used reactive dyes are as follows (Fig. 1):

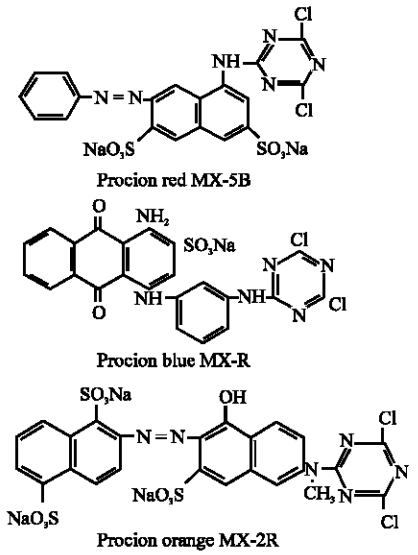

Fig. 1: Structural formula

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These dyes having good washing and rubbing fastness. These dyes are also available in the market. In most of the cases light fastness properties of dyed jute and jute products are not so good. For these reasons different treatments of jute fabrics are necessary to improve their light fastness properties. Therefore, this works have been under taken to solve this problem.

MATERIALS AND METHODS

Jute fabric: In this study plain woven jute carpet backing cloth (CBC), made of *Corchorus Olitorius* was used as starting grey fabric. The fabric (150-9 Oz/36, 15×13) was obtained from Bangladesh Jute Mills Corporation (BJMC). The experiment was conducted at Dyeing and Printing Laboratory, Chemistry division, Bangladesh jute Research Institute, Dhaka in 2005.

Singeing and desizing: For smooth and uniform surface, the grey jute fabric was singed on the Bunsen burner flame to remove loose and unwanted radiant ultimate fibres from the surface of the fabric. To and fro turns on the flame were made each side of the fabric by hand as quickly as possible.

The well singed grey jute fabric was then desized in a stainless steel bucket using diastase 1 g L^{-1} and lissapol 0.1 g L^{-1} (litre) for 45 min at 60-65°C and 20:1 liquor ratio. The fabric was then cooled, washed and air-dried.

Scouring: The desized fabrics were scoured with sodium carbonate 3 g L^{-1} containing a wetting agent lissapol 0.5 g L^{-1} by keeping fabrics to liquor ratio of 20:1 at 80-90°C. The fabrics were then cooled, washed and air dried.

Liquid ammonia treatment: The scoured fabrics were treated with anhydrous liquid ammonia mercerization at -33°C for 10 min (Sukur *et al*., 1995). Then the fabrics were washed with cold water and neutralized with 1 g L^{-1} of sulphuric acid and finally washed with cold water thoroughly.

Caustic soda mercerization: The scoured fabrics were mercerized with sodium hydroxide 17.50% (w/v) solution at room temperature for 5-10 min (Rahman, 1980). The fabrics were washed with hot water, cold water and neutralized with sulphuric acid 10 g L^{-1} and washed with normal water thoroughly and dried at room temperature.

Hydrogen peroxide (normal) bleaching: The differently pretreated jute fabrics were then bleached with 10 g L^{-1} hydrogen peroxide (35% v/v), 6 g L^{-1} sodium silicate, 0.5 g L^{-1} lissapol and 1 g L^{-1} sodium carbonate at liquor ratio 20:1, pH 10-11 and 80-85°C for 1 h. Then the bleached fabrics were washed successively with cold and hot water, then hydro-extracted and air-dried at room temperature.

Dyeing with cold brand reactive dyes: Differently treated and bleached jute fabrics were dyed with different reactive dyes. The required amount of dyestuff (2% o.w.f.) was pasted with cold water and dissolved by pouring water with stirring. The dye bath was set with requisite amount of water and predissolved dye at a material liquor ratio 1:20. The prepared samples were emerged into the cold dye bath and the dyeing was continued for 10 min. After 10 min, 35 g L^{-1} common salt was added to the dye bath in three parts and dyeing was continued for 30 min at room temperature (25-30°C). Then 4 g L^{-1} soda ash was added to the bath for fixation of dye molecules in the fabric and the dyeing was continued for further 30 min at room 25-30°C. The dyed fabric was rinsed well (Shahidullah, 2005). Finally, the fabric was soap washed with 2% soap and 1% soda for 20 min at 60-70°C and then thorough washed and air dried. Finally, the various properties of jute fabric were determined.

