Treatment of Cotton With Chitosan - An Initiative Towards Salt Free Dyeing.

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Abstract

This paper presents the possibility of salt free dyeing of cotton fabric with reactive dye by treating the fabric with chitosan. In the experiment the fabric was treated with chitosan of different concentrations (1%, 2%, 3% & 4%) before dyeing. The chitosan treated fabric was then dyed with reactive dye without using salt. The dyeing performance and the fastness of shade have been analyzed by comparing the chitosan treated dyed samples with corresponding similar fabric samples dyed with salt. The dye absorption, i.e. K/S value, of chitosan treated fabrics was found as 1.6, 1.7, 2.2 and 2.9 respectively for 1%, 2%, 3% and 4% chitosan concentration whereas the K/S value of untreated fabric was 1.9. Though the fabric with lower chitosan concentration may not absorb dyes as much as the fabric dyed with salt, but when the chitosan concentration in fabric is increased, it is quite possible to obtain similar dye absorption or even better than that the fabric dyed with salt. Color fastness to washing, rubbing and perspiration were also analyzed. In case of washing and perspiration, chitosan treated fabrics have shown almost similar fastness ratings to untreated dyed fabrics. However untreated fabrics have shown better rubbing fastness specially wet rub.

Keywords : *Chitosan; Reactive dye; Absorption; Salt free dyeing, Cotton*

1. Introduction

Cotton is a natural cellulosic fiber. The polymer chain of cotton consists of several hundred to more than thousand ? (1 - 4) D-glucose units (Crawford, 1981) linked to each other. It builds up negative charges on its surface when immersed in water resulting an inverse effect on exhaustion of anionic dyes. Reactive dye is the only worldwide acceptable dye for the coloration of cotton goods due to their ease of applicability, cost, brilliancy of color and high wet fastness properties (Houshyar and Amirshahi, 2002). As the reactive dyes are anionic and cotton fibers gain anionic surface charge in water, the charge repulsion adversely affects the dye bath exhaustion. Large quantities of electrolyte (30-100 g/l) (Jin-zong, 2003) are added to overcome this problem. These electrolytes are neither exhaust nor destroyed and hence remain in the discharged dye liquor which leads to enormous environmental problem (Ma and Jz, 2002).

Many researchers in different countries worked to minimize (Burkinshaw et al., 2000) or eliminate (Blackburn and Burkinshaw, 2003, Zhang et al., 2007, Montazer et al., 2007, Srikulkit and Santifuengkul, 2000) the use of electrolyte concentration in reactive dye liquor. The introduction of cationic sites within the cellulose is the most expected technique (Mahbubul Bashar and Khan, 2012) to increase the dye adsorption. Cationic sites can be introduced either by aminization or cationization (Renfrew and Hunter, 1999). Treatment of cotton with chitosan is an aminization technique to introduce cationic site within the fiber polymer structure.

Chitosan [?-(1-4)-2-amio-2-deoxy-D-glucopyranose] is a nontoxic and biodegradable (Li et al., 1992) biopolymer, abundantly found in nature; specially in the exoskeletons of crustaceans (Abdou et al., 2008, Sagheer et al., 2009), arthropods and mollusks (Harish Prashanth et al., 2002, Peniche

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as well as the cell walls of certain fungi (Ku?era, 2004, Chatterjee et al., 2005, Suntornsuk et al., et al., 2008), 2002, Abdou et al., 2008) in the form of Chitin. Chitin is deacetylited in alkaline medium to obtain chitosan. Chitosan can be applied on cotton fiber in various methods (Houshyar and Amirshahi, 2002). Cotton fibers forms a crosslink with chitosan (Lee et al., 2010) resulting positive dyesites on the fiber surface.

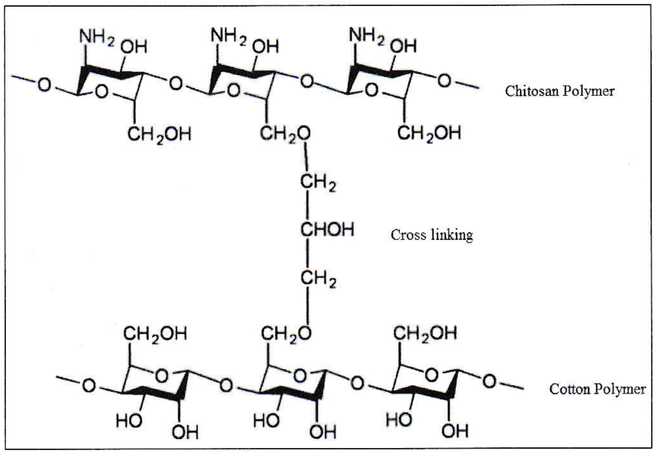

Figure 1: Cross-linking of chitosan with cotton fiber polymer.

