World Journal of Research and Review (WJRR)
ISSN:2455-3956, Volume-5, Issue-4, October 2017 Pages 62-69

Chemical Modification of Jute Fibers for Improving its Hydrophobicity and Dyeability with Reactive Dyes

Sharfun Nahar Arju , Md. Afsar Ali

Abstract--**Dyeability of jute fabrics with reactive dyes is not very good due to its high crystallinity and high degree of orientation. To achieve this goal with a view to improving the dyeability of jute fabrics, a new approach of chemical modification of jute fibers has been proposed. Indosol-E50 (polyethylene polyamine), Glycidyl trimethyl ammonium chloride (Glytac) as well as conventional sodium hydroxide (NaOH) were used as modifiers for surface modification of jute fibers. In addition, reactive dye with and without sodium chloride (NaCl) and sodium carbonate (Na_2CO_3) was used to observe the nature of modification of jute fibers. Treated fibers were characterized by water absorbency, Fourier Transform Infrared (FTIR) spectra, color measurement, and wash fastness test. Application of Indosol E-50 changes the hydrophilic nature of the jute fibers significantly. Compared to the raw jute fibers, the modified jute fibers treated with reactive dye without using NaCl and Na_2CO_3 had higher color strength (K/S) values under the same dye concentration. Furthermore, the dyeing of Glytac (with NaOH) and Indosol E-50 treated jute fibers ensured higher K/S, fixation, and better washing fastness and rendered the fiber surface more hydrophobic than those of raw jute fibers.**

Index Terms - **Dyeing, Hydrophobicity, Jute fiber, Surface modification.**

I. Introduction

Among the various natural fibers, jute fiber occupies the second place in terms of world production levels of cellulosic fibers. One of the major countries of jute production is Bangladesh, due to its natural fertile soil. Jute fiber is a lignocellulosic fiber containing three main categories of chemical compounds, namely cellulose (58–63%), hemicellulose (20–24%), and lignin (12–15%), and some other small quantities of constituents such as fats, pectin, and aqueous extract. Owing to its eco-friendly and biodegradable nature, the demand for jute fiber is raising day by day [1]. Nearly, 75% of jute goods are used as packaging materials, burlap, gunny cloth, hessian, and sacks.

In the discipline of textile dyeing, most researches [2-5] focus on introducing cationic sites into the cellulosic fibers for interaction with anionic dyes. The fiber-reactive substituted amino compounds are the most common cationic modifiers. By introducing amino groups, the cellulosic fiber will be cationized giving a high substantivity for anionic dyes. Reactive dyes are anionic dyes which are mostly used to dye cellulosic fibers. These dyes contain a reactive group, either a
haloheterocycle or an activated double bond, that, when applied to a fiber in an alkaline dye bath, forms a chemical bond with a hydroxyl group on the cellulosic fiber. Reactive dyeing is now the most important method for the coloration of cellulosic fibers. Since the cellulosic fibers assume a negative charge on their surface in aqueous solution, a larger amount of salt is usually required to reduce the electrostatic repulsion between fibers and anionic dyes. This is one source of pollutant in waste water produced from dye houses. Reactive dyes have a low utilization degree compared to other types of dyestuff, since the functional group also bonds to water, creating hydrolysis. When alkalinity is introduced in the dye bath in order to facilitate the formation of covalent bond between the fiber and the functional groups of the reactive dye, the only 60-65% dye utilization is attainable even with the use of salt in the normal dyeing systems [6]. However, the hydrolysis of reactive dyes is usually accelerated by the increase in sodium hydroxide concentration.

In theory, dyeability of jute fiber is almost similar to cotton, which is generally dyed with direct dyes or reactive dyes, but the results are not very good due to its high crystallinity and high degree of orientation [7]. For this, recently some studies [8-10] had been done to improve the dyeabilities of jute fibers. Acrylamide and its mixture with different chemicals [11-13], Acrylic acid presence of catalysts under thermal treatment [14-15] , Ethylene di-Amine and Hydrazines [16], Chitosan [17] were used to modify the jute fibers to improve its textile related properties and dyeability with reactive dyes. Glytac and sodium hydroxide treated jute fibers [18] were dyed with reactive dyes in combination with common salt and soda ash. Simultaneous dyeing and finishing methods (pad-dry-cure) of jute fabrics were carried out using various reactive dyes with crosslinking agents [19].
In the studies mentioned above, various researchers have used different procedures to modify jute fibers with a view to improving the dyeing and other textile related properties. However, further studies on the modification of jute fibers are still necessary in order to understand and improve the dyeing properties along with other characteristic of jute fibers.

The present paper focuses on the study of chemical modifications of jute fabrics involving chemical treatments with various chemicals, such as Glytac, Indosol E-50, and NaOH, in the presence and absence of reactive dye with or without salt and soda ash for the analysis of dyeing and other textile related properties.

Sharfun Nahar Arju, Department of Wet Processing Engineering, Bangladesh University of Textiles (BUTex), Dhaka 1208, Bangladesh
Afsar Ali,Department of Mechanical Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka 1000 Bangladesh

II. EXPERIMENTAL

A. Materials

Jute fabrics

Jute fabrics were used without further treatment (scoured and bleached). Plain woven structured fabrics of untreated jute yarn were collected from Bangladesh Jute Research Institute (BJRI). Specification of woven structured fabrics was – number of yarn per inch (both directions): 10-12, number of twist per inch: 4-5, yarn count: 241 tex, fabric strength: about 20MPa. Same yarns were used in both the directions (warp and weft) of the fabrics.

