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Studies on the Dyeing Properties of Fabrics from Sulphonated Jute Fibres with Other Fibres

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Abstract: Fabrics were prepared by plain weaving with the blended yarns made of sulphonated jute fibre in different combination with cotton, rayon, acrylic, polyester and silk waste. It has been observed that the blending of the sulphonated jute fibre with cotton or any other flexible fibre improved the draping properties of the fabrics made there from and that these fabrics in actual use have gracious look and firmness almost to the same extent of those draping properties of the cotton fabrics. The dye ability of this blended fabrics was studied using a basic dye (Rhodamine-B red) and reactive dye (Procion-M red). The dye absorption of jute increases from 68 to 88% as it was sulphonated and the sulphonated jute blended fabrics took up almost the same of amount of dyes which was around 70% from both dye-bath, indicating that the accessibility of blended fabric samples to the dye molecules was practically the same. The colour shades on different fabric sample were almost similar in compare with dyed cotton fabrics. The colour fastness of the blended fabrics were also closed to the cotton fabrics.

Key words: Sulphonation, jute blended fabrics, draping properties, dye absorption, colour fastness

INTRODUCTION

Jute is a natural fibre which suffers as a textile fibres for inherent defects which limit its spinning to course yarn to produce coarse packing cloths (Rahman, 1989; Ali *et al.*, 2000a). Cotton and jute occupy the first and second places, respectively, in terms of world production levels of cellulosic fibres. However, compared with cotton, the diversified application of jute has been greatly handicapped due to the inherent shortcomings of the fibre (Ali *et al.*, 2001a). In recent years, serious attempts have been made to develop alternative end-uses for jute in specially textile sectors and value-added products (Daul, 1952; Banerjee *et al.*, 1985). Jute fibre blends with cotton and other natural and synthetic fibres have been high lighted as one of the main outlets for jute towards an entirely new sector of the textile furnishing and apparel industries (Mukherjee *et al.*, 1981). To generate the more profits from jute and jute blended products, appropriate commercially feasible technologies must be developed to overcome the problems associated with the processing of jute and jute blended products. It has been reported that sulphonation improves the physico-mechanical properties of the jute fibre (Ali *et al.*, 2001b; Islam *et al.*, 2000; Ali *et al.*, 2000; Meridth, 1945). The sulphonated jute fibre was mechanically processed and blends with cotton, rayon, acrylic, polyester and silk to make fine yarns and their properties of the yarns were reported (Meridth, 1952). On the major problems that restricts the application of jute products is that jute suffers seriously from light-induced discolouration. Different fabrics samples were prepared by plain weaving with the blended yarns made of sulphonated jute fibre in different combination with cotton, rayon, acrylic, polyester and silk waste (Banerjee *et al.*, 1988). The mechanical properties of these fabrics were determined to observed their serviceability in practical usages and to ascertain their suitability in practical as jute blended cotton and synthetic fabrics (Grasso *et al.*, 1994; Anandjiwala *et al.*, 1991). Few dyestuffs will attain the same light fastness on jute as achieved on cotton, the fastness ratings often being 0.5-1.5 points lower than that on cotton and, in some cases, a drop of 2-3 points is observed. By blending jute fibre with cotton and other natural and synthetic fibre, the problem can be somewhat alleviated by the cotton component, however, the blended fabric on its own does not fulfill the requirements of apparel or furnishing fabrics, especially when the jute content is relatively high in the blend. In order to achieve a high level dye absorption properties of jute blended products, basic dye (Rhodamine-B red) and reactive dye (Procion-M red), which are renowned for their excellent light fastness properties on dyed polyamide fibre have been employed in this study for the dyeing of jute blended fabrics (Meier, 1961; Giles, 1966; Sarkanen, 1984). This study

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deals with the detail fabric preparation and dye absorption and colour fastness properties of fabrics from sulphonated jute fibre blends with other fibres.

MATERIALS AND METHODS

Materials: Jute plant of variety C-145 (Corchorus Capsularies) was collected from the experimental plot of Bangladesh Jute Research Institute and retted under fresh water for 18 days. The fibre was separated and sun dried. The resulting fibre was used as the fibrous raw materials. Sodium sulphite, Sodium bisulphite, Sodium carbonate, Anthraquinone, EDTA and basic dye (Rhodamine-B red) and reactive dye (Procion-M red) were used as received.