Chitosan can easily absorb anionic dyes such as direct, acid and reactive dyes by electrostatic attraction due to its cationic nature (Mahbubul Bashar and Khan, 2012). The introduction of chitosan on cotton fiber can offer the possibility of reactive dyeing without electrolyte with desired level of exhaustion. The current paper investigated the dyeing performance of cotton fabric treated with chitosan dyed without salt and compared the results with the fabric dyed with salt.

2. Experimental

2.1 Sample preparation and dyeing

Scoured, bleached (1050C, 30 min) and enzyme (500C, 60 min) treated 100% single jersey cotton knit fabric (120 GSM) was used in all the experiment. The fabric samples prepared for salt free dyeing were treated with chitosan prior to dyeing. Chitosan chips (color off white, deacetylation >70%) were prepared in the laboratory of Institute of Radiation and Polymer Technology (IRPT), Bangladesh Atomic Energy Commission, Dhaka Bangladesh. Chitosan solution was prepared by dissolving chips in distilled water in the presence of 2% acetic acid. Then the fabric was treated in chitosan solution for 60 minutes at 600C temperature, squeezed to remove excess solution and dyed. The dyeing was carried out in Sandolab infrared lab dyeing machine (Copower Technology Ltd., Taiwan) by using a commercial reactive dye (Novacron Red FN2BL form Swiss Colours Ltd., Bangladesh). Detergent (Imeron PCLF) and Leveling agent (Drimagen E3R) were collected from (Clariant, Bangladesh) and used as received. Soda ash and Acetic acid were collected from local market and all were of analytical grade.

2.2 Recipe formulation

Fabric samples were dyed with the above mentioned dye at 1% (on the weight of material) shade without salt (in case of chitosan treated fabric) and with salt (for untreated fabric). Four different percentages of chitosan (1%, 2%, 3% and 4%) were used for the treatment of fabric. General recipes are given in the Tables- 2&3.

Table1. Recipe for 1.0% (owf) shade with salt.

Ingredients	Dye (%)	Salt g/l	Soda ash g/l	Wetting Agent g/l	Leveling Agent g/l	*M:L
Amount	1.0	20	8.0	1.0	1.0	1:10

Table2. Recipe for 1.0% (owf) shade without salt.

Ingredients	Sample-1	Sample-2	Sample-3	Sample-4
Chitosan (%)	1	2	3	4
Dye (%)	1.0	1.0	1.0	1.0
Soda ash (g/l)	8.0	8.0	8.0	8.0
Wetting Agent(g/l)	1.0	1.0	1.0	1.0
Leveling Agent (g/l)	1.0	1.0	1.0	1.0
*M:L	1:10	1:10	1:10	1:10

Dyeing procedure

5.0 g (± 5%) fabric samples were dyed with salt and without salt in exhaust dyeing method. The dyeing procedure of treated and untreated fabrics is given in Figures-2&3.

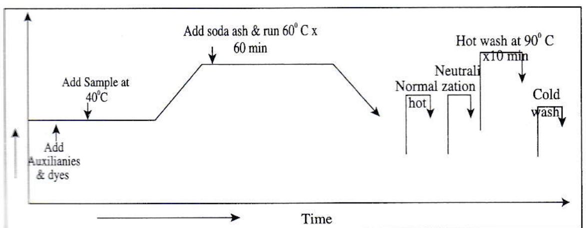

Figure 2: Conventional dyeing scheme with salt.

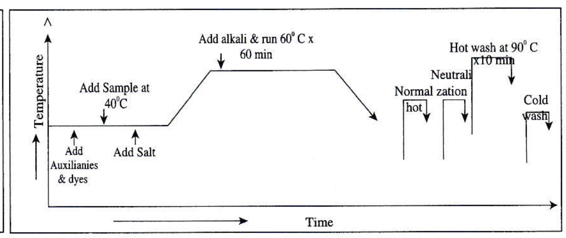

Figure 3: Dyeing scheme chitosan treated fabric without salt.