Chemical

Glytac (C6H14ClNO) from Sigma-Aldrich Comp., United States of America, Indosol E-50 liquid (polyethylene polyamine in aqueous solution) and reactive dye Drimarene Red K-8b (composition: C, Cl, F, H, Li, N, Na, O, S) from Clariant, Switzerland were used in this research work. NaOH, Na2CO3, and NaCl from BDH, (UK) and Ecal soap PA (nonionic detergent), from Thailand were also used in the present study.

B. Methods

Chemical treatment of jute fabrics

To observe the effect of chemical treatment, five different procedures were followed to treat the jute fabrics as shown in Table 1. All the procedures were carried out with the concentration of Glytac- 60 g/l, NaOH - 20g/l, Indosol E-50- 4g/l, NaCl - 40g/l, and Na2CO3 - 10g/l. The concentration of these chemicals was selected after studying different relevant literatures [18, 19]. Also, 1% Drimarene Red K-8b was used in every procedure except G-1 procedure of Table 1. It is important to note that no catalyst was used in any treatment procedure of Table 1. All the treatments shown in Table 1 were carried out in a sealed steel container in a laboratory dyeing machine Rota Dyer with the material to liquor ratio of 1:15 and at the temperature of 60°C for 60 minutes. When more than one chemical is used at a time to treat the fabrics, a mixture of chemicals is first prepared, which is then used to treat the fabrics. Such type of mixture is indicated by a plus (+) sign in Table 1. For an example, the sample G-3 S-1 implies that it was treated with the mixture of Glytac and Drimarene Red K-8b. On the other hand, the sample G-2 S-1 implies that it was first treated with Glytac. Then this Glytac treated sample was again treated with Drimarene Red K-8b. After treatment, the samples were then taken out and washed with water at least three times in order to remove any residual chemical so that a final pH value of 7 was maintained and then dried in open air. For wash fastness test, samples were washed by placing them in a mixture of Ecal soap – PA (0.50gm/l) and water at temperature of 95°C for 10 minutes. Afterwards, samples were hot washed at 80°C for 10 minutes. Finally, samples were washed with normal water repeatedly until the pH value of 7 was obtained.

C. Characterization s

Water absorbency

AATCC/ASTM Test Method TS-018 procedure was followed for water absorbency test.

Table I: Different treatment procedures

Group	S-1	S-2	S-3	S-4
G-1	Treatment with Glytac	Treatment with NaOH	Treatment with Glytac + NaOH	Treatment with Indosol E-50
G-2	Treatment of G-1S-1 sample with Drimarene Red K8b	Treatment of G-1S-2 sample with Drimarene Red K8b	Treatment of G-1S-3 sample with Drimarene Red K8b	Treatment of G-1S-4 sample with Drimarene Red K8b
G-3	Treatment with Glytac + Drimarene Red K8b	Treatment with NaOH + Drimarene Red K8b	Treatment with Glytac + NaOH + Drimarene Red K8b	Treatment with Indosol E-50 + Drimarene Red K8b
G-4	Treatment of G-1S-1 sample with Drimarene Red K8b + NaCl + Na_2CO_3	Treatment of G-1S-2 sample with Drimarene Red K8b +NaCl + Na_2CO_3	Treatment of G-1S-3 sample with Drimarene Red K8b + NaCl + Na_2CO_3	Treatment of G-1S-4 sample with Drimarene Red K8b + NaCl + Na_2CO_3
G-5	Treatment with Glytac + Drimarene Red K8b + NaCl + Na_2CO_3	-	Treatment with Glytac + sodium hydroxide + Drimarene Red K8b + NaCl + Na_2CO_3	Treatment with Indosol E-50 + Drimarene Red K8b +NaCl +Na_2CO_3

Measurement of color

The reflectance values at all wavelengths were measured by using a Minolta Spectrophotometer. The reflectance value (R) of dyed fabrics at the maximum wavelength of absorbency (λ max) is found and color strength (K/S) is calculated using the built-in software of the computer color matching system. These values are calculated using the following Kubelka Munk equation:

$$K/S = \frac{(1-R)^2}{2R} \quad (1)$$

where K is the Kubelka-Munk absorption coefficient and S is the scattering coefficient of the dyed sample at the wavelength of maximum absorption.

By using a Minolta Spectrophotometer and following the International Commission on Illumination (CIE) L*a*b* color space, the values of L*, a*, and b* of the selected samples were also analyzed. In the study of color perception, one of the first mathematically defined color spaces, the CIE 1931 XYZ color space, is created by the CIE in 1931. A Lab color space is a color-opponent space with dimension L for lightness and a and b for the color-opponent dimensions, based on nonlinearly compressed CIE XYZ color space coordinates. The maximum value for L* is 100, which represents a perfect reflecting diffuser. The minimum value for L* is zero, which represent black. The a* and b* axes have no specific numerical limits. The positive and negative values of a*, respectively, indicate the red and green. On the other hand, the positive and negative values of b* indicate the yellow and blue, respectively.

Determination of fixation (% F)

The percentage of dye fixation (% F) was calculated using the following equation:

$$F = \frac{(K/S)_a}{(K/S)_b} \times 100\%$$

(2)

where K/S is the color strength with the values after soaping (a) and before soaping (b).

Testing of wash fastness

ISO standards 105-C02 method was followed for wash fatness test. A specimen of 10 × 4 cm was attached with a multifiber fabric strip. Washing solution containing 5g/l soap was taken in the laboratory dyeing machine with a liquor ratio of 1:50. The specimen was treated for 45 minutes at 50 ± 2°C. The specimen was then removed and rinsed in normal water and dried in shadow. The change in color and degree of staining was evaluated visually using geometric grey scale.

