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The Preferable Technique of Jute Fabric Dyeing with Basic Dye

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Abstract
In this study, bleached hessian jute fabric samples were dyed with basic dye for 0.5, 1, 2, 3 and 4 shade% using polyacrylamide as an exhausting agent. Same type of jute fabric samples was dyed with same basic dye for same shade% without using any exhausting agent as well as using the common salt as an exhausting agent. Comparisons among corresponding shade% of different fabric samples showed that the samples dyed with polyacrylamide exhaustion method are slightly lighter in color than the fabric samples dyed with other two methods. The color depth of fabric samples dyed with common salt and without any exhausting agent were found almost same at different shade%. The wash and rubbing fastness of these jute fabric samples were tested. The wash fastness results of all these three type of samples were found moderate. The rubbing fastness of these three type of samples were found quite good and comparable to each other. These results imply that jute fabric should be dyed with basic dye without using any exhausting agent for different shade%.

Keywords: Jute Fabric, Basic Dye, Polyacrylamide, Common Salt, Spectrophotometry, Color Fastness.

1. Introduction
Jute is a cheap biodegradable natural fiber which is composed of mainly cellulose (58-63%), hemi-cellulose (20-22%), lignin (12-14%) and small amount of pectin and wax [1, 2]. Traditionally jute is used for making packaging material. Due to the eco-friendly nature, jute is now used for making diversified and value-added products including upholstery, furnishing textiles, handicraft items, soft toys, and even apparels [3-5].

Although the color fastness is not always very good and the range of achievable color is not very wide, the dyeing of jute fiber is mainly carried out by the basic dye, because jute cellulose has a direct affinity towards the basic dye [6]. However, it is seen that sometime common salt is used for better exhaustion during dyeing of jute fiber with the basic dye [7, 8], although there is no theoretical reason to use common salt as exhausting agent here.

Again the use of polyacrylamide in dyeing of cotton with basic and reactive dye have been reported in previously published articles [9, 10]. The reason is mentioned that the amide groups ($-CONH_2$) in polyacrylamide enhance the affinity of cotton cellulose substrate for these dyes. It is necessary to check the dyeing possibility of jute fabric with the basic dye using polyacrylamide as an exhausting agent as well as it is necessary to check the color depth of fabric samples in this technique. So we performed a series of experiments to check the dyeing possibility of jute fabric with basic dye using polyacrylamide as an exhausting agent for different shade%. We also dyed jute fabric samples with basic dye without using any exhausting agent and using common salt as exhausting agent to find the most preferable method of dyeing jute fabric among these three dyeing techniques.

2. Materials and Methods

2.1. Scouring and bleaching of jute fabric

Table 1. Scouring and bleaching recipe of 100% hessian jute fabric sample.

Chemicals	Amount
Sodium Hydroxide	1 g/L
Soda ash	6 g/L
Detergent	2 g/L
Hydrogen peroxide	8 g/L
Stabilizer	2 g/L
Wetting agent	2 g/L
Sequestering agent	1 g/L
Temperature	100 °C
Time	60 min.
M:L	1:20

Table 2. The recipe of dyeing of jute fabric samples with PAE method.

Shade%	0.5	1.0	2.0	3.0	4.0
Polyacrylami	0.3	0.3	0.3	0.3	0.3
Acetic acid	2	2	2	2	2
Sequestering	1	1	1	1	1
Wetting	1	1	1	1	1
M:L	1:2	1:2	1:2	1:2	1:2
pH	4.5	4.5	4.5	4.5	4.5
Temperature	100	100	100	100	10
Time (min.)	50	50	50	50	50

100% plain hessian jute fabric (GSM 294) was used for scouring and bleaching. Scouring and bleaching of fabric was done in a bath with the recipe shown in table 1. The samples were then washed thoroughly, neutralized and dried.

2.2. Dyeing of jute

Five samples of jute fabric were dyed with 0.5%, 1%, 2%, 3% and 4% basic dye (Basic Orange 22). 0.3% polyacrylamide was used as an exhausting agent. From now this dyeing process will be illustrated as PAE method. The dyeing recipe is shown in Table 2.

The dyeing process was as follows: 1% stock solution of basic dye was made in a conical flask. The required amounts of stock solution for each shade% were taken in the dye pots of laboratory dyeing machine (ECO DYER Rapid, China). Then the required amount of sequestering agent and wetting agent were taken. 0.1% stock solution of polyacrylamide in water was made in a conical flask. Required amount of polyacrylamide solution was taken in the dye pots and stirred. Then the required amount of acetic acid and water were taken in the dye pots and stirred. 10 g of scoured and bleached jute fabric samples were taken in each dye pots and the samples were agitated. The temperature was then raised to 100 °C and dyed for 50 minutes. After dyeing, the samples were thoroughly washed. The dyed samples were then washed by hot water with 1 g/L detergent at 65 °C to remove unfixed dye and rinsed thoroughly and dried.

