Effect of Chitosan and Mordants on Dyeability of Cotton Fabrics with Natural Dye from Barks of *Ficus Religiosa Linn*

P. Saravanan[1], G. Chandramohan[2], J. Maria Jancy Rani[3], P. Shanmuga Sundaram[4]

[1]Assistant Professor, Department of Chemistry, Kings College of Engineering, Punalkulam, Thanjavur, Tamil Nadu-613303, INDIA.

{[2]Associate Professor, [3]Research Scholar} Department of Chemistry, A.V.V.M. Sri Pushpam College, Poondi, Thanjavur, Tamil Nadu 613502, INDIA.

[4]TÜV Rheinland Bangladesh Pvt. Ltd., Gulshan-2. Dhaka-1212, BANGLADESH.

Corresponding Addresses:

[1]p.v.saravana@gmail.com, [2]chandramohan1956@gmail.com, [3]mariajancyrani@gmail.com, [4]ps.sundaram@bd.tuv.com

Research Article

Abstract: Natural dyes can be anything that comes from natural sources such as barks, flowers, leaves, roots, insects, shells, and mineral substances. They are used for food coloring, painting and textile dyeing. Using natural dyes in textile processing have been shown a greater interest because they are more eco-friendly than synthetic dye and show a variety of colors from one natural dye depending on dyeing process and types of mordants. In present study, the cotton fabric was treated with chitosan at different concentrations to finda suitable concentration on dye ability with natural dye from barks of *Ficus Religiosa Linn.* The influence of dyeing methods with mordants, i.e. pre-mordanting, post-mordanting and simultaneous mordanting was determined. The light and wash fastness of chitosan treated samples were measured compared with untreated samples. Chitosan-treated cotton fabric improved both dyeability and fastness compared with untreated cotton fabric. The cotton fabrics treated with chitosan not only provided better depth of shade but also provided better wash fastness and light fastness than those of the untreated fabrics. The use of different mordants and mordanting methods affected the dye shade and depth of shade differently on the dyed fabrics both with and without chitosan. The range of colour developed on dyed materials were evaluated in terms of (L*a*b*) CIELAB coordinates and the dye absorption on the cotton was studied by using K/S values.

Keywords: Extraction, Natural dye, *Ficus Religiosa Linn,* chitosan, mordant and cotton fabric

Introduction

A dye is a coloured substance which can be made to adhere to fabrics such as cotton, cotton or linen. Natural dyes are obtained from flowers, trees, shrubs, berries, leaves, insects and minerals. These dyes have been used for centuries to produce colors for fabrics, yarns, leather, foods, etc. Natural dyes can give subtle and soft colours through to the brightest colour to the yarns and fabrics [1].Use of natural dyes in colour action of textile materials and other purpose is just one of the consequences of increased environmental awareness [2]. Natural dyes exhibit better biodegradability and generally have a better compatibility with the environment. Also they possess lower toxicity and allergic reactions than synthetic dyes [3]. Today, in the world of growing environmental consciousness; natural colour ants have attracted the attention of everyone. Natural dyes used in food are screened for safety but the information is not known for most of the natural dyes used in craft dyeing and with potentially wider use. There is a tendency to assume that consumable natural products are safer and better than synthetic product because they came naturally. [4] Chitosan (Fig.1) is a polymer obtained from deacetylation of chitin, is a cationic polysaccharide with linear chain consisting of β-(1,4)-linked 2-acetamino-2-deoxy-β-D-glucopyranose and 2-amino-2-deoxy-β- D-glucopyranose [5]. Chitosan are used in dietary supplements, water treatment, food preservation, agriculture, cosmetics, paper, medicinal application and fabric modification[6]. There has been a large increase in chitosan research during the past decade. This is due to its biocompability, biodegradability, non-toxicity, and other unique properties such as film forming ability, chelation and adsorption properties and antimicrobial activity.[7] It is a deacetylated of chitin produced from prawn shells, shrimp shells, crab shells, fly larva shells and squid pens[8].