FTIR spectroscopy

The surface chemistries of the treated and raw jute fabrics were evaluated by using an FTIR Prestige-21, Shimadzu, Japan Fourier Transform Infrared Spectroscopy (FTIR) instrument at a resolution of 2 cm^{-1}. Average of 30 scans was recorded in absorbance units from 4000 to 500 cm^{-1}.

III. Results and Discussion

As mentioned in a preceding section, five different treatment procedures were considered to characterize the treated jute fabrics. The effects of treatment on different parameters are discussed in the sequel.

A. *Water absorbency*

Water absorbency test was carried out for all the samples of five different groups of Table 1. The test results of these samples are shown in Fig.1, which indicates the time required for a drop of water to be fully absorbed by the jute fabrics. Besides these samples, raw jute fabric was treated with 1% Drimarene Red K8b only at 60°C temperature for 60 minutes. Again, another raw jute fabric sample was treated with normal dyeing method, i.e. jute fabric was treated with the mixture of 1% Drimarene Red K8b, sodium chloride (40g/l), and sodium carbonate (10g/l) at 60°C temperature for 60 minutes. These two samples were used as a control sample in this study which are not shown in the Fig.1. Water absorbency of these two samples was 2.32 and 2.37 minutes, respectively. Figures 1(a) and 1(b) show that S-4 samples of all the groups of Table1 are the most hydrophobic among other samples. Further, among all the S-4 samples, the samples S-4 of G-1 and G-3 exhibit the highest value of time to absorb a drop of water. Thus, in general, application of Indosol E-50 with or without Drimarene Red K8b had changed the hydrophobicity of the jute fiber significantly. It can be understand from the proposed reaction Scheme 1 to 3, where the hydrocarbon groups of Indosol E-50 are introduced on the jute fibers. Therefore, these fiber surfaces possess the highest hydrophobic nature. Again, all the samples of G-3 show the higher hydrophobic character than that of the samples of other groups. Apart from the samples S-4, the sample S-3 of G-3 shows the highest value of time among the samples of Fig. 1(a). That is treatment with the mixture of Glytac, sodium hydroxide and Drimarene Red K8b gives higher hydrophobicity than those treated with the mixture of Glytac and sodium hydroxide only. Further, Fig. 1(a) shows that the samples S-2 are less hydrophobic than the samples S-1 and S-3 of their corresponding groups. In addition, comparison of

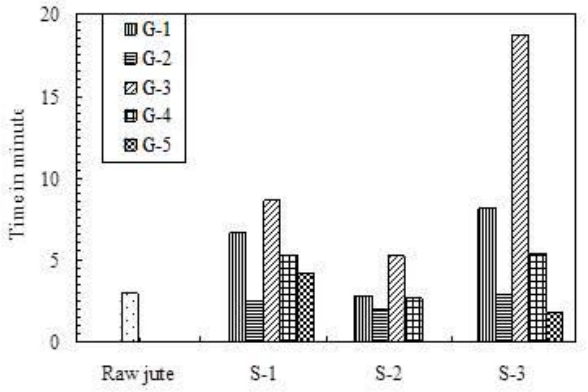


Fig. 1(a): Water absorbency of raw jute and S-1 to S-3 samples.

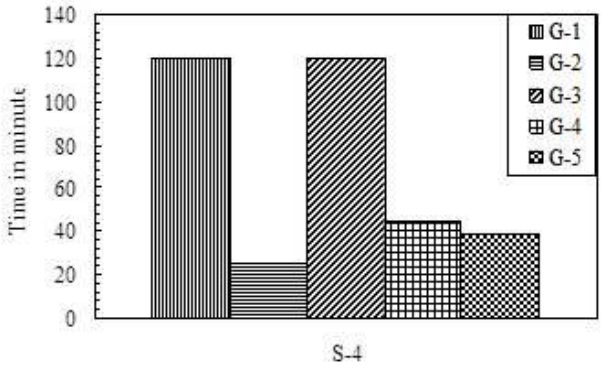


Fig. 1(b): Water absorbency of S-4 samples.

samples of G-2 and G-3 exhibits that the treatment of fibers with the mixture of dye and other chemicals (G-3) ensure the higher hydrophobicity than the sequential treatments of fibers (G-2) by the corresponding chemical and dye. This is due to the fact that Drimarene Red K8b and chemicals react between themselves as well as fibers to increase the hydrophobicity of the fibers under G-3 but Drimarene Red K8b alone cannot react well with the already treated jute fibers under the group G-2. In case of treatment using the mixture of Drimarene Red K8b, sodium chloride and sodium carbonate, the samples under the groups G-4 and G-5 need less time to absorb water than the same category of samples under G-1 and G-3. This is due to the presence of sodium chloride and sodium carbonate in the mixture (for G-4 and G-5) which may interact with dye and fiber so that it reduces the hydrophobicity of the fibers indicating the increased polarity of the fibers.

B. *Effect of treatment on color strength (K/S)*

The color depth of treated jute fabrics was evaluated in terms of K/S values from the Kubelka- Munk function (Eq.1), where the reflectance R was measured with a Minolta Spectrophotometer. Higher value of K/S indicates the higher dye uptake (depth of color) of the fabrics [20]. To evaluate the

depth of color of the samples, different procedures were followed for the groups G-2 to G-5 and these samples are plotted against K/S values for graphical representation in Fig.2. To observe the effect of Glytac, sodium hydroxide and Indosol E-50 on dye uptake, raw jute fabric was treated with 1% Drimarene Red K8b only which was considered as the control sample one (Con. 1) for G-2 and G-3 samples as shown in Fig. 2. On the other hand, the normal dyed raw jute fabric (jute fabric dyed with the mixture of 1% Drimarene Red K8b, NaCl (40g/l), and Na2CO3 (10g/l)) was considered as the control sample two (Con. 2) for G-4 and G-5 samples. From Fig.2, the following points are noted:

