

EFFECT OF DIFFERENT PRETREATMENT ON VARIOUS PROPERTIES OF UNDYED AND DYED JUTE FABRICS

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ABSTRACT

The jute fabrics were desized, scoured, caustic soda mercerized at room temperature (25-30°C) and ammonia mercerized at -33°C and bleached. Then the above fabrics were dyed with Procion orange MX-2R (Reactive dyes) dye applying by standard procedure to investigate the change in different properties like moisture regain, abrasion resistance and flexural rigidity etc. of dyed jute products. The x-ray analysis also have done of those undyed, differently treated-dyed jute fabrics. It is found 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 case. The number of abrasion rotations decreased on the treatment of the fabrics but ammonia treated samples gave better abrasion resistance than other samples. The differently treated dyed jute fabrics appear to decrease flexural rigidity or stiffness. It was also found that the brag space values (d) were 4.83 Å, 5.02 Å and 4.00 Å for normal bleached, ammonia mercerized- bleached and caustic soda mercerized-bleached fabrics respectively. The value of brag space (d) of those dyed fabrics of normal bleached, ammonia mercerized-bleached and caustic soda mercerized-bleached fabrics were found to be 4.96 Å, 5.40 Å and 4.49 Å respectively. The brag space (d) values of the dyed fabrics are higher than undyed fabrics. The liquid ammonia (-33°C) treated jute fabrics shows better properties than other treated fabrics. So, it can be concluded that anhydrous liquid ammonia (-33°C) treatment and bleaching process before dyeing/printing is suitable for the diversification of jute for value addition.

Keywords: Jute fabrics, reactive dyes, liquid ammonia and caustic soda mercerization, bleaching

INTRODUCTION

The technical jute fiber consists of strands i.e. bast bundle fiber 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 fiber bundle contains cells or ultimate fibers which are joined together

with natural cementing materials as lignin and hemi-cellulose etc. Similarly each ultimate fiber 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 wall¹⁻².

Chemically jute fiber 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 coloring matters. The hemicellulose portion is a mixture of pentosan (xylan: 12-14 %), polyuronide (4-5 %) and contains acetyl groups (3.2-3.5%) etc³⁻⁵.

The uses of jute materials are gradually decreasing due to keen competition from synthetic products. So, non-traditional and value added products are shout in wider scale. The presence of wax, pectin and mineral matters in jute creates some problems in dyeing, printing and finishing. For these reason various treatment like scouring, mercerizing and bleaching are required for better dyeing, printing and finishing of jute and jute products for diversified use of jute products.

Simultaneously the pretreatment or chemical modification and after treatment is essential for proper dyeing and printing. Anhydrous liquid ammonia penetrates through cellulose relatively easily and reacts with the hydroxyl groups after breaking the hydrogen bond that swelling and decrystallization of ammonia on cellulose formed two complexes such as cellulose-II and cellulose-III is obtained when ammonia is allowed to evaporate and cellulose-I is obtained when ammonia is washed with water⁶. In recent years, liquid ammonia treatment has been used to develop a new process called "Prograde" to produce superior quality sewing threads with improved strength and luster by J. & P Coats

ltd., U.K.^{7, 8}. Similarly, a process of liquid ammonia treatment of fabric has been developed by TEDECO, Norway, and details of the process are described by Skaathun⁹. Yarn of different cotton varieties treated by Prograde process showed 40% to100% increase in strength as well as improved whiteness and dye affinity etc. Liquid ammonia processing is cheaper than conventional mercerization.

It has been found that different physicochemical properties of raw jute fabrics are not so good. These properties of jute and jute products can be improved by different treatments. For these reasons different treatments of fabrics were done. In this study, this work is under taken to improve the physicochemical properties of dyed jute products.

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", 15X13) was obtained from Bangladesh Jute Mills Corporation (BJMC).

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 fibers 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 1g/L and lissapol 0.1g/L (liter) for 45 minutes at 65-65°C and 20:1 liquor ratio. The fabric was then cooled, washed and air dried.

Scouring: The designed fabrics were scoured with sodium carbonate 3g/L containing a wetting agent lissapol 0.5g/L 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 minutes. Then the fabrics were washed with cold water and neutralized with 1g/L 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 minutes. The fabrics were washed with hot water, cold water and neutralized with sulphuric acid 10g/L and washed with normal water thoroughly and dried at room temperature.

