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Improvement of the Color Fastness Properties onto Bleached Sulfonated Jute with Direct Dyes

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ABSTRACT

Jute fiber has been sulfonated with sodium sulfite in presence of ethylenediamine and bleached with hydrogen peroxide. Bleached sulfonated jute has been dyed with direct dyes (e.g. Direct Yellow 29, Direct Yellow 9, Direct Red 28 and Direct Orange 31). The light and wash fastness, multifabric staining, and breaking strength of dyed bleached sulfonated jute has been studied and compared with that of dyed bleached raw jute. Sulfonation significantly improves light and wash fastness, less staining. On exposure to UV light loss in breaking strength of dyed bleached sulfonated jute with Direct Orange 31 is minimum in comparison with other dyes.

Keywords: Sulfonation, bleaching, jute, color fastness, breaking strength

INTRODUCTION

Direct dyes are available synthetic dyes amongst the commercial dye range. They are still the brightest and the most brilliant in hue of the synthetic dyes and widely used for the dyeing of cotton, jute, kenaf, flax. Dyes of this type are anionic in character and in general owe their water solubility to the presence of sulfonate groups ($^{-}HSO_3$). However, since jute itself adopts an anionic surface charge in water, these dyes have low intrinsic affinity for the fiber. The repulsive charge between dye and jute fiber can be overcome by adding an electrolyte such as sodium chloride or sodium sulfate, which has the effect of screening the surface charge on the fiber[1]. Jute fiber possesses better affinity than cotton with direct dyes due to the presence of lignin. But from the practice, it has been observed that the color fastness of jute with direct dyes very poor. A number of attempts have been made to modify the jute fiber using different types of metal salts and vinyl monomers to improve the color fastness properties [2-7]. A few efforts were made to improve the light fastness, which is the major problem for jute when it is exposed to sunlight [8]. But no researcher tried sulfonation of jute fiber for the improvement of the color fastness properties.

In the present investigation an effort was made to improve color fastness properties of direct dyes e.g. Direct Yellow 29, Direct Yellow 9, Direct Red 28 and Direct Orange 31 applied on bleached sulfonated jute fiber. An assessment of light and wash fastness, and breaking strength of dyed bleached sulfonated jute has been done. The results have been compared with that of bleached raw jute fiber.

EXPERIMENTAL

Materials

Bleached raw and sulfonated jute fibers were used as material for the investigation. Four direct dyes, Direct Yellow 29(C.I. 1956), Direct Orange 31(C.I. 23655) Direct Yellow 9 (C.I. 1954) and Direct Red 28 (C.I. 22120) were obtained from commercial sources (SIGMA and BDH) and were used as received. All other chemicals used were of C.P. grade and were used as such without further purification

Sulfonation

Jute fiber was sulfonated with 12% (owf) of sodium sulfite in presence of 0.2 %(owf) EDA (Ethylenediamine) as a delignifying agent at 160°C for 3 hrs [9].

Scouring and bleaching: In order to remove the wax, oil, resin and coloring matter from the fiber, first, all fibers were scoured by standard method with a solution of 4 % sodium carbonate, 1% sodium hydroxide and 0.5 % wetting agent at 75° C for 0.5 hour [1]. It was then bleached by standard method in launderingometer with 2.1 % hydrogen peroxide together with 6 % sodium silicate and 0.5% sodium carbonate to maintain pH 11 initially. Percentage was based on the weight of the material, in the liquor ratio of 15:1. Bleaching was continued for 1.5 hour at 95°C. It was then washed and dried [10].

Dyeing

The dye bath was prepared by 2% of Direct Red , Direct Orange , Direct Yellow and Congo Red separately with 0 .1% wetting agent based on the weight of the material and 80g/l sodium sulfate and 10g/l soda ash, in the liquor ratio was 30:1. Sample was added to each dye bath and dyeing was commenced after 5 min at room temperature. The temperature was then raised to 90 °C at a rate of 1.5 °C/min. Dyeing was continued at this temperature for 50 min before cooling to 70 °C at a rate of 3 °C/min. The dyed sample were rinsed thoroughly in cold and hot water and finally distillated water and then dried in air oven[11].

Fastness testing

The color fastness of the dyed fibers to laundering and light were assessed using AATCC test methods [12]. Fastness to laundering was evaluated by AATCC Method 61-1996 (2A) using an Atlas Launderometer. Multifiber fabric was employed for the evaluation of staining on cotton. Fastness to light was evaluated by AATCC Method 16E using an Atlas CI 3000+ Xenon Weather ometer. The samples were each exposed to 80 AATCC Fading Units, corresponding to 84.8 h continuous exposure under a xenon lamp at an irradiance power of 1.1 W/m2/nm at 420 nm. The grey scale was used for color change and for staining, giving color difference

Breaking Strength testing

Breaking strength of dyed bleached sulfonated jute fiber was tested according to ASTM method D 2524-94.