The K/S value of the untreated jute fabric (Con. 1) is comparatively lower than the K/S value of all the samples under the group G-2 and G-3 except the sample S-2 of G-2. The maximum K/S value is found for the sample S-4 of G-2 (Indosol E-50 treated jute fabric again treated with Drimarene Red K8b) among the samples under the group G-2 and G-3 and for the sample S-4 of G-4 (Indosol E-50 treated jute again treated with the mixture of Drimarene Red K8b, NaCl, and Na2CO3) among the samples under the group G-4 and G-5. There is a significant change in K/S value of the sample S-4 of G-2 among all the samples under the group G-2 and G-3. This sample also gives the higher K/S value than the K/S value of Con. 2. This tells that without exhausting agent (sodium chloride) and fixing agent (sodium carbonate), Indosol E-50 treated jute fiber molecule react with dye molecule largely, so that dye uptake of the sample (S-4 of G-2) is higher than that of normal dyed fabric (Con. 2).

Apart from the sample S-4 of G-2, sample S-3 of G-3 gives the higher K/S value than the K/S values of the other samples of group G-2 and G-3. Sample S-2 of G-2 gives the lowest K/S value among these two groups including Con. 1., i.e. jute fabrics treated with the mixture of Glytac, NaOH, and Drimarene Red K8b gives higher K/S value than those first treated with Glytac, and then again treated with NaOH.

There is no significant change in K/S value of the sample S-1, S-3, S-4 of G-4 and the sample S-1 of G-5 comparing to Con.2, but the sample S-2 of G-4 and the samples S-3 and S-4 of G-5 give the remarkably lower K/S value than K/S value of all other samples under the groups G-4 and G-5 including Con.2 samples. In other words, dye uptake of these three samples is very low. This low K/S value may be for the following reasons. When these samples are treated with the mixture of Drimarene Red K8b, NaCl, and Na2CO3, strong repulsion forces may exist between fiber and dye molecule in the dye bath which would lead to hindering the absorption of dye.

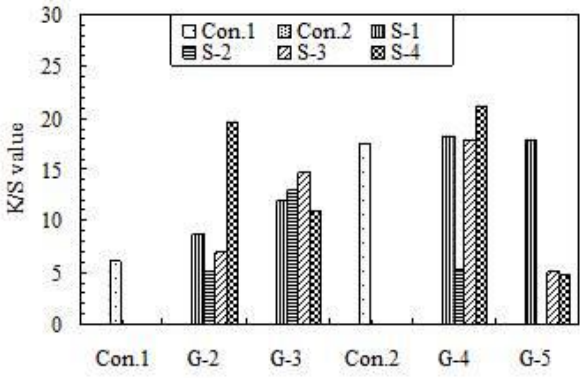
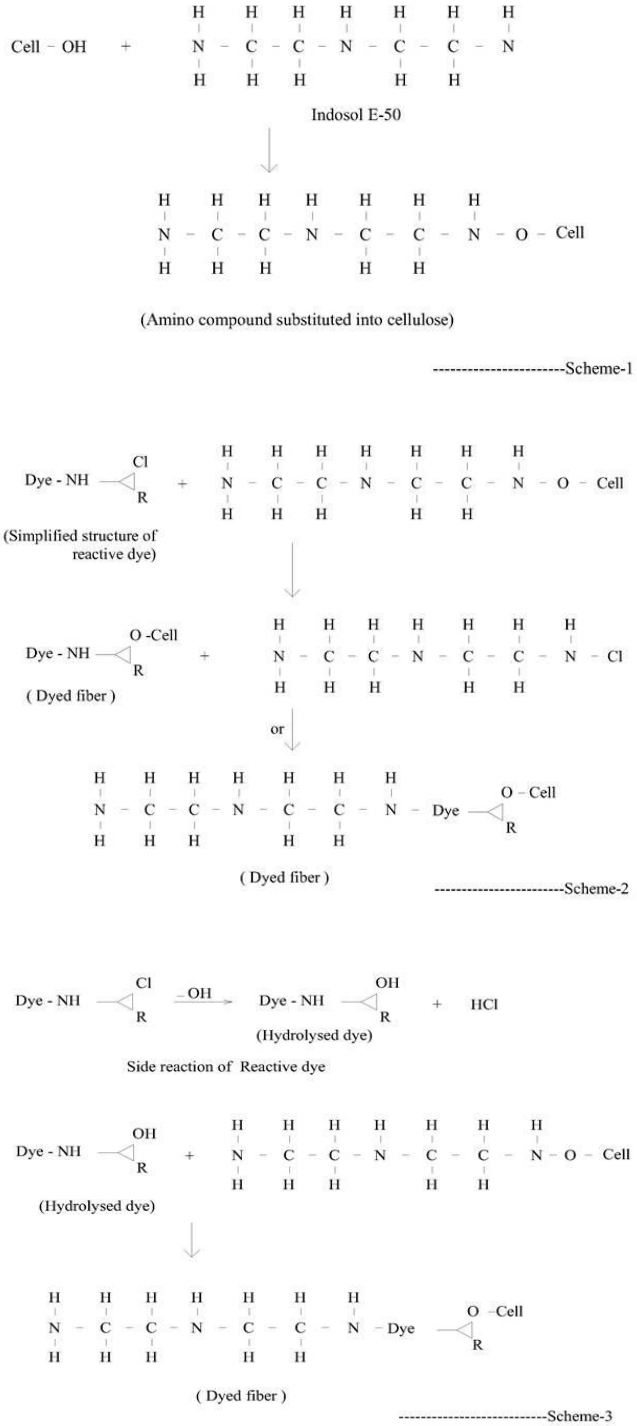


Fig. 2: K/S values of different samples.