Hydrogen peroxide (normal) bleaching: The differently pretreated jute fabrics were then bleached with hydrogen peroxide using 10g/l (gram per liter) H_2O_2 (35% v/v), 6g/l sodium silicate, 0.5 g/l lissapol, 1g/l sodium carbonate at MLR (Material liquor ratio) 20:1, pH: 10-11 and $80-85^{\circ}\text{C}$ for 1 hour. The bleached fabrics were then washed successively with cold and hot water, finally hydro-extracted and air dried at room temperature.

Dyeing with cold brand reactive dyes¹⁰ (Procion orange MX-2R): Differently treated and bleached jute fabrics were dyed with Procion orange MX-2R. 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 minutes. After 10 minutes, 35g/l (liter) common salt was added to the dye bath in three parts and dyeing was continued for 30 minutes at room temperature ($25-30^{\circ}\text{C}$). Then 4g/l soda ash was added to the bath for fixation of dye molecules in the fabric and the dyeing was continued for further 30 minutes at room $25-30^{\circ}\text{C}$. The dyed fabric was rinsed well. Finally, the fabric was soap washed with 2% soap and 1% soda for 20 minutes at $60-70^{\circ}\text{C}$ and then thorough washed and air dried. Finally the various properties of jute fabric were determined.

Moisture regain percentage^{11, 12} 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. $65\pm 2\%$ relative humidity at $20\pm 2^{\circ}\text{C}$ for 48 hours and reweighed carefully in the conditioned atmosphere. 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 shown in Table-1.

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Table 1: The moisture regain percentage of untreated and differently treated undyed and dyed jute fabrics

Sample 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 minutes at -33°C ,
- Sample 4 = Normal bleached fabric,
- Sample 5 = Ammonia mercerized for 20 minutes at -33°C and bleached fabric,
- Sample 6 = Caustic soda mercerized and bleached fabric.

Abrasion resistance¹³ The fabrics were conditioned for 48 hours in a standard atmosphere (i.e., 65±2% relative humidity at 20±2°C). Four circular pieces of fabrics were cut from each sample by the device available in the testing department of BJRI. These four samples were fitted over an abrasion tester (Goodbrand and Co. Ltd. Made in England) and then they were subjected to abrasion by another piece of abrading cloth placed to the lower plates. During the abrasion, the samples were given a circular and tumbling motion. The number of rotation up to rupture of the samples was noted. The results are given in Fig.1.

Dry crease recovery angles¹⁴ The crease recovery angles of the samples were determined in the following ways:

- a) **Test specimen:** Rectangular test specimens (dimension 40 mm. and 15 mm.) were cut both in the warp and weft direction from the uncreased, unbend and undeformed part of the control and differently treated samples with the help of a device given in the tester.
- b) **Conditioning:** The test specimens were conditioned for at least 48 hours in the

standard atmosphere for testing textiles as defined in BS 1051 (i.e. 65±2% relative humidity at 20±2°C). The crease recovery angles were determined by the Shirely crease recovery tester.

- c) **Loading:** The specimen was folded end to end and held in this position by tweezers, gripping no more than 5mm for the ends. This specimen was then placed on the marked area of the lower plate of the loading device and the load was applied gently; without delay and kept for 5 minutes ± 5 seconds. There after the load was removed by means of tweezers, the sample was then transferred directly to the specimen holder of the measuring instrument.
- d) **Determination of the Crease recovery angles:** While the specimen was in the holder, the instrument was adjusted continuously to keep the free limp always in vertical position. The Crease recovery angle was read after 5 minutes after the removal of the load. Mean value to the nearest degree for both warp and weft specimens were then calculated. The results are shown in Table-2.