Preparation of fabrics: Different samples of fabrics about ten meter in length and one meter in width were made by weaving on the ordinary power looms of Deepak Textile Mills and of Jutton Project Bangladesh Jute Research Institute, Dhaka. The weaving was performed with the blended yarns made of the sulphonated jute fibre in different combination with cotton, rayon, acrylic, polyester and silk waste. The set of warp and weft yarns was done on the one up and one down principle followed for weaving plain or square cloth.

Measurement of cloth cover: The cloth cover of the sulphonated jute fibric was determined by the following relationship:

$$K_c = (K_1+K_2-K_1K_2/28)$$

Where, K_c = Cloth Cover, K_1 = Warp cover factor and K_2 = Weft cover factor.

The fraction of space per inch of cloth covered by warp yarn is known as warp cover factor, which was obtained as:

$$K = \frac{\text{thread per inch}}{\sqrt{\text{count}}} = \frac{n}{\sqrt{N}}$$

Similarly, the weft cover factor was calculated. The thread per inch n was counted with the help of a traveling thread counter.

Stiffness and flexural rigidity: A strip of cloth (6×1 inch) was cut to the size of the template of the tester and slide into the direction parallel to its length, so that its end is projected from the edge of the horizontal platform of the tester. The length of the overhang cloth was measured when the tip of the test specimen was depressed under its own weight to the point where the lines joining the tip of the horizontal platform make an angle of 41.5 degree with horizontal plane. The bending length, C was determined by the following equation:

$$C = \frac{L}{2}$$

Where, L = the overhang fabric length

The flexural rigidity (G), which is a measure of stiffness associated with the handle of cloth, was determined from the following relationship:

$$G = WC^3 \times 10^3 \text{ mg cm}^{-1} = \text{mNmm}$$

Where, C = bending length, W = cloth weight (gm) per square cm N = Newton

Draping properties: The draping properties of the fabric specimen were measured by standard procedure of the fabric research laboratories of USA. The fabric sample was cut into a circular specimen of about 10 inch diameter and supported on a circular disk of about 5 inch diameter of the drapemeter. The circular specimen was drapped over the circular disk supporter of the drape meter and assumed some folded configuration. The drape was measured, as the drape coefficient F, which is the ratio of the projected area of the draped specimen to its undraped area, after deduction of the area of the supporting disk.

$$F = \frac{As - Ad}{A_D - Ad}$$

Where, A_D = the area of the specimen, A_d = the area of the supporting disk and A_s = the actual projected area of the specimen.

Measurement of dyeability: The dying of the fabric samples from the sulphonated jute fibre blends was accomplished using rhodamine-B red and Procion-M red dues. Rhodamine-B red is the direct basic dye and applied to the fabric samples in dye-bath containing rhodamine dye 1% (1 g), acetic acid 30% (2 g) per 100 g of the sample at temperature near 100°C for an hour. The procion-M red was used as a reactive dye having triazine group to react with hydroxyl group of jute cellulose. The fabric samples (100 g) were immersed into the dye solution containing Procion-M red dye (1 g) at ambient temperature for half an hour and then sodium carbonate (4 g) and sodium chloride (40 g) were added to the dye bath to fix the dye molecules in the fibre. The color fastness of the dyed fabric samples was measured with reference to sunlight, water and mechanical rubbing in accordance to the standard procedures.