To compare the shade variations of fabric samples dyed with PAE method with fabric samples dyed with common salt as exhausting agent (from now illustrated as the CSE method) and fabric samples dyed without any exhausting agent (from now illustrated as WEA method), ten samples were again dyed with the same basic dye for same shade% of 0.5, 1, 2, 3 and 4 with CSE method and WEA method (five samples for each method). The sequestering agent, wetting agent, acetic acid, M:L, temperature and required time were kept same as for the PAE method. The amounts of common salt taken in CSE method are shown in Table 3.

Table 3. Amount of salt taken in CSE method.

Shade%	Common Salt (g/L)
0.5	10
1.0	12.5
2.0	15
3.0	17.5
4.0	20

2.3 Spectrophotometry

X-Rite Spectrophotometer (USA) was used to compare the color differences among the fabric samples dyed with WEA CSE and PAE methods.

3. Results and Discussion

3. 1 Table 4 shows the spectrophotometric results of 0.5%, 1%, 2%, 3% and 4% shade of fabric samples dyed with CSE method and WEA method. For all shade%, the fabric samples dyed with CSE method were taken as standard. The CMC overall color difference, CMC DE values between fabric samples dyed with CSE method and WEA method showed that the CMC DE values are very small (less than 1) which indicate that the color depth of corresponding shade% between these fabric samples are almost same (shown in Figure 1). CMC DE values were calculated from CIE 1976 L*a*b* (CIELAB) coordinates. The positive and negative values of lightness difference DL* at different shade% also indicate that the depth of color of these two samples are almost same.

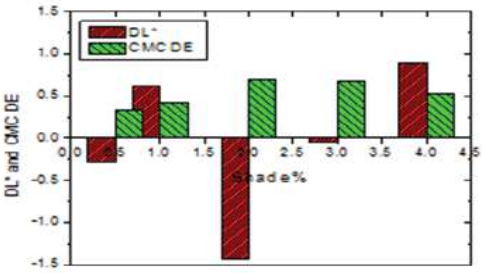

Figure 1. Change of DL* and CMC DE with the increase of shade% of fabric samples dyed with CSE method and WEA method.

Table 4. Spectrophotometric results of fabric samples dyed with CSE method and WEA method of different shade%.

Shade%	Illuminant	Lightness difference, DL*	Red/green difference, Da*	Yellow/blue difference, Db*	Chroma difference, DC*	Hue difference, DH*	CMC overall color difference, CMC DE
0.5	D65	-0.28	0.27	-0.18	0.04	-0.32	0.33
1.0	D65	0.62	-0.63	-0.33	-0.66	0.27	0.43
2.0	D65	-1.43	-0.52	-0.79	-0.94	-0.10	0.70
3.0	D65	-0.05	-1.07	-0.16	-0.81	0.72	0.68
4.0	D65	0.90	-0.70	-0.57	-0.88	0.17	0.53
0.5	F02	-0.27	0.20	-0.22	-0.12	-0.27	0.27
1.0	F02	0.65	-0.60	-0.32	-0.54	0.40	0.47
2.0	F02	-1.55	-0.26	-0.92	-0.94	-0.16	0.73
3.0	F02	0.01	-0.96	-0.13	-0.55	0.80	0.69
4.0	F02	0.98	-0.66	-0.52	-0.76	0.35	0.57

Table 5 shows the spectrophotometric results of 0.5%, 1%, 2%, 3% and 4% shade of fabric samples dyed with CSE method and PAE method. For all shade%, the fabric samples dyed with CSE method were taken as standard.The positive DL* values indicate that all fabric samples dyed with PAE method are lighter than their respective standard. The CMC DE values between fabric samples dyed with CSE method and PAE method also indicate that the fabric samples dyed with PAE method are slightly lighter than the samples dyed with CSE method (as shown in Figure 2).

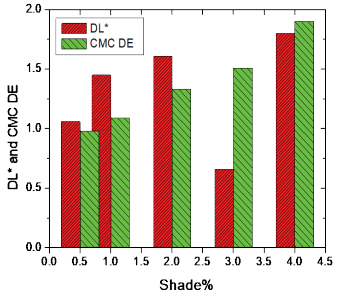

Figure 2. Change of DL* and CMC DE with the increase of shade% of fabric samples dyed with CSE method and PAE method.