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Fig. 1: Abrasion resistance of control and differently treated-dyed jute fabrics

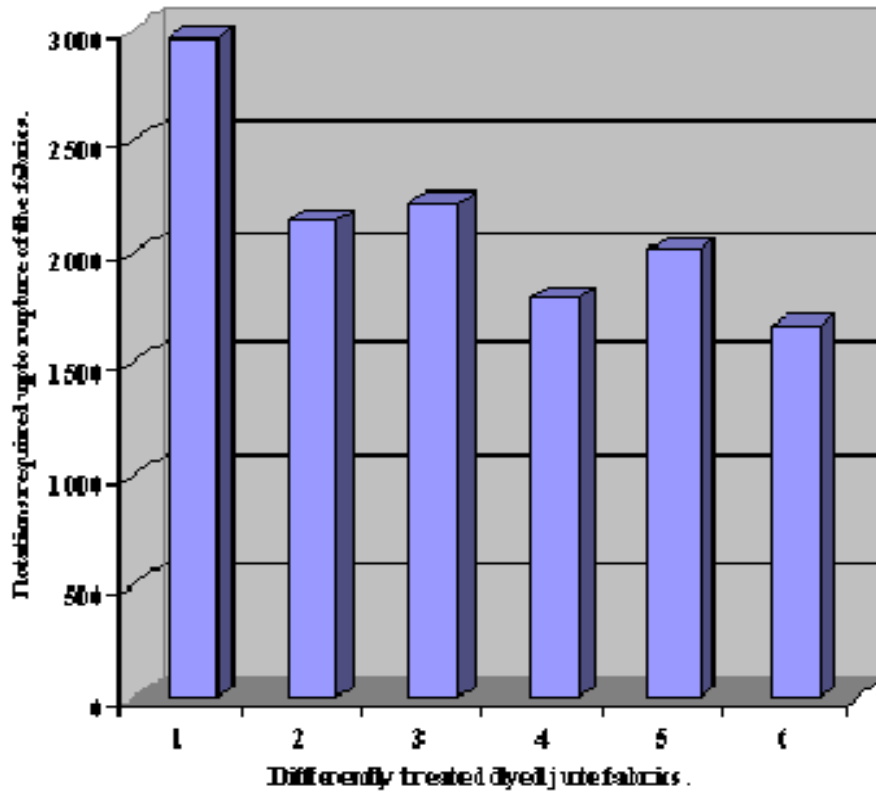


Table 2: Crease recovery angles of control and differently treated-dyed samples

Sample	Dry crease recovery angle		Wet crease recovery angle	
	Warp	Weft	Warp	Weft
1	75	79	80	82
2	78	85	83	88
3	89	100	97	115
4	95	105	102	119
5	112	120	115	125
6	115	122	121	128

Wet crease recovery angles¹⁴ The samples (20 mm x 10 mm) were cut warp and weft wise from the fabric and immersed for about 10 minutes in the wetting out liquor (lissapol-N, 2g/L). They were then shaken to remove the surface droplets which were then loaded with a 500g weight. After 3 minutes, weight and upper glass plates were removed carefully and the glass plate with adhering

specimens were so arranged that the projecting of the test strip lied in a horizontal direction. After 3 minutes, the crease recovery was determined. The results are shown in Table-2.

Flexural rigidity¹⁵ The test samples were conditioned for 48 hours in a standard atmosphere (i.e., 65±2% relative humidity at

20±2°C) and were cut with the help of the template (16 cm. X 2.5 cm.) then both template and specimen were transferred to the plate form with the test fabrics underneath. Both were slowly pushed forward. The strip of the fabric commenced to drop over the edge of the platform and the movement of the template (i.e. the scale) and the fabric was continued until the tip of the specimen was viewed in the mirror. The bending length could immediately be read off from the scale mark opposite to a zero line engraved on the side of the platform. Each specimen was tested four times at each

end and again with the strip turned over. Mean values for the bending length in warp and weft directions were calculated. The flexural rigidity was calculated from the following formula:

$$G = w \times c^3 \times 10^3 \text{ mg/cm.}$$

Where,

G = flexural rigidity of the fabric,

w = weight per square centimeter,

c = bending length of the Shirley stiffness tester,

The results are shown in Table-3.

Table 3: Flexural rigidity of differently treated dyed (Procion orange MX-2R) jute fabrics

Samples	Flexural rigidity (mg/cm)		Δ FR
	Warp	Weft	
1	2157	1914	243
2	1767	1510	257
3	1891	1629	262
4	1311	1065	246
5	1423	1176	247
6	1289	1068	221

RESULTS AND DISCUSSION

Bangladesh has 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. In recent, the production of sophisticated jute-textile products such as decorative, hanging, upholstery and furnishing fabrics is essential for the diversification of jute. For making the above products dyeing/printing is most essential for diversification of jute. The performance of dyed jute materials was improved through different pretreatment. So, the pretreatment is necessary for proper dyeing. The jute fabrics were treated with different swelling agents and bleaching were carried out for better dye absorption and the improvement of different physicochemical properties of diversified jute products.