RESULTS AND DISCUSSION

Physico-mechanical properties of fabrics: The fabrics made from the sulphonated jute fibre and its blends with cotton, rayon, acrylic, polyester and silk waste show a very good prospect of performance, as they are comparable to the structure of cotton fabrics. The results on the fabric construction with yarns made from 100% sulphonated jute fibre have been described in Table 1. The details of the fabric samples prepared from the sulphonated jute yarns blended with or without cotton, rayon, acrylic, polyester and silk waste are shown in Table 2. The plain weave structure was chosen for fabric construction from sulphonated jute fibre and its blends with other fibres, because maximum fabric about 70% is of plain structural pattern. From Table 1 and 2 it will be seen that each kind of fabric was woven with equal set of warp and weft maintaining optimum spacing in the intersection of the yarns. The variations in the number of threads per unit length of fabric were in correspondence to the yarn tex, but the cover factors for both warp and weft and their resulting effect on the fabric were maintained almost identical. The fabric samples prepared from non blended sulphonated jute fibre had cover factors of warp and weft at about 10 with cloth cover 16 and those prepared from blended sulphonated jute fibre had the values of about 9 and 15 for cover factors of warp and weft and cloth cover, respectively. The weights per unit area were, however, different for different cloths in accordance with the quality of yarns used. The geometrical properties of the fabrics prepared from blended sulphonated jute fibre were favorably compared with those of the fabrics prepared from 30 tex cotton yarns. The results on the mechanical properties of the fabric samples woven with the sulphonated jute yarns blending with/without cotton, rayon, acrylic, polyester and silk waste have been shown in Table 3. The light weight fabric were made with these blended yarns preferably with 30 tex yarns taking from each lot of 65/35 blends as shown in Table 3. The mechanical properties of these fabrics were determined to observe their serviceability in the practical usages and to ascertain their suitability as jute blended cotton and synthetic fabric. Shirtings and suitings are usually made from cotton, wool, silk and synthetic yarns or the blended yarns thereof. The use of jute after having sulphonated in the field of making such fabrics has been a possibility. The results shown in Table 3 indicate that the softness and handling characteristics represented by the bending length and flexural rigidity of the blended fabrics were very much comparable to those of cotton fabrics with identical fabric structure. The bending length and flexural rigidity of fabric samples prepared from sulphonated jute fibre blended with cotton were 1.9 cm and 9.3 mN mm, respectively, which were only 0.3 and 4.9 points higher than those of the cotton fabrics and were in proximity to the values for other blended fabrics. These properties for sulphonated jute/silk waste/rayon blended fabric were much lower being 1.5 cm bending length and 3.37 mN mm flexural rigidity due to the presence of higher percentage of silk waste (80%) and only 10% of sulphonated jute fibre in it.

The strength properties of the fabric samples from fibre blends were in the range of 18 to 21 kgf, which were evidently very near to 22.8 kgf strength of cotton fabrics. It signifies that the durability and serviceability of the fabrics under any sort of stress and deformation during

Table 1: Structure of fabrics made from 100% sulphonated jute fibre

Fabric sample	Yar composition	Count (tex)	Threads per cm	Cover factor	Cloth cover	weight g cm^{-2}
A	Suphonated jute	warp 276	ends 6.0	warp 10.5	17.1	206
	fibre	weft 276	picks 6.0	weft 10.5		
B	Suphonated jute	warp 140	ends 8.3	warp 10.3	16.8	172
	fibre	weft 140	picks 8.3	weft 10.3		
C	Suphonated jute	warp 70	ends 11	warp 10.0	16.4	158
	fibre	weft 70	picks 11	weft 10.0		
D	Suphonated jute	warp 50	ends 14	warp 10.1	16.6	145
	fibre	weft 50	picks 14	weft 10.1		

Table 2: Details of fabric construction from sulphonated jute yarns blended with other fibres

Fabric sample	Yar composition	Count (tex)	Threads per cm	Cover factor	Cloth cover	weight g cm^{-2}
A	Suphonated jute	warp 30	ends 15.8	warp 9.1	15.3	138
	fibre (65:35)	weft 30	picks 15.8	weft 9.1		
B	Suphonated jute	warp 30	ends 15.8	warp 9.1	15.0	140
	fibre (65:35)	weft 30	picks 15.2	weft 8.8		
C	Suphonated jute	warp 30	ends 15.8	warp 9.1	14.8	142
	fibre (65:35)	weft 18	picks 15.0	weft 8.5		
D	Suphonated jute	warp 18	ends 15.8	warp 9.1	14.8	134
	fibre (65:35)	weft 18	picks 15.0	weft 8.5		
E	Suphonated jute	warp 18	ends 21.0	warp 9.5	15.7	102
	fibre (10:80:10)	weft 18	picks 21.0	weft 9.5		
F	Cotton 100%	warp 30	ends 21.0	warp 9.4	14.5	110
		weft 30	picks 21.0	weft 9.4		

Table 3: Mechanical properties of fabrics prepared from sulphonated jute fibre yarns blending with/without cotton, rayon, acrylic, polyester and silk waste