3 Results and discussions

3.1 Color depth analysis

In the current research, color depth of the dyed fabrics was analyzed by measuring the K/S values of samples. Higher the value of K/S more dye will absorb in the fabric. Color measuring instrument (spectrophotometer) determines the K/S value of a given fabric through Kubelka-Munk equation as follows (Broadbent, 2001).

$$\frac{k}{S} = \frac{(1-R)^2}{2R} \quad \text{-------------(1)}$$

Where R = reflectance percentage, K = absorption and S = scattering of dyes. The values found for all the fabrics the depth of shade is shown in following Figure 4.

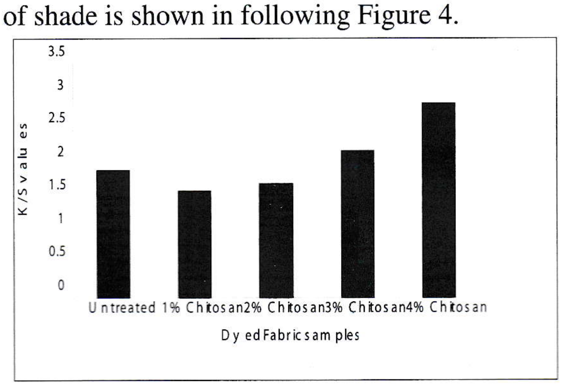

Figure 4: Dye absorption of treated and untreated fabric samples.

Table 3: Color fastness to washing (color change and staining).

Sample	Test Result						
	Color Change	Color Staining					
		A	C	N	P	Ac	W
Dyed with salt	4/5	5	4/5	5	5	4/5	4/5
Dyed with chitosan 1%	4/5	4/5	4/5	5	5	4/5	4/5
Dyed with chitosan 2%	4/5	5	4/5	5	5	4/5	4/5
Dyed with chitosan 3%	4/5	4/5	4	5	5	4/5	4/5
Dyed with chitosan 4%	4/5	4/5	4	5	5	4/5	4/5

Ac=Acrylic, C=Cotton, N=Nylon, P=Polyester, A=Acetate, W=Wool

Table 4: Perspiration fastness test (color change and staining).

Sample	Test Result						
	Color Change	Color Staining					
		Ac	C	N	P	A	W
Dyed with salt	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Dyed with chitosan 1%	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Dyed with chitosan 2%	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Dyed with chitosan 3%	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Dyed with chitosan 4%	4/5	4/5	4/5	4/5	4/5	4/5	4/5

Ac=Acrylic, C=Cotton, N=Nylon, P=Polyester, A=Acetate, W=Wool

3.2 Comparison of Color Fastness

Three types of color fastnesses such as color fastness to rubbing, washing and perspiration of the dyed fabrics were measured. Color fastness to washing and perspiration were assessed in respect of color change and staining with multifiber fabric (acetate, cotton, nylon, polyester, acrylic, wool). Table -3, 4 and 5 show the fastness ratings for different treated and untreated fabric samples.

Table 5: Color fastness to rubbing (dry and wet rub).

Sample No.	Test Result	
	Dry	Wet
Dyed with salt	5	4
Dyed with	4/5	3
Dyed with	4/5	3
Dyed with	4/5	2/3
Dyed with	4	2/3

The tables' shows that the fastness ratings of chitosan treated and untreated fabrics are almost similar both in case of color fastness to washing and perspiration (color change and staining). However, in case of rubbing fastness, the wet rubbing of chitosan treated fabrics have shown lower rating than untreated fabric, especially for higher chitosan concentration. The chitosan present in the fabric enhance the dyesite causing deeper shade. Hence, as a general consequence of achieving deeper shade, the chitosan treated fabric samples have shown slightly lower fastness rating in comparison to lighter untreated fabric.

4. Conclusion

Treatment of cotton with chitosan increased the cationic sites in the fiber polymer that results higher absorption of reactive dye. The concentration of chitosan in fabric played a noticeable effect on dyeability. In this study, the increment of chitosan concentration gives the similar or more dye absorption i.e. higher K/S value of fabric compare to the fabric dyed with salt. The fastness properties of the chitosan treated fabric also shows almost similar result with the untreated fabric. Hence the treatment of cotton with chitosan for improved reactive dyeability provides an enormous scope for further investigation to suit today's need of ecofriendly dyeing.

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