Dyeing with hot brand reactive dyes: Differently treated and bleached jute fabrics were dyed with Procion H dyes like, Procion brilliant yellow H-3G and Procion brilliant green H-4G. The requisite amount of dye stuff (2% o.w.f.) was pasted with cold water and dissolved by pouring warm water with continuous stirring. The dye bath was set with required amount of water and predissolved dye at a material liquor ratio 1:20. The prepared fabrics were entered into the dye bath and the dyeing was continued for 10 min. After 10 min, 60 g L^{-1} common salt was added in three parts and dyeing was continued for further 30 min at 65°C. Then 20 g L^{-1} soda ash and 1.5 g L^{-1} caustic soda were added to the bath for fixation of dye molecules in the fabric and the dyeing was continued for further 30 min at 80°C. The dyed fabric was rinsed well. Finally, the fabric was soaped, thoroughly washed and air dried and their various properties were measured.

Light fastness: The colour fastness property of samples were measured according to international method (Anonymous, 1978). The method for assessing colour fastness is described as follows:

Colour fastness to day light: In this method, a black wooden table (1×1 m) was used as the surface for fixing the fabric samples to be exposed to direct sun light. The surface of the table was fixed to the south face making it 45° angle so that the rays of the sun light directly falls on the surface of the table where the samples are fixed. The samples were exposed to sun light from 9 am to 2 pm in open clear day light. In this study,

untreated, differently treated and dyed samples were exposed to direct sun light at different time (5, 10, 25, 50 and 100 h) along with eight dyed wool standard (blue scale). The light fastness property was assessed by comparing the fading of the samples with that of the standard. The results are shown in Table 1-6.

Moisture regain percentage: The standard method was used to measure the moisture regain percentage of untreated and differently treated dyed and undyed jute fabrics. The experimental samples were dried at 105°C to a constant weight and exposed to standard atmosphere i.e., 65±2% relative humidity at 20±2°C for 48 h and reweighed carefully in the conditioned atmosphere (MacMillan and Mukharjee, 1950; Skinkle, 1949). The percentage of moisture regain was calculated from the following relation:

$$R = (y-x)/x \times 100$$

Where, R represents moisture regain percent; x and y are the dry and moist weight of the samples respectively. The results are described in Table 7.

Determination of nitrogen content percentage of untreated and differently treated dyed and undyed jute fabrics: The nitrogen content percentage of untreated and differently treated undyed and dyed jute fabrics was

Table 1: Light fastness properties of untreated and differently treated undyed jute fabrics

	Change in colour after exposure in day light for different time (h)				
Samples	5	10	25	50	100
1	4	3	2-3	2	1-2
2	4	3	2-3	2	1-2
3	6	5	4-5	4	3
4	4	3-4	3	2-3	2
5	6	5	4-5	4	3-4
6	4-5	4	3-4	3	2

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

Table 2: Light fastness properties of untreated and differently treated dyed (Procion orange MX-2R) jute fabrics

	Change in colour after exposure in day light for different time (h)				
Samples	5	10	25	50	100
1	4-5	4	3-4	3	2-3
2	4-5	4	3-4	3	2-3
3	6-7	6	5	4-5	4
4	5	4-5	4	3-4	3
5	6-7	6	5-6	5	4-5
6	6	5	4-5	4	3-4

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

Table 3: Light fastness properties of untreated and differently treated and dyed (Procion red MX-5B dyes) jute fabrics

	Change in colour after exposure in day light for different time (h)				
Samples	5	10	25	50	100
1	4-5	4	3-4	3	2
2	4-5	4	3-4	3	2
3	6	5-6	5	4-5	4
4	5	4-5	4	3-4	3
5	6-7	6	5-6	5	4-5
6	6	5	4-5	4	3-4