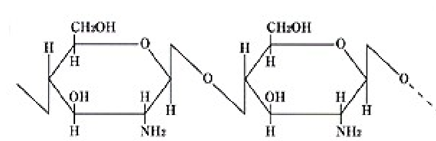

Figure 1: Structure of chitosan

*Ficus Religiosa Linn*is a large, fast growing deciduous tree. It is a heart-shaped, long-tipped leaves on long slender petioles and purple fruits growing in pairs. It is a medium size tree and has a large crown with the wonderful spreading branches [9]. It shed its leaves in the month of March and April. The fruits of the peepal are hidden with the figs. The figs which contain the flower grow in pairs just below the leaves and look like the berries. Its bark is grey in and peels in patches. It is one of the blondest living trees. *Ficus Religiosa Linn*is used in traditional medicine for about 50 types of disorders including asthma, diabetes, diarrhoea, gastric problems, inflammatory disorders and sexual disorders. The leaf extracts of peepal contain anti-inflammatory as well as analgesic properties which are effective in controlling rheumatic pains and arthritis. The peepal fruit extracts had reduced convulsions resulting from the electrical shocks and chemicals. The extracts were also helpful in inducing deep sleep on the subjects. The fig extracts of peepal were investigated for their possible role in improving the memory of the subjects [10].

2. Materials and Methods

2.1 Materials

2.1.1Source

The barks of *Ficus Religiosa Linn*was collected fromcampus of MSAJ College of Engineering, sirucheri, kanchipuram district (fig. 3).

Figure 2: *Ficus Religiosa Linn* tree

Figure 3: Barks of *Ficus Religiosa Linn*

2.1.2 Substrates

Desized, scoured and bleached cotton fabric was used for used for dyeing

2.1.3 Chemicals used

AR grade metallic salts such as copper sulphate, ferrous sulphate, alum, potassium dichromate, nickel sulphate and stannous chloride were used as chemical mordants.

2.2 Experimental Methods

2.2.1 Dye extraction

Barks of tree were cut into small pieces and soaked in distilled water and heated in a beaker kept over a water bath for 2 hours to facilitate quick extraction. Then it was filtered and the filtrate was collected in a separate beaker.

2.2.2 Preparation of chitosan solution

Chitosan solutions were prepared at 0.25%, 0.5%, 0.75% and 1.0% concentrations. Each amount of chitosan was dissolved in 1% acetic acid and left overnight at room temperature. Then the solution was filtered to remove any insoluble materials and it was used for treatment [11].

2.2.3 Pre-treatment of chitosan on cotton fabrics

Cotton fabrics were pre-treated by each chitosan solution. Chitosan treated cotton fabrics were dried at 100^{o}C for 5 minutes. After that, treated fabrics were dyed with dye solution[11].

2.2.4 Dyeing procedure

The chitosan treated and untreated cotton samples were dyed with dye extract keeping M : L ratio as 1:30. Dyeing was carried out at 80^{o}C and continued for 1 hour.

2.2.5 Mordating: The chitosan treated and untreated cotton fabrics were treated with different metallic salts mordantsby following three methods [12].

(i) Pre-mordanting: In this method, cotton samples were pretreated with the solution of different chemical mordants and then dyed with dye extract.

(ii) Post mordtanting: In this method, dyed cotton samples were treated with solution of different chemical mordants.

(iii) Simultaneous mordanting: In this method, the cotton samples were dyed with dye extract as well as different chemical mordants.

2.2.6Colour fastness

The colour fastness of the dyed samples were tested according to IS standards. Colour fastness to washing, and light fastness were determined from standard test methods IS-687-79and IS-2454-85 [13].

2.2.7 Measurement of colour strength

The spectral reflectances of the dyed samples were measured using a Text flash spectrophotometer (Data colour corp.). The K/S values were calculated by Kubelka-Munkequation.

$$K / S = (1 - R)^2 / 2R$$

Where R is the decimal fraction of the reflectance of the dyed samples at λ_{max}. K is the absorption coefficient and S is scattering coefficient [14].

3. Result and Discussion

3.1 Preparation and optimization of aqueous extract of *Ficus Religiosa Linn*

The barks of *Ficus Religiosa Linn* were found to discharge colour in hot water very easily. Increasing the quantity of barks 5 g to 20 g per 100 mL water boiled for 1 hour is accompanied with the increase in colour strength and depth in colour [15]. It was observed that, colour of the dye extract was dark red colour (fig. 4).

Figure 4: Aqueous extract frombarks of *Ficus Religiosa Linn*

3.2 Optimization of Chitosan Concentration

The results in table 1 show that the colour strength, K/S values, of all chitosan-treated fabrics had higher values than the untreated fabrics. The K/S values increased gradually with an increase in the concentration of chitosan. The results indicated that chitosan treatment on fabric provided more dye sites than untreated fabric. These can be explained that natural dyes contain unsaturated moiety bearing ionisable groups such as hydroxyl and carboxylic groups. In water with right pH value, they become water soluble due to their presence in anionic forms. Cotton by its nature is negatively charged in water, thus exhibiting poor absorption for natural dyes due to repulsion effect. The application of chitosan could help to improve the absorption of natural dyes by the cationic characteristic. It is well-known that chitosan is capable of forming ionic interaction with cotton cellulose, rendering cotton cellulose positive charged. Asa result, chitosan treated cotton is anticipated to favourably absorb natural dyes through the ionic interaction between dye-anions andfiber-cations mechanism. However, treatment of chitosan affected to hand properties and colour of fabrics. Chitosan made the fabric stiffer and a bit yellower than untreated fabrics. In this research, 1% chitosan concentration was used for dyeing of cotton fabric because of desirable stiffness fabric.