RESULTS AND DISCUSSION

The color change of dyed bleached raw and sulfonated jute fibers after laundering is summarized in Table I in terms of the grey scale rating and ? E. In all cases, bleached sulfonated jute was significantly better than that of bleached raw jute fiber. This can be explained by the fact that the van der waals forces linking between the dyes and sulfonated jute fiber are much stronger than the raw jute fiber. It is observed from the Table that wash fastness of Direct Orange 31 was better than other dyes. Table II showed the staining on the adjacent undyed multi fabrics caused by the dyed fibers during laundering. The jute fiber treated with sodium sulfite in presence of ethylenediamine and dyed with direct dyes produced less staining over untreated jute fiber, since the amount of lignin of treated jute was more than 50% lower than that of raw jute causes reduced the removal of dye from the dyed treated jute fiber. Table III summarizes the light fastness properties of dyed fibers and fabrics. In all cases bleached sulfonated jute was better than that of bleached raw jute. This happens, probably, due to the presence higher amount of lignin in bleached raw jute fiber. The high reactive groups present in lignin are phenolic hydroxyl groups [13]. Lignin is highly sensitive to the action of light. When UV-light fall upon dyed jute fiber, the phenolic hydroxyl groups of lignin in jute created free radicals. These free radicals undergo transformation into quinoid structures and showed yellowing on surface of fiber thus causing easily fading of dyed bleached raw fiber [14]. Conversely, dyed bleached sulfonated jute fiber contains minor amount of lignin and more than 60% of the phenolic hydroxyl groups were blocked by $^{-}HSO_3$. Therefore after sulfonation when the fiber is subjected to light in presence of atmospheric oxygen, photo-yellowing can not be accelerated as much as bleached raw jute fiber.

Table I: Wash fastness of bleached sulfonated jute fibers dyed with direct dyes
(?E = before and after wash fastness difference)

Sample	Direct Red 28		Direct Orange 31		Direct Yellow 29		Direct Yellow 9	
	?E	Grey scale rating	?E	Grey scale rating	?E	Grey scal rating	?E	Grey scale rating
Bleached raw jute fiber	8.45	1.5	8.10	1.5	10.50	1.5	9.10	1.5
Bleached sulfonated jute fiber	5.02	2.5	3.94	3.0	4.20	3.0	6.23	2.5

Table II: Staining on cotton fabric caused by dyed bleached sulfonated jute fiber

Sample	Gray scale rating			
	Direct Red 28	Direct Orange 31	Direct Yellow 29	Direct Yellow 9
Bleached raw jute fiber	2.0	2.0	1.5	2.0
Bleached sulfonated jute fiber	2.5	3.5	3.0	2.5

Table III: Light fastness of bleached sulfonated jute fiber dyed with direct dyes

Exposure Period(AFU)	Sample	L Value			
		Direct Red 28	Direct Orange 31	Direct Yellow 29	Direct Yellow 9
80	Bleached raw jute fiber	2-3	3	3	2-3
	Bleached sulfonated jute fibe	4	5	4-5	4

It is observed from Table IV that the percent loss in breaking strength of dyed bleached sulfonated jute was lower than that of bleached raw jute for all of dyes. The plausible explanation of such behavior is that the photo-oxidative degradation is initiated by lignin, which acts as a sensitizer and causes degradation of cellulose in all possible manners through the formation of hydrogen peroxide [15]. The reaction involved in photo-chemical degradation of jute is mainly oxidative in nature and on prolonged exposure to UV light the constituent of cellulose chain are gradually attacked and ultimately broken down into the smaller fragments, as a result, breaking strength of jute decreased.

Table IV: Breaking strength of dyed bleached sulfonated jute fiber on exposure to UV light

Exposure Period(AFU)	Sample	Breaking Strength(g/denier)			
		Direct Red 28	Direct Orange 31	Direct Yellow 29	Direct Yellow 9
0	Bleached raw jute fiber	2.70	2.62	2.68	2.75
	Bleached sulfonated jute fiber	2.63	2.73	2.80	2.60
80	Bleached raw jute fiber	1.65	1.70	1.70	1.66
	Bleached sulfonated jute fiber	2.15	2.30	2.34	2.11

CONCLUSIONS

The dyeing fastness properties of bleached sulfonated jute fiber has been evaluated using Direct Yellow 29, Direct Yellow 9, Direct Red 28 and Direct Orange 31. The wash fastness of dyed bleached sulfonated jute fiber had better impact than that of dyed bleached raw jute fiber .The sulfite treated jute provided better force of interaction with the dye and reduced its tendency to be washed out on laundering. The light fastness of dyed bleached sulfonated jute fiber was much better than that of dyed bleached raw jute fiber. The sulfonation of jute protected photo-fading chemically attached of sulfonic group in the phenolic hydroxyl groups of lignin. The loss in breaking strength of dyed bleached sulfonated jute was significantly lower than that of dyed bleached raw jute. The color fastness properties of dyes are in the order of Direct Orange 31> Direct Yellow 29> Direct Red 28> Direct Yellow 9.

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