The above observations indicate that the treatment of jute

fibers (except sample S-4 of G-5) with Indosol E-50 (with or without exhausting and fixing agent) significantly increases the dye uptake than that of raw jute fibers. Treatment with Glytac only and mixture of Glytac and NaOH also give the higher dye uptake than that of raw jute fibers. This is due to the fact that the dye reactivity on pretreated fabric was greater because of the presence of amino groups provided by Glytac [18] or Indosol E-50 [19]. Possible reaction mechanism among cellulose, Indosol E-50, and reactive dye can be explained by the scheme 1 to 3 below. Therefore, modification with the Indosol E-50 can increase the uptake of reactive dye.

C. Evaluation of CIE Lab coordinates Equations

Single red shade (1%) was produced throughout the experiment, by which the color opponent a* value was analyzed. The samples under the group G-2 to G-5 are plotted against a* values for graphical representation in Fig.3. All the samples under the groups G-2 and G-3 (except the sample S-2 of G-2) show higher a* value than that of con.1. The sample S-4 of G-2 (Indosol E-50 treated sample again treated with Drimarene Red K8b) shows the highest value of a* among the samples of this group. The sample S3 of G-3, i.e., jute fabric treated with the mixture of Glytac, sodium hydroxide, and Drimarene Red K8b shows the highest a* value among the samples under the group G-2 and G-3. So jute fabric treated with the mixture of Glytac, sodium hydroxide and Drimarene Red K8b gives higher a* value than that treated individually with Glytac and sodium hydroxide. The sample S-3 of G-4 corresponding to the treatment with the mixture of Glytac and sodium hydroxide and again treated with the mixture of Drimarene Red K8b, sodium chloride, and sodium carbonate shows the highest a* value among all the samples under the groups G- 4 and G-5 including the normal dyed jute fabric (Con.2). This result indicates the influence of Glytac or sodium hydroxide or Indosol E-50 on the depth of the shade of reactive dyed jute fabric at different procedures. To evaluate the effect of Glytac, sodium hydroxide and Indosol E-50 on the color tone of the treated jute fabrics, L*, a*, and b* values of the samples of group G-2 and G-3 were analyzed and the values are given in Table 2. Apart from the sample S-2 of G-2, a* values, as shown in Table 2, indicate that all the samples are in more red tone and L* values indicates that the samples have dark shades. The b* values indicate that most of the samples are in more yellow tone but the sample S-4 of G-2 and the sample S-3 of G-3 are slightly more blue. L*, a*, b* values of the sample S-3 of G-2 indicates darker, more reddish and more bluish than that of other samples including Con. 1, which leads to increase K/S value as shown in Fig 2.

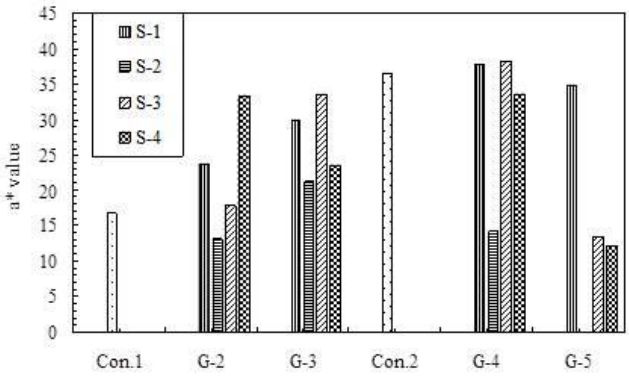


Fig. 3: a*values of different samples.

Table 2: Color coordinates values of different samples

Color coordinate	Con. 1	S-1	S-2	S-3	S-4
L*	50.22	G-2: 44.61	55.31	48.40	33.76
		G-3: 40.33	40.24	37.81	41.81
a*	16.71	G-2: 23.78	13.25	17.74	33.38
		G-3: 29.93	21.22	33.55	23.64
b*	6.71	G-2: 2.60	14.68	6.38	-1.37
		G-3: 1.04	9.15	-0.34	1.86

Table 3: Fixation of different samples

Sample		Fixation (*F* %)
Con.2		77.90
G-4	S-1	78.75
	S-3	84.97
	S-4	90.83
G-5	S-1	81.47

Table 4: Wash fastness of treated and untreated jute fabrics

Wash fastness rating		Con.-2	Sample G-4			G-5
			S-1	S-3	S-4	S-1
Change in color		4-5	3-4	3-4	4	4
Staining	Acetate	4-5	3-4	4	3-4	4
	Cotton	4	3	3	2	2
	Nylon	4-5	3-4	4	3-4	3-4
	Polyester	4-5	4	4	4	3-4
	Acrylic	4-5	4	3-4	3-4	3
	Wool	5	5	5	4-5	4-5

D. *Effect of treatment on fixation properties*

Fixation values of some selected samples are given in Table 3. This result demonstrates that the sample S-4 of G-4 (Indosol E-50 treated jute fabric again treated with Drimarene Red K8b, sodium chloride, and sodium carbonate) gives the highest fixation value among all the samples. This increased value is about 16.6% more than normal dyed jute fabric. The fixation value of the sample S-3 of G-4 is about 9% more than that of normal dyed jute fabric. So, it can be said that

treatment with the mixture of Glytac and sodium hydroxide gives the higher fixation value than those treated with Glytac only (sample S-1 of G-4). Thus, it can be concluded from Table 3 that the dye fixation of the treated jute fibers was obviously higher than those of raw jute fibers under the same dyeing condition. This could be explained based on the forces of repulsion and attraction expected to occur during the dyeing process. These forces arise due to the presence of free hydroxyl groups in jute cellulose, anionic groups present in dyes, and amino ions in Indosol or in Glytac, besides other factors [17]. The presence of amino groups on treated jute fibers reduces the repulsion between the free hydroxyl groups of cellulose and the anionic groups of dyes (Scheme 1 to 3). As a result, these treated jute fibers show higher fixation.