Sample No.	Fabric Composition	Bending length (cm)	Flexural rigidity (mn NN)	Tensile strength (kgf)	Drape coefficient %
A	Sulphonated jute/cotton (65/35) blend, 30 tex yarn	1.9	9.3	20	38
B	Sulphonated jute/rayon (65/35) blend, 30 tex yarn	2.0	11.0	20	39
C	Sulphonated jute/rayon (65/35) blend, 30 tex yarn	2.2	15.0	21	41
D	Sulphonated jute/rayon (65/35) blend, 30 tex yarn	2.2	12.0	21	42
E	Sulphonated jute/rayon (10:80:10) blend, 30 tex yarn	1.5	3.6	19	34
F	Cotton (100%) yarn 30 tex	1.6	4.4	23	35
G	Sulphonated jute (100%) 50 tex yarn	2.8	31.0	29	57

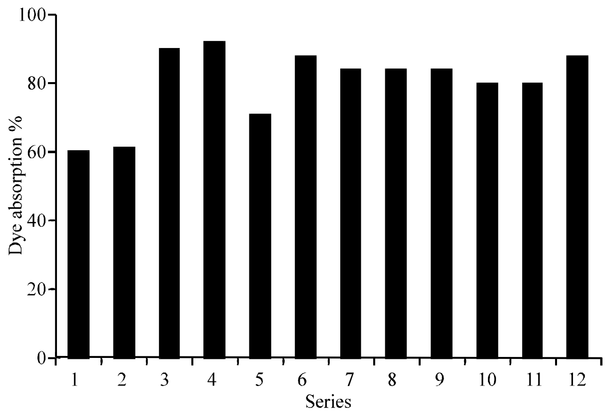
Table 4: Dying properties of fabrics from sulphonated jute fibre after blending with cotton, rayon, acrylic, polyester and silk waste

				Fastness of Dye					
		Dye uptake (%)		Water		Rubbing		Light	
Sample No.	Fabric description	a	b	a	b	a	b	a	b
A	Suphonated jute-cotton blend ration (65:35)	71	72	2.7	5.0	3.0	4.0	4.5	6.0
B	Suphonated jute-rayon blend ration (65:35)	69	68	1.5	4.0	3.0	4.0	3.7	5.0
C	Suphonated jute-acrylic blend ration (65:35)	73	72	2.0	4.6	2.0	5.0	4.6	6.0
D	Suphonated jute-polyester blend ration (65:35)	68	68	2.0	4.8	2.0	4.0	4.0	6.0
E	Suphonated jute-silk waste blend ration (20:80)	70	70	2.0	3.8	2.0	4.0	3.5	5.8
F	Suphonated jute (100%)	74	75	3.0	4.6	3.0	3.0	4.9	6.9
G	Cotton (100%)	74	74	4.0	5.0	2.9	4.8	4.9	6.9

a = Rhodamine-B red dye and b = Procion-M red dye

their uses are not much less than the cotton fabrics. The sulphonated jute blended fabrics draped very gracefully in almost the same way the cotton fabrics draped over a circular support. The Table 3 shows that the drape coefficient of the blended fabrics were found in the range of 38 to 42, which were 3 to 7 point higher than that of cotton cloth and 16 to 19 points less than the comparatively coarser fabric woven from 50 tex yarns of sulphonated jute fibre without blending with any other fibre. This indicated that the blending of the sulphonated jute fibre with cotton or any other flexible textile fibres improved the draping properties of the cloth made thereform and that these fabrics in actual use would have gracious look and firmness almost to the same extent of those draping properties of cotton fabrics. On the other hand, the sulphonated jute fibre on being blended with silk waste produced comparatively better fabrics as regards with their draping and other mechanical properties.

Dye absorption: It is seen from the Table 4 that the absorption of dye measured as percentage of dye uptake by the different fabric specimen under test was approximately of the same extent which was around 70%. The selection of dyes and carriers in the recipes was so made that the different fabric samples (sulfonated jute-cotton, sulfonated. jute-rayon, sulfonated jute-acrylic, sulfonated jute-polyester and sulfonated jute-silk waste) took up almost the same amount of dyes from both the dye-bath indicating that the accessibility of the fabric samples to the dye molecules were practically the same. The dye up-takes of the sulphonated jute fabric (100%) and cotton fabric (100%) were only about 2-3 and 1-2% higher than their blends. This indicated that the sulphonated jute fibres were compatible during dyeing in association with cotton in their blend. The sulphonated jute blended fabric samples were compared with different chemical treated jute fibre samples as shown in Fig. 1 in respect of their dye absorption. The results shown in the Fig. 1 indicated that the dye up-take varied for different jute samples texturised in their fibrillar structure in different way due to the different chemical agents. The dye absorption increases from 68 to 88% as jute fibre was sulphonated, which was decreased by about 15-18% on having the sulphonated fibre spun to yarns with/without blended with other textile fibres, natural or synthetics. This was due to the decrease of the exposed area of the fibre on spinning to yarns.



