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Effect of natural extracts and mordants on dyeability of cotton fabrics for UV Protection

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Abstract

In this study, Chitosan and Stannous chloride ($SnCl_2$) were used for pretreatment of cotton fabrics to improve the dye uptake of fabric. The treated samples were dyed with Indian Madder root extract to enhance the UV protection properties of fabric. Light and wash fastness properties for both stannous chloride treated and chitosan treated samples were examined. Better fastness properties was obtained for both the samples when compared to untreated samples.UPF values absorbed are higher for SnCl2 treated sample compared to Chitosan treated sample but both the samples shows excellent UV protection i.e. UPF>50.

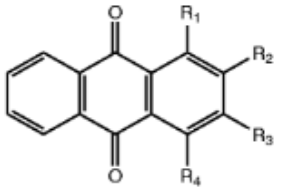
Keywords- Chitosan, Stannous Chloride, Indian Madder, UV protection.

I. INTRODUCTION

High, momentary openness to bright radiation (UVR) from the sun causes burns from the sun and long haul openness prompts skin disease. An essential justification for the expanded frequency of skin diseases is credited to ozone consumption. Awareness about the need for sun protection has been increasing in recent years due to incidence of skin damage, acceleration of the skin ageing and sun burn etc. To avoid the long term exposure of sun radiation directly to human skin, colored dress plays a significant role in protection from harmful UV rays than undyed apparels [1]. Hence mordant plays an important role for dye uptake in higher concentration by the fabric. Several mordants, namely alum, stannous chloride and ferrous sulphate etc. are used in various research works to improve the dyeability of textile materials [2]. Among this stannous chloride is an important mordant used for improving the dye uptake of cotton, wool and silk fabrics.

Chitosan is the deacetylated subsidiary of chitin, has been predominantly used in textile materials in recent years which serve up several functional purposes. Chitosan can likewise be utilized in the color shower to work on the dyeability of materials. This may be because of the electrostatic fascination between the protonated amino gathering in chitosan and the anionic color prompting very high partiality for some classes of colors. As chitosan is more ecofriendly than manufactured colors, they have shown a more noteworthy interest in material coloring.

Many research works has been carried out on application of natural dyes on textile materials to analyze the UV protection property[3]. Among this, Indian madder extracts are often used in sun – block cream which provides broad spectrum of protection against UVA, UVB radiation. Dyeing cotton fabrics with Indian Madder root increases the ultraviolet protective abilities of the fabric and can be considered as an effective protection against ultraviolet rays. The following figure shows the compounds of Indian madder extract[4].



Compounds	R_1	R_2	R_3	R_4
Purpurin	OH	OH	H	OH
Munjistin	H	OH	COOH	OH
Xanthopurpurin	H	OH	H	OH
Pseudopurpurin	OH	COOH	OH	OH
Nordamncanthal	OH	CHO	OH	H
Rubiadin	OH	CH_3	OH	H

Fig.1. Chemical components of Indian Madder

Madder roots contain dye present in the free or bound glucosides which are anthraquinone derivatives responsible for dyeing the fabrics. Hence this work aims to enhance the dye ability of cotton fabrics with the application of chitosan and stannous chloride followed by dyeing with Indian Madder root extract. The dyed samples were examined for fastness properties and UV protection factor

II. MATERIALS

A. Materials

In this study cotton fabric, ethanol, chitosan, Stannous chloride and Indian madder roots were used. The fabric was purchased from Tirupur market and the Indian madder roots were purchased from Herbal store, Coimbatore.

III. METHODS

A. Pretreatment process

The cotton fabric purchased has been subjected to pretreatment process like desizing, scouring, bleaching etc.

B. Selection of mordanting methods

There are three methods of mordanting viz., pre-mordanting simultaneous and post modanting[5]. Among the three methods, pre-mordanting method was suitable for many natural dye sources especially for the selected dyes with all mordants. Hence pre-mordanting method was selected for improvement of colourfastness of natural dyes on cotton fabric with fixing agents.

C. Pretreatment of cotton fabric using stannous chloride

1) Optimization of mordant concentration

To optimize the mordant concentration, 5 samples of 10x10 cm cotton fabric was taken and immersed in separate solutions containing SnCl2 at 5%, 7%, 9%, 10% & 11% concentration respectively for 45 min at room temperature with M:L ratio of 1:40. The fabrics were then dipped into separate dye baths each with 5% concentration and the dyeing process carried out for 1 hour. Dye absorption of cotton fabrics samples were analyzed by k/s value[6]. Dye absorption increases with increase in mordant concentration and reaches a maximum value at 10% concentration, then it decreases.

D. Dyeing of cotton fabric

1) Dye extraction process

Indian madder root was grind into powder and the dye extraction from the powder takes place by using Soxhlet apparatus. Grinded root powder was extracted using ethanol.

2) Optimization of dye concentration

To optimize the dye concentration, number of 10x10 cm fabrics were taken and immersed in separate solutions containing 10% stannous chloride for 45 min. The fabrics samples then entered into separate dye baths where each contains 10%, 20%, 30%, 40%, 43%, 45%, 47%, 50% and 60% dye concentration respectively. The dyeing process was carried out for 1 hour at 80^{O}C with M:L ratio of 1:40. Dye absorption depth of cotton fabrics samples were analyzed by k/s value. Dye absorption increase with increase in dye concentration and reaches a maximum value at 50% concentration.

E. Pretreatment of cotton fabric using chitosan

Chitosan solution was prepared to pre-treat