E. Effect of treatment on wash fastness properties

Wash fastness test were carried out for the samples S-1, S-3 and S-4 of G4 and the sample S-1 of G5, considering the higher depth of the color of the samples. The results were compared with those of normal dyed jute fabric (Con.-2). Table 4 shows the wash fastness rating for normal dyed and treated fabrics. It shows that there is not much difference in case of change in color between the normal dyed fabric and treated fabrics. However, in case of staining, most of the samples show moderate to fair rating. The sample S-4 of G-4 and the sample S-1 of G-5 show poor rating of staining on cotton. So it can be concluded from Table 4 that treated jute fibers have little effect on change in color but considerable effect on staining of cotton. The wash fastness depends upon the physical and chemical properties of fibers, the class of the dyes and their forces of interaction, and their interaction with soap solution. Unfix dye removed from the treated sample during washing had higher substantivity towards cotton than the dye removed from raw jute. As a result treated jute fibers show poor staining on cotton.

F. FTIR analysis

FTIR analysis was performed for the samples under the group G-3 only, because these samples show the highest hydrophobicity among the samples of all groups. Figure 4 shows the comparison of the FTIR spectra of the raw jute and all the samples under group G-3. It is seen that the sample S-1 gives the highest percentage of transmittance (*T*%), i.e. lowest absorption value in the hydroxyl region among all the samples including untreated jute fibers. This indicates the lower amount of OH group present in the fiber of S-1. In addition, the peak at 1636 cm^{-1} of FTIR absorption spectrum of untreated jute shifted to 1641 cm^{-1} in case of sample S3. This FTIR absorption spectrum of the sample S-3 corresponds to R–NH_2 bending for the primary amines. The increase of the peak at 2924 cm^{-1} suggests an increase of aliphatic link (C-H) for the sample S-3. Thus, it is found that the Glytac was successfully applied on the jute fiber. It can be noted that there is an absorption band at 1730 cm^{-1} and 1240 cm^{-1} for the untreated jute fibers, which no longer exists for S-2 sample. The hemicelluloses contain groups that absorb in the carbonyl region and ester group on surface of the fiber. They are soluble in aqueous alkaline solutions. During alkali treatment, a substantial portion of uronic acid and fatty substances might be removed resulting in disappearance of this peak at 1730 cm^{-1} and 1240 cm^{-1} [21]. Relatively strong peak observed in the Indosol treated fibers (S-4) at 1740 cm^{-1} indicates C=O vibration. Also, it shows signals at 1502 cm^{-1} and 1509 cm^{-1}, which can be attributed to amide II (NH) modes on the basis of the structure of Indosol E-50. This finding leads to conclude that Indosol E-50 can be fixed into the jute fibers through the reaction of the aldehyde groups of the hemicellulose with the amino groups provided by Indosol E-50. The product of this reaction (Scheme -1) again reacts with reactive dye molecule whereby dye uptake of jute fabrics increased significantly (Scheme 2 to 3).

G. Effect of Glytac concentration on K/S and a values*

In order to examine the effect of Glytac concentration on dye uptake, the treatments were carried out using Glytac of different concentrations (10–70 g/L) and 1% Drimarene Red K8b and keeping the samples at 60°C for 60 min. Figure 5(a) shows that the K/S value increases with the increase in Glytac concentration and the optimum K/S value was obtained at a Glytac concentration of 60 g/L. Glytac concentration versus a* value also indicates the similar result as shown in Fig.5(b). Thus, dye uptake increases with the increase of Glytac concentration. Therefore, it can be explained that positive charges on jute fiber would increase when Glytac concentration increased, which would be manifested by the

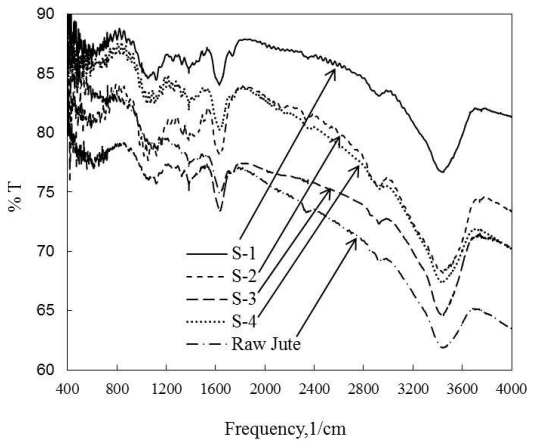
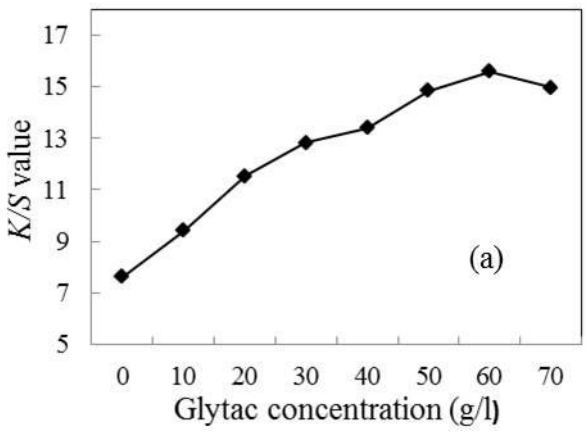


Fig. 4: FTIR spectra of treated and untreated jute fabrics.