Table 5. Spectrophotometric results of fabric samples dyed with CSE method and PAE method of different shade %.

Shade%	Illuminant	DL*	Da*	Db*	DC*	DH*	CMC DE
0.5	D65	1.06	-1.50	-0.88	-1.64	0.59	0.98
1.0	D65	1.45	-1.18	-1.99	-2.28	-0.36	1.09
2.0	D65	1.61	-2.27	-2.24	-3.17	0.36	1.33
3.0	D65	0.66	-2.63	-3.37	-4.28	-0.12	1.51
4.0	D65	1.80	-3.29	-3.93	-5.13	0.04	1.90
0.5	F02	0.97	-1.20	-1.01	-1.41	0.69	0.92
1.0	F02	1.40	-0.98	-2.12	-2.34	0.00	1.03
2.0	F02	1.67	-1.92	-2.19	-2.79	0.82	1.36
3.0	F02	0.60	-2.25	-3.56	-4.18	0.47	1.52
4.0	F02	1.83	-2.86	-3.99	-4.84	0.81	1.93

Figure 3 shows the variation of color strength, K/S values with the variation of shade percentages for all three methods. The maximum K/S values found at 490 nm wave length are plotted against different shade percentages for all type of samples (shown in Figure 3). For all shade percentages, K/S values found for samples dyed with CSE method and WEA method are very close to each other, i.e. K/S found for both type of samples are almost same. However, K/S values found for samples dyed with PAE method are slightly lower than the K/S values found for samples dyed with other two methods. This implies that although dyeing of jute fabric with basic dye using polyacrylamide is possible, but in fact dyeing of jute fabric without the use of any exhausting agent is the best dyeing process.

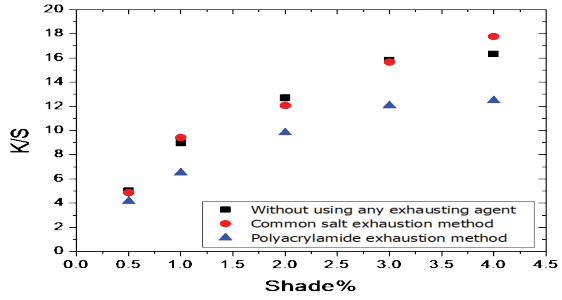

Figure 3. Increase of color strength (K/S) with the increase of shade%.

Thus jute cellulose has direct affinity towards the basic dye. The reaction between jute cellulose and basic dye is as follows:

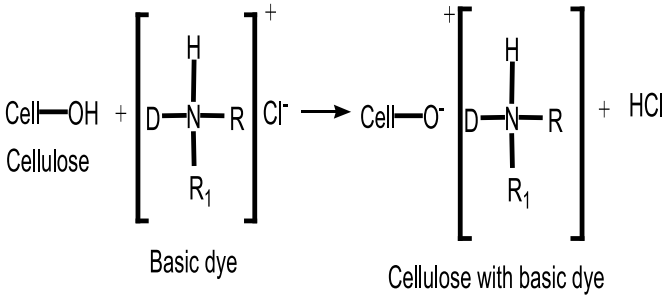

Figure 4. Reaction between jute cellulose and basic dye.

The reaction between jute cellulose and polyacrylamide as well as the reaction between polyacrylamide added jute cellulose and basic dye are as follows:

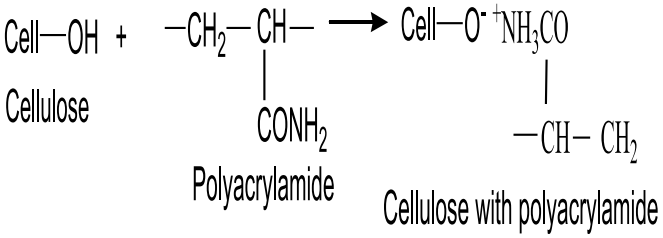

Figure 5. Reaction between jute cellulose and polyacrylamide.

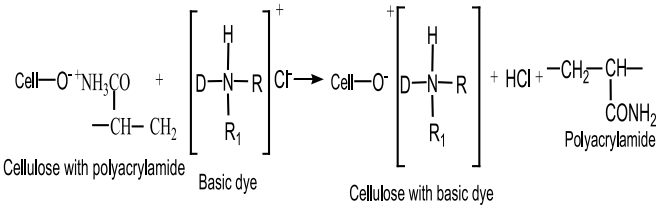

Figure 6. Reaction possibilities between polyacrylamide added jute cellulose and basic dye.