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

Table 4: Light fastness properties of untreated and differently treated dyed (Procion blue MX-R dyes) jute fabrics

	Change in colour after exposure in day light for different time (h)				
Samples	5	10	25	50	100
1	4-5	4	3-4	2-3	2
2	4-5	4	3-4	2-3	2
3	6-7	6	5	4	3-4
4	4-5	4	4	3	2
5	6-7	6	5	4-5	4
6	5-6	4-5	4	3-4	3

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

Table 5: Light fastness properties of untreated and differently treated and dyed (Procion brilliant yellow H-3G) jute fabrics

	Change in colour after exposure in day light for different time (h)				
Samples	5	10	25	50	100
1	4-5	4	3-4	3	2-3
2	4-5	4	3-4	3	2-3
3	6-7	6	5-6	5	4-5
4	5-6	5	4-5	3-4	3
5	7	6-7	6	5-6	5
6	6	5-6	4-5	4	3-4

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

Table 6: Light fastness properties of untreated and differently treated dyed (Procion brilliant green H-4G) jute fabrics

	Change in colour after exposure in day light for different time (h)				
Samples	5	10	25	50	100
1	5	4	3	2-3	2
2	5	4	3	2-3	2
3	6-7	6	6	5-6	5
4	5-6	4-5	4	3-4	3
5	7	6-7	6-7	6	5-6
6	6	5-6	5	4	3-4

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

Table 7: The moisture regain percentage of untreated and differently treated undyed and dyed jute fabrics

Samples No.	Moisture regain % of undyed jute fabrics	Moisture regain % of dyed jute fabrics
1	12.03	11.95
2	12.19	12.15
3	12.25	12.19
4	13.05	12.79
5	13.78	13.41
6	13.97	13.55

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

determined by Kjeldhal method (Mann and Sauders, 1960; Rahman, 1997). The dry powder sample (1 g) was taken in a Kjeldhal flask. Potassium sulphate (10 g), anhydrous copper sulphate (0.5 g) and concentrated sulphuric acid (20 mL) were added to the sample in the flask. The flask was shaken until the contents were well mixed. The flask was fitted with a pear shaped glass valve and heated with a small flame in a fume cupboard until the foaming ceased. Then the flame was increased until the mixture boiled. The heating was continued for 3-4 h with occasional shaking until the liquid was pale green. The mixture was cooled, diluted cautiously with water (500 mL). Then milliliter of this mixture was transferred to an ammonia distillation apparatus. A few fragments of granulated zinc were added to avoid bumping during distillation, followed by addition of cold 50% NaOH solution until the flask contents were alkaline (deep blue). The mixture was heated to boil, distilled off until the distillate was no longer alkaline to brilliant blue paper. The distillate was collected by means of a tube dipping bellow the surface of 10 mL N/10 HCl in the receiving flask. The access acid in the receiving flask was then titrated with N/10 NaOH solution using methyl red indicator. A blank titration was carried as above, but without using jute sample and subtracted from experimental value for necessary correction. The percentage of nitrogen content was calculated from the formula; 1 mL HCl (0.1N) used = 0.0014 g nitrogen:

$$\text{Nitrogen content (\%)} = \frac{(V_2 - V_1) \times N_A \times 0.0014 \times 100}{W}$$

Where:

V_1 = Volume of standard acid used in the titration
V_2 = Volume of standard acid used in the blank titration
N_A = Normality of the acid
W = Weight of the sample

The results were shown in Table 8.

Table 8: Nitrogen content percentage of untreated and differently treated undyed and dyed (Procion orange MX-2R) jute fabrics

	Nitrogen content (%)	
Samples	Undyed fabric	Dyed fabric
1	0.32	0.36
2	0.37	0.44
3	0.71	0.77
4	0.35	0.48
5	0.68	0.78
6	0.34	0.45

The experimental samples were represented as follows: Sample 1 = Control fabric; Sample 2 = Scoured fabric; Sample 3 = Ammonia mercerized for 20 min at -33°C; Sample 4 = Normal bleached fabric; Sample 5 = Ammonia mercerized bleached fabric; Sample 6 = Caustic soda mercerized bleached fabric