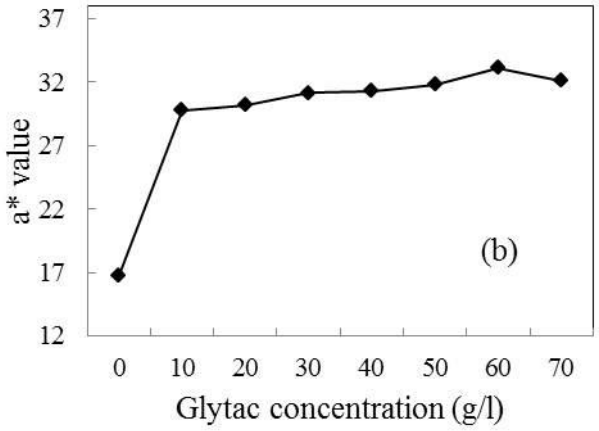


Fig. 5: Effect of Glytac concentration on (a) K/S value and the(b) a* value.

sequent dye uptake increase. Weiming wang et al. [18] modified the jute fiber with Glytac and sodium hydroxide and then dyed with reactive dye in presence of sodium chloride (exhausting agent) and sodium carbonate (fixing agent). They also found the optimum dye uptake at the Glytac concentration of 60g/l.

Finally, it is found that the new treatment procedures introduced in this paper improve the hydrophobicity, dye uptake, wash fastness, and fixation properties of the jute fibers significantly. Specifically Indosol E-50 treated jute fabric again treated with Drimarene Red K8b only (G-2 S-4) had 12% more dye uptake (K/S value). So, it is obvious that without exhausting (common salt) and fixing (sodium carbonate) agents, this treatment (G-2 S-4) saves the dye wastages and as well as the cost of exhausting and fixing agents. In addition, during this process the fabric was in pure neutral state (pH of Indosol E-50 is 7) and contained very less quantity of hydrolyzed dye. Hence, neutralizing and subsequent acid washing treatments can be reduced. Thus, a substantial reduction in the requirement of water and their treatment cost is ensured. Also, this provides a very good scope for reuse of bath water as it contains no hydrolyzed dye and no consumed or converted auxiliaries

IV. Conclusions

Chemical modification of jute fibers with Glytac, sodium hydroxide, mixture of Glytac and sodium hydroxide, Indosol E-50 with or without reactive dye (Drimarene Red K8b) was performed under different procedures. Indosol E-50 rendered the jute fiber surface more hydrophobic in comparison with other chemicals. Indosol E-50 treated jute fabric again treated with Drimarene Red K8b only gave the maximum K/S value, which was 12% higher than the normal dyed jute fabrics. By using this treatment procedure, the following advantages were observed: elimination of salt as an electrolyte, maximum fixation of dye, minimum hydrolysis of dye, significant savings in process costs, environmentally friendly. Apart from the samples S-4 of all the groups, the sample S-3 of G-3, i.e. jute fabrics treated with the mixture of Glytac, sodium hydroxide, and reactive dye has significant improvement in hydrophobicity along with significant dye uptake.

Acknowledgment

Authors are indebted to Bangladesh University of Textiles (BUTex) and Clariant Bangladesh limited for providing their laboratory facilities.