The amine ($–NH_2$) group of polyacrylamide may be formed by protonated amino group when coming in close contact with the hydroxyl group of jute cellulose in aqueous medium (as shown in Figure 5), thus it retarded the basic dye to react directly to jute cellulose and for this reason the depth of color was found by using polyacrylamide as an exhausting agent is slightly lighter. However, reaction of the basic dye with polyacrylamide added jute cellulose is also possible. As shown in Figure 6, the protonated amino group of polyacrylamide in aqueous medium might attract the chlorine anion close to it and at the same time dye cation would come close to cellulose anion and anchoring of dye molecules with jute fabric is also possible in this way at elevated temperature (up to 100^{oC}). The shade% dependence of K/S values of PAE method in respect to WEA and CSE methods, however, indicate that interaction of dye cations with dipole of amide groups might have happened in dye solution/dye liquor for which some dye wastage was occurred. For this reason, K/S values increase more slowly (with the increase of shade%) in the case of PAE method.

3.2. Color fastness to wash

Table 6 shows the comparison of color fastness to wash among the samples dyed with WEA method, CSE method and PAE method. ISO 105 C60:1994 method was followed to evaluate the wash fastness. This test (C2S) is designed to determine the color which may be transferred from the surface of a colored textile material to multi fiber test cloth for washing at 60^{oC} for 30 minutes. The samples dyed with 3 and 4 shade% were evaluated for wash fastness test. The sample size was 10 cm x 4 cm and washed with 4 g/L ECE reference detergent & 1 g/L sodium perborate solution. The changes of color of fabric samples after wash showed slightly better grey scale rating in case of samples dyed with PAE method for both 3 and 4 shade % as shown in table 6. The staining of colors on the fibers (di-acetate, cotton, polyamide, polyester, acrylic and wool) of multi fiber test cloth from the dyed samples were also evaluated. The results of grey scale rating were found almost same for all the three types of samples as shown in Table 6.

Table 6. Color fastness to wash.

	For samples dyed with		For samples dyed with CSE		For samples dyed with PAE	
	3%	4%	3%	4%	3%	4%
Change in Color	2	2	2-3	2	3	3
Di-Acetate	2-3	2-3	2-3	2-3	2-3	3
Cotton (Stain)	4	4	4	4	4-5	4-5
Polyamide	2-3	3	2-3	2-3	2-3	2-3
Polyester (Stain)	5	5	5	5	5	5
Acrylic (Stain)	5	5	5	4-5	4-5	4-5
Wool (Stain)	2-3	2-3	2-3	2-3	3	3

3.3 Color fastness to Rubbing

Table 7 shows the comparison of color fastness to rubbing among the fabric samples dyed with WEA CSE and PAE methods. This test is designed to determine the transfer of color from the dyed samples to the crock meter test cloth for rubbing. Here dry and wet rubbing fastness were compared. ISO 105 x 12:1993 method was followed to measure the rubbing fastness. The samples dyed with 3 and 4 shade % were evaluated for rubbing fastness test. The sample size was 14 cm x 5 cm. The dry rubbing fastness was found very good with the grey scale rating and 5 the wet rubbing fastness was also found good with the grey scale rating 4 for fabric samples dyed with all the three methods for both 3 and 4 shade% as shown in Table 7.

Table 7. Color fastness to rubbing.

Shade %	For samples dyed with		For samples dyed with CSE		For samples dyed with PAE	
	Dry	Wet	Dry	Wet	Dry	Wet
3	5	4	5	4	5	4
4	5	4	5	4	5	4

4. Conclusion

Jute fabric samples were successfully dyed with the basic dye using polyacrylamide as exhausting agent. The jute fabric samples were also dyed with the basic dye without using any exhausting agent as well as using the common salt as an exhausting agent. The Comparison between fabric samples dyed without any exhausting agent and fabric samples dyed with the common salt as an exhausting agent showed almost the same color depth for all color shade%. However, fabric samples dyed using polyacrylamide as exhausting agent were found slightly lighter in color depth in comparison with both the other two types of sample at all shade% measured. Although the wash fastness of jute fabric samples dyed with basic dye were found not so good, but the fastness among these three dyeing methods were found almost same and quite comparable to each other. The rubbing fastness of jute fabric samples was, however, found quite good for these three dyeing processes. These results imply that the dyeing technique of jute fabric without using any exhausting agent is the most preferable method of dyeing jute fabric among these three methods.

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