Table 1: K / S values of chitosan treated cotton fabric at different concentrations

Chitosan Concen trations (%)	Chitosan treated cotton fabric				Chitosan treated cotton fabric with dyeing			
	L*	a*	b*	K/S at 400 nm	L*	a*	b*	K/S at 400 nm
0	92.84	-0.04	4.54	0	69.85	3.35	15.54	1.50
0.25	92.62	-0.18	4.95	0.01	58.65	6.62	19.32	4.97
0.50	92.75	-0.15	5.45	0.02	56.32	7.23	18.24	5.28
0.75	92.28	-0.12	5.78	0.03	55.48	7.36	18.75	5.63
1.0	91.89	-0.16	5.83	0.04	55.58	6.14	18.12	5.72
1.50	89.18	-0.13	6.26	0.08	49.74	7.42	17.31	7.68

3.3 Dyeing behavior of the dye extract

The cotton fabrics (both chitosan treated and untreated fabrics) were dyed with chemical mordants. It was observed that, the dye uptake was found to be good in post mordanting method. Post mordanting method showed a higher depth of shade than that of other two methods is shown in figure 5.

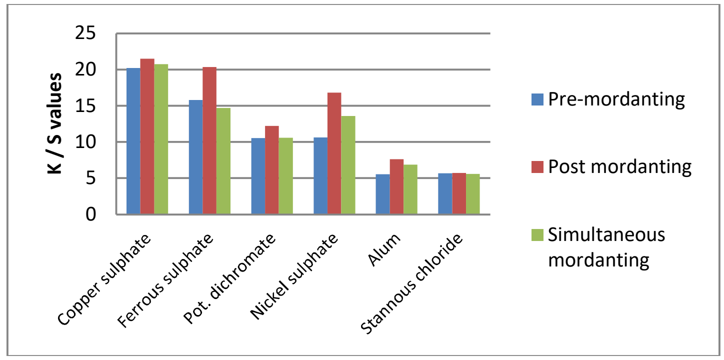

Figure 5: Surface colour strength (K/S values) of dyed cotton fabrics after pre, post and simultaneous mordanting methods

3.4 Effect of mordants and chitosan on dyed fabrics

The effect of mordants on color intensity(K/S) of chitosan-treated and untreated fabricwas examined by Text flash spectrophotometer. The effect of mordants on K/S value and colour differences of dyed fabrics treated with 1% chitosan and untreated as shown in Table 2 and Table 3.Comparison of the results in Tables 2 and 3 showed that the chitosan treated cotton fabrics had a higher depth of shade (K/S value) than those of the untreated fabrics for all mordants as shown in figure6. This result indicated that chitosan provided more dye site on fabric surface.

Table 2: Effect of mordants on dyeing properties of dyed fabrics without chitosan treatment

Mordant	CIE L* a* b*			K/S value
	L*	a*	b*	
Without mordant	44.71	5.61	16.20	15.27
Copper sulphate	75.54	4.15	29.64	21.51
Ferrous sulphate	48.55	5.57	11.34	20.33
Potassium dichromate	64.32	4.54	24.69	12.19
Nickel sulphate	68.34	3.74	21.53	16.79
Alum	57.23	-2.57	24.57	7.60
Stannous chloride	45.26	10.65	15.54	5.71

Table 3: Effect of mordants on dyeing properties of dyed fabrics with chitosan treatment

Mordant	CIE L* a* b*			K/S value
	L*	a*	b*	
Without mordant	44.71	5.61	16.20	17.25
Copper sulphate	75.54	4.15	29.64	26.64
Ferrous sulphate	48.55	5.57	11.34	23.51
Potassium dichromate	64.32	4.54	24.69	13.35
Nickel sulphate	68.34	3.74	21.53	18.69
Alum	57.23	-2.57	24.57	9.34
Stannous chloride	45.26	10.65	15.54	7.29