1. raw jute fibre, 2. Defatted jute fibre, 3. Delignifield jute fibre, 4. Peroxide bleached jute fibre, 5. Alkali treated jute fibre, 6. Sulfonated jute fibre, 7. Sulfonated jute cotton fabric, 8. Sulfonated jute/rayon fabric, 9. Sulfonated jute/acrylic fabric, 10. Sulfonated jute/polyester fabric, 11. Sulfonated jute/silk fabric, 12. Cotton fabric

Fig. 1: Dye absorption properties of sulphonated jute fibre

Dye fastness: The depth of the dye shade produced initially on all the blended fabric samples was brilliant as those specimen fabrics absorbed almost exhaustively the dye molecules from the solutions. The brightness of the colour on the fabrics was put in contact with the environmental agencies like water, sunlight and mechanical rubbing. The colour fastness properties of the fabrics dyed with the basic dye (rhodamine-B red) and the reactive dye (procion red) under the experimental conditions were measured and the results have been shown in Table 4. The fastness ratings of the basic color (rhodamine-B red) to different agencies were in general less than those of the reactive dyes (procion-M). In the wash fastness test, there was an appreciable loss of color shade originally produced on the sulphonated jute blended fabric samples dyed with the basic dye and the gray scale ratings for fastness were experiments the depth of the dye shade using the reactive dye, procion red changed to a very limited extent corresponding to the ratings 4-5.

The fastness of the basic dyes on the test specimen of the sulphonated jute blended fabrics to cracking or rubbing was also very low as those fabric samples stained heavily the white cotton fabric of the test procedure, which corresponded to 1-2 degree or rating of the gray scale. But the fastness values for procion red dye on different fabrics were good enough to be equivalent to the fastness degree from 4 to 5. The light fastness of the different fabric samples dyed with rhodamine-B, the basic dye was moderately good to fairly good corresponding to the range from 3-5 of the blue standard and was good to very good corresponding to 5-6 of the standard values for procion dye applied on those fabrics. Table 4 also shows the evaluation of 100% cotton fabrics dyed and tested identically. The results were very much comparable to those of the 100% sulphonated jute fabrics. The color shades on the different blended fabric samples dyed with different class of dyes were almost similar in depth and sharpness to the dyed cotton fabrics. The colour fastness properties of those blended fabrics were also assumed to be closely consistent with those of the cotton fabric samples under the test. This suggests that the textile materials prepared from the sulphonated jute fibre alone or, its blends with cotton, rayon, acrylic, polyester and silk waste may be dyed with approximately the same magnitude as regards dye absorption, dye affinity and dye fastness as compared with the cotton fabrics.

CONCLUSION

The geometrical properties of the fabrics from the blended yarns were favorably compared with those of the cotton fabrics made of yarns of same count 30 tex. The softness and handling characteristic represented by the bending length and flexural rigidity of blended fabrics were very much comparable to those of cotton fabrics. It was found that the blending of the sulphonated jute with cotton or any other flexible fibre improved the draping properties of the cloths and to have gracious look. The dye ability of this blended fabrics was studied using a basic dye (rhodamine-B red) and reactive dye (procion-M red). The dye absorption of jute increases from 68% to 88% as it was sulphonated and the sulphonated jute blended fabrics took up almost the same of amount of dyes which was around 70% from both dye-bath indicating that the accessibility of blended fabric samples to the dye molecules was practically the same. The colour shades on different fabric sample were almost similar in depth and sharpness to the dyed cotton fabrics. The colour fastness properties of these blended fabrics were also assumed to be closely consistent of the cotton fabrics under the test. The sulphonated jute fibre and its blending products are promising materials for the diverse use of textile sectors in comparison with other fibres.

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