Swelling means expanding of fiber caused by the influence of solvent or a chemical reagent. The cellulose molecules

that are present in varying length are not arranged in natural fibers haphazardly, but form fibrils in which the majority of the cellulose molecules are oriented in the direction of the fiber axis. Such orderliness is found in the crystalline region of cellulose. However, the areas lying between the crystalline regions are semi-crystalline and amorphous and are of very great significance for physical and chemical properties of the cellulose fibers as textile materials.

In caustic soda mercerization, in fact, no substantial chemical reaction takes place but the inter-chain forces are weakened due to breakage of certain hydrogen bonds and the strength of the material decreases and simultaneously the cavities in the non-crystalline region of the fiber appear and resultant fiber becomes homogenous, soft and crimped. A change in the crystal structure takes place, the original cellulose I (native cellulose) being transformed to cellulose II when the fiber is completely mercerized¹⁷.

Treatment of cotton fibers with anhydrous liquid ammonia has also been developed to enhance the properties of cotton. This treatment brings about an improvement in physico-chemical properties and influence on dye absorption¹⁸. Anhydrous liquid ammonia is quite volatile and has been reported to cause swelling of cellulose fiber. It has been known to be a swelling agent for cellulose fibre¹⁹ since 1930's. Considerable work has been done on liquid ammonia as an alternative to caustic soda in the mercerization of cotton cellulose for increased strength, softness, luster and dye absorption etc.

Anhydrous liquid ammonia penetrates cellulose relatively easily and reacts with the hydroxyl groups after breaking the hydrogen bond. The reaction presumably occurs in the less ordered as well as in the crystalline region of the fibre⁶. Hess and Gunderman⁶ observed swelling and decrystallization of cellulose. When cellulose is treated with anhydrous liquid ammonia at a temperature near its boiling point (-33°C) a 1:1 complex with a monoclinic cell having $a = 1.27$, $b = 1.075$, $c = 1.03$ nm and $\gamma = 133.5^\circ$ is formed^{20, 21}.

The moisture regain percentage of untreated and differently treated dyed and undyed jute fabrics were measured. The results are shown in Table 5. It was observed from this 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 fiber have higher absorptive capacity and are more reactive to chemical reagents/dyes²². 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 untreated and differently treated dyed conditioned fabrics were tested over an abrasion tester and the numbers of abrasion

rotations up to rupture of the test samples were recorded. The results are shown in Fig. 1. It was observed that the number of abrasion rotations decreased on the treatment of the fabrics. This might be due to the loss of lignin, hemicellulose etc. as referred in case of strength¹⁴. As a result the abrasion resistance of the fabrics decreased after different treatment. It was also observed that ammonia treated samples gave better abrasion resistance than other samples which has similarity with loss of weight and strength of ammonia treated fabrics.

Crease is an important property of a fabric, generally caused by a fold due to pressure on the fabrics. The tendency to crease depends on the structural characteristics of the cellulose fibers. With a high degree of orientation, a pronounced tendency to crease diminishes.

Crease recovery is the removal of crease determined by crease recovery angle. It was observed from table 2 that the crease recovery angles at dry/wet state of differently treated dyed fabrics were higher than untreated/control fabrics. This is may be due to swelling of the fiber in the fabric. It appears that the treatment has developed the ability of the fabrics to recover from deformation. On the other hand the weft crease recovery angle is higher than warp crease recovery angle. This is due to the more shrinkage obtained in weft direction.

It was also found that the wet crease recovery behavior was higher than that of dry crease recovery behavior when the fabrics were treated differently. The improved crease recovery of the treated fabrics may be due to remove or release of the hydrogen bond forming capacity of cellulose hydroxyl groups which is indicated with the swelling effect of fiber.

The materials which have good crease recovery properties exhibit excellent soft handle, draping and appearance as well as a lack of flabbiness as washing proceeds. The untreated materials have less crease recovery angle tend to more limp and flabby on washing²³.

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The differently treated dyed jute fabrics appear to decrease flexural rigidity or stiffness shows in Table-3 which indicate that the samples became more flexible after different treatment. This flexibility developed due to swelling and loss of lignin, hemicellulose of jute. This swelling property was improved by breaking hydrogen bonds in the fiber cellulose molecule. It will be helpful to develop the soft handling properties of the jute products²⁴. It is also observed from table that difference between warp and weft flexural rigidity are more or less same.

CONCLUSION

The uses of jute materials are gradually decreasing due to keen competition from synthetic products. So, non-traditional and value added products are shout in wider scale. The presence of wax, pectin and mineral matters in jute creates some problems in dyeing, printing and finishing. For these reason various treatment like scouring, mercerizing and bleaching are required for better dyeing, printing and finishing of jute and jute products for diversified use of jute products. It has been observed from the above discussion that anhydrous liquid ammonia treated sample gave better results than other treated fabrics. So, it can be concluded that anhydrous liquid ammonia (-33°C) treatment and bleaching process before dyeing is suitable for the diversification of jute for value addition.

REFERENCES

1. S. N. Kar. 1954. *The Jute Fibre*, Sri Gouranga Press, Calcutta.
2. T. K. Guha Roy, S. Chatterjee, D. Adhikari and A. K. Mukherjee, 1988. *J. Text. Inst.* **79**: 108.
3. C. Doree. 1947. *The Methods of Cellulose Chemistry*, Chapman and Hall Ltd. London, p. 487.
4. N. N. Das, S. C. Das and A. K. Mukherjee. 1948. Origin of Acidity in Jute Fibber, *Textile Res. J.* Marck, pp. 166-191.

5. W. G. Mac Millan. 1957. *Jute the Golden Fibre*, Pakistan Today Press, Dacca, p. 143.
6. K. Hess and J. Gunderman. 1937. *Cellulose Fibres: Action of Liquid Ammonia*, Ber. **B70**: 1788-1799.
7. R. M. Gailey. 1970. *The liquid ammonia treatments of yarns and threads*, Bellevue, Manchester, U.K., 9-20.
8. R. M. Cowper. 1970. *The liquid ammonia treatments of yarns and threads*, Belle vue, Manchester, U.K., 21-25.
9. O. Skaathun. 1970. *The liquid ammonia treatments of fabrics*. Bellevue, Manchester, U.K., 34-50.
10. E. R. Trotman. 1975. *Dyeing and Chemical Technology of Textile Fibres*. Charles and Griffin Company Ltd., London, U. K.
11. W. G. Macmilan and P. R. Mukharjee. 1950. *Fibres* **2**: 173-183.
12. J. H. Skinkle. 1949. *Textile Testing*, Chemical Publishing Co., Inc. Brooklyn, New York, pp.10-32.
13. J. H. Skinkle. 1949. *Textile Testing*, Chemical Publishing Co., Inc. Brooklyn, New York, pp.136-143.
14. S. M. Badier Rahman. 1997. *Ph. D. Thesis*, Studies on the Chemical Modification of jute fiber/fabric/yarn by cross linking reaction. University of Dhaka.
15. J. H. Skinkle. 1949. *Textile Testing*, Chemical Publishing Co., Inc. Brooklyn, New York, pp. 124-125.
16. H. Tadokora. 1979. *Structure of Crystalline Polymers*, Wiley-Inter. Science Publications, John Wiley & Sons, New York, pp. 40.
17. Peters, R. H., 1963. *Textile Chemistry*, Vol. 1, Elsevier, Amsterdam.
18. Shore, J., 1955. *Celluse Dyeings*, (SDC). Alden Press, Oxford, pp: 115-116.
19. Barry, A. J., F. C. Peterson and A. J. King, 1938. *J. Am. Chem. Soc.* **58**: 333.

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20. Warwicker, J. O. 1972. *Cellulose Chem. Technol.* **6**: 85.
21. Zeronian, S. H., 1985. *Cellulose Chemistry and its Application*, Chichester: Ellis Horwood, pp. 159.
22. R. H. Peters. 1967. *Textile Chemistry*, Elsevier Publishing Company Ltd. New York, **2**, 350-352.
23. J. T. Marsh. 1951. *An Introduction to Textile Finishing*, Chapman and Hall Ltd.
24. M. Shahid Ullah, 2005. *Ph. D. Thesis*, Physico-Chemical Aspects of Dyeing of Jute and Jute Products. Jahangirnagar University.

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