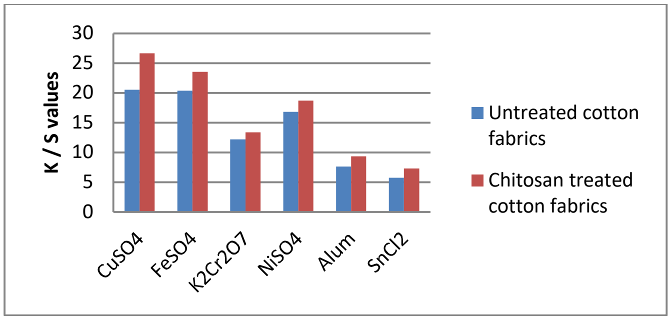

Figure 6: Effect of chitosan on dyed cotton fabrics

3.5 Fastness properties for the dyed cotton fabrics

Washing fastness (WF) and light fastness (LF) results of the dyed fabrics with and without chitosan treatment are indicated in table 4.Dyed cotton fabric treated with chitosan improved both washing and light fastness. In addition, the results indicate that the use of mordants also improved the fastness property of the dyed fabric. This may be due to greater complex-forming ability of the metal ions with dye molecules.

Table 4: Fastness values for cotton fabrics dyed with barks of *Ficus Religiosa Linn*

Mordant	Fastness			
	Untreated dyed cotton fabric		Chitosan treated dyed cotton fabric	
	WF	LF	WF	LF
Without mordant	3	II	4	III
$CuSO_4$	4-5	III-IV	5	IV
$FeSO_4$	3-4	III / IV	4-5	IV
$K_2Cr_2O_7$	3	II/III	4	IV
NiSO4	3	II	4-5	IV/V
Alum	3/4	III	4	IV-V
$SnCl_2$	3	II / III	3-4	IV

3.6 Conclusion

The purpose of this work was to study the effect of chitosan on the dyeing properties of barks of *Ficus Religiosa Linn* on cotton fabric. The results of this study are concluding that, chitosan can improve the colour intensity on cotton fabric. This may be because the chitosan provided more dye sites on the fabric surface. Chitosan treated fabric not only provide better depth of shade, also provided better fastness property. Use of different mordants and the mordating methods affected the depth of the shade on the dyed fabrics differently.

References

1. Zin Mar Win and Moe MoeSwe, World Academy of Science, Engineering and Technology, 2008;pp 536-540
2. Gupta, V.K. Sachan, R.A., Singh V.P. and Shasma, S.K., Indian Textile Journal,1998; PP. 16-18
3. Kumar V. and Bharti, B.V. , Indian Textile Journal, 1998; PP. 18-20
4. . M Alam, M. L. Rahman and M. Z. Haque, Bangladesh J. Sci. Ind. Res. 2007; 42(2), 217-222,
5. Mathur NK, Narang CK., J. Chem. Educ., 1990; 67, 938–42
6. Pradip Kumar Dutta, Joydeep Dutta and V S Tripathi, J. Sc. Ind. Res.,2004; 63, 20-31
7. Md. MonarulIslama,, Shah Md. Masumb, M. Mahbubur Rahmana, Md. Ashraful Islam Mollab, A. A. Shaikhc and S.K. Roya, International Journal of Basic & Applied Sciences,2011; 11 No: 01
8. Gu R., Sun W., Zhou H., Wu Z., Meng Z., Zhu X., Tang Q., Dong J. and Dou Q., Biomaterials,2010; 31(6): 1270-1277
9. Prasad, P.V., Subhaktha, P.K., Narayana, A. and Rao, M.M., Bull. Indian Inst. Hist. Med., Hyderabad, 2006; 36, 1-20
10. Makhija, Sharma, Khamar, Scholars Research Library Annals of Biological Research, 2010; Vol.1, Iss 4, pp 171-180
11. Piyaporn Kampeerapappun, Trongsu Phattararittigul, Sutida Jittrong and Dararat Kullachod, Chiang Mai J. Sci.,2010; 38(1), 95-104
12. P. Saravanan, G. Chandramohan and S. Saivaraj, Asian Journal of Research in Chemistry, 2012;5(3)
13. Shanker R. and Vankar P. S, Dyes and Pigments, 2007; Vol. 74, No.2, pp. 464-469
14. S. Habibzadeh, H. Tayebi, E. Ekrami, A. Shams Nateri, M. Allahinia and M. Bahmani, World Journal of Applied sciences,2010; Vol 9(3), pp 295-299
15. Rakhi Shanker and Padma S Vangar, Dyes and Pigments,2006; pp-1-6.