References

[1] A. K. Samanta, A. Konar, and S. Datta, “Dyeing of jute fabric with tesu extract: part II- Thermodynamic parameters and kineties of dyeing,” Indian Journal of fibre and Textile Research, vol. 37, 2012, pp. 172-177.
[2] S. Ali, S. Saleem, S. Umbreen, and T. Hussain, “Cationizing efficiency and performance of antimicrobial agent on cotton fabric dyed with vinyl sulfone based reactive blue dye,” Indial Journal of Fibre and Textile Research, vol. 34, 2009, pp. 274-278.
[3] X. Song, “New dyeing technologies using reactive dyes (part I),” China Textile Leader, vol. 9, 2007, pp. 108-111.
[4] N. Ristić, and I Ristić, “Cationic modification of cotton fabrics and reactive dyeing characteristics,” Journal of Engineered Fibers and Fabrics, vol. 7(4), 2012, pp. 113-121.
[5] J. Jang, S.W. Ko, and C. M. Carr, “Investigation of improved dyeability of cationized cotton via photografting with UV active cationic monomer,” Coloration Technology, vol. 117(3), 2001, pp. 139-146.
[6] M. S. K. Subramanian, M. Gobalakrishnan, S. Kumaravel, R. Nithyanadan, K. J. Rajashankar, and V. Thiak, “Influence of cationization of cotton on reactive dyeing,” Journal of Textile and Apparel, Technology and Management, vol. 5(2), 2006, pp. 23-30.
[7] X. Liu, H. Zhou, C. Lu, J. Zhang, and C. Peng, “Research on the dyeing and finishing of jute textile products,” Guangxi Textile Science & Technology, vol. 31, 2002, pp. 2-6.
[8] A. K. Samanta, S. Chakraborty, and T. K. G. Roy, “Dyeing of Jute with Reactive Dyes: Optimisation of the Process Variables and Assessment of Colour fastness Characteristics,” Journal of The Institution of Engineers (India): Series E, vol. 93 (1), 2012, pp. 15-24.
[9] A. Konar, S. Chakraborty, T. R. Kar, and A. K. Samanta, “Effects of Amino-acid Modification of Jute Fabric on its Textile Related Properties and Dyeability with Selective Reactive Dyes,” International Review of Applied Engineering Research, vol. ; 4(1), 2014, pp. 51-67.
[10] A. Konar, S. Mukherjee, T. R. Kar, and A. K. Samanta, “Salt-free Reactive Dyeing of Amino-Acid Modified Jute. Indian Journal of Natural Fibre,” vol. 1(1), 2014, pp. 15-28.
[11] A. K. Samanta, S. Mitra, G. Basu, K. Kumar, and Mahalanabis, “Chemical Modification of Jute By Low Degree of Aerial Graft-Copolymerization of Acrylamide And Its Mixtures With Ethylene Glycol And Aminosilicone Using K2S2O8 Pre-Treatment Technique Under Limited Aqueous System,” Journal of polymer materials, vol. 24, 2007, pp. 294.
[12] A. K. Samanta, and P. Agarwal, “Effect of N-Methylol Acrylamide And Ethylene Diamine Treatment On Its Textile Related Properties of Jute Fabric,” Journal of polymer materials, vol. 26(3), 2009, pp. 293-313.
[13] P. Ghosh, D. Dev, and A. K. Samanta, “Effect of graft copolymerization of mixtures of acrylamide and methyl methacrylate on mechanical properties of jute fibers of different compositions,” Journal of applied polymer science, vol. 68, 1998, pp. 1139-1147.
[14] P. Ghosh, and D. Das, “Modification of Jute by Acrylic Acid in the Presence of Na3PO4 and K2S2O8 as Catalysts Under Thermal Treatment,” Journal of Applied Polymer Science, vol. 68, 1998, pp. 63-74.
[15] G. M. A. Khan, “Dyeing of Grafted Jute Fibre with Reactive Dyes and Its Improved Properties,” Thammasat Int. J. Sc. Tech., vol. 12(3), 2007, pp. 8-13.
[16] A. K. Samanta, A. Konar, P. Agarwal, and S. Datta, “Effects of Chemical Modiification of Jute Fabric With Ethylene di-Amine And Hydrazines On Its Textile Related Mechanical Properties And Dyeability,” Journal of polymer materials, vol. 27(3), 2010, pp. 203-233.
[17] D. Gupta, and A. Haile, “Multifunctional properties of cotton fabric treated with chitosan and carboxymethyl chitosan. Carbohydrate Polymers,” vol. 69, 2007, pp. 164-171.
[18] W. Wang, B. Xu, Z. Cai, and J. Yu, “Study on Chemical Modification and Dyeing Properties of Jute Fiber,” The Journal of The Textile Institute, vol. 101(7), 2010, pp. 613-620.
[19] M. K. Uddin, M. E. Molla, S. M. B Rahman, M. A. K. Azad, H. M. Z. Hossain, and M. M. U. Jubayer, “Physical Properties of Jute Dyed

Fabric Crosslinked with DMDHEU," J. Boil. Sci., vol. 7, 2007, pp. 68-70.
[20] M. Yamada, Y. Amano, Horikawa, K. Nozaki, and T. Kanda, "Mode of action of celluloses on dyed cotton with a reactive dye. Journal for the study of British cultures," vol. 69, 2005, pp. 45-50.
[21] X. Y. Liu, and G. C. Dai, "Surface modification and micromechanical properties of jute fiber mat reinforced polypropylene composites," eXPRESS Polymer Letters, vol. 1(5), 2007, pp. 299-307.

First Author

Dr. Sharfun Nahare Arju, PhD (BUET, Dhaka, Bangladesh), M. Sc. (The University of Bolton, UK)., B. Sc.in Textile Engineering (Dhaka University, Bangladesh), Life Member of ITET, Fellow of Institute of Engineers, Bangladesh

List of Publication

1. "A New Technique for Reactive Dye Uptake by Jute Fabrics and their Physico-mechanical Properties", S. N. Arjua,b, A. M. Afsarb, D. K. Dasb, Mubarak A. Khanc , Journal of Textile and Apparel, Technology and Management (JTATM), Our decision is to: Accept the revision on dated 27/01/2015 (email) vol. 9, No. 2, Spring 2015
2. "Effects of Jute Fabric Structures on the Performance of Jute Reinforced Polypropylene Composites", Sharfun N Arju, Afsar A M, Mubarak A Khan and Dipak K Das, Journal of Reinforced Plastics and Composites (JRPC), DOI: 10.1177/0731684415589360, 0(0) 1–9, 2015.
3. "Role of Reactive Dye and Chemicals on Mechanical Properties of Jute fabrics Polypropylene Composites" S. N. Arjua, A. M. Afsarb, , D. K. Das, Mubarak A. Khan, Procedia Engineering (2014), pp. 199-205, DOI information: 10.1016/j.proeng.2014.11.837
4. "Use of Transition Metal Ions to Enhance Flame Retardancy of Ammonium Polyphosphate, Pyrovatex or Proban Treated Cotton Fabrics", Sharfun Nahar Arju, Canadian Journal on Scientific and Industrial Research, Vol. 1, No. 1, July 2010
5. "Use of Transition Metal Ions to Enhance Flame Retardancy of Ammonium Polyphosphate Treated Back coated Cotton Fabrics", Sharfun Nahar Arju, International Journal of Engineering & Technology, 2010, IJET-IJENS Vol: 10 No: 03 25, pp 25-30.

Second Author

Dr. Afsar Ali, B.Sc. Engg.(BUET), M.Sc. Engg.(Tohoku University, Japan), Ph.D. (Tohoku University, Japan).

Research field: Composite Materials, Functionally Graded Materials (FGMs), Fracture Mechanics, Elasticity, No. of publications: more than 100, Member of Bangladesh Society of Mechanical Engineers (BSME), Fellow of Institute of Engineers, Bangladesh, Member of Korean Society for Composite.