RESULTS AND DISCUSSION

Bangladesh have special advantages for getting ammonia as a byproduct from fertilizer factory. It is an indigenous and available alkali can be used easily as a substitute of caustic soda. Moreover, treatment of jute and jute products with liquid ammonia weight loss is less than that of caustic soda (Sukur *et al*., 1995). Again light fastness of liquid ammonia treated jute is higher than that of caustic soda treated one. In liquid ammonia mercerization some hydrogen bonds break down and consequently reduction in hydroxyl groups may be photostabilization increase. Therefore less free radical formation is occurred thus photodegradation is minimized.

An international method was used to evaluate the light fastness properties of untreated and differently treated dyed and undyed jute fabrics. In this study, different experimental samples were exposed to direct sun light at different time (5, 10, 25, 50 and 100 h) along with eight dyed wool standard (blue scale). The light fastness was assessed by comparing the fading of the samples with that of the standard. The results are shown in Table 1-6. It was observed from the table that the colour change increased with the increase of exposure time. It was also found from Table 1 that light fastness properties of ammonia treated-bleached undyed jute samples gave higher than other treated undyed sample. Simultaneously it has been seen that less change in colour is occurred incase of ammonia mercerized (-33°C)-bleached and dyed fabrics (sample-5) than other treated and dyed fabrics. Because it is presumed that anhydrous liquid ammonia acts as photostabilizing agent through reduction thus protect the fibre from oxidation and colour degradation. Therefore the light fastness property of this fabric (sample-5) is better than those of other treated bleached and dyed fabrics. So it can be concluded that anhydrous liquid ammonia treatment can be utilized as photostabilizing agent for bleached and dyed jute products.

The moisture regain percentages of untreated and differently treated dyed and undyed jute fabrics were measured (Table 7). It was observed from table that the moisture regain percentage of the jute fabrics increased after different treatments. This is due to swelling, increases the accessibility area, the resulting fibre have higher absorptivity capacity and are more reactive to chemical reagents/dyes. It was also seen from this table that the moisture regain percentage of dyed fabrics decreased in all the cases. This may be due to blocking of some hydroxyl groups of jute cellulose by the dye molecule. The decrease of moisture absorption affinity which will helpful to obtain better light fastness properties of dyed samples than undyed fabrics.

The nitrogen content percentage of untreated and differently treated undyed and dyed jute fabrics was determined by Kjeldhal method (Table 8). It was observed from the table that nitrogen content percentage of ammonia treated fabrics increased which is bounded with cellulose fibres. It was also seen that the nitrogen content percentage of the dyed fabrics was higher than undyed jute fabrics. This is due to the presence of nitrogen in the dye molecule. For this reason liquid ammonia treated dyed fabrics showed maximum light fastness than undyed and other treated-dyed jute fabrics. Hindered piperidines is believed to depend upon their ability to form stable nitroxyl radicals which than scavenge macroradicals photooxidation. This way possible liquid ammonia treatment some stable nitrogen containing radical is formed (Abdullah, 1983). So, it can be concluded that anhydrous liquid ammonia mercerization and bleaching before dyeing and printing is suitable for better light fastness as well as diversification of jute and jute products uses.

CONCLUSIONS

The singed and desized carpet backing cloths were treated with different chemicals and then dyed with various reactive dyes. Light fastness, moisture regain, nitrogen content etc were determined. The light fastness property of anhydrous liquid ammonia treated fabric was better than those of other treated bleached and dyed fabrics. The moisture regain percentage of dyed fabrics decreased. This may be due to blocking of some hydroxyl groups of jute cellulose by the dye molecule. The decrease of moisture absorption affinity which will helpful to obtain better light fastness properties of dyed samples than undyed fabrics. So, ammonia treated samples gave better light fastness properties. The nitrogen content percentage of ammonia treated dyed fabrics was higher than undyed and other dyed jute fabrics. So, it can be concluded that anhydrous liquid ammonia mercerization and bleaching before dyeing is suitable for diversification of jute and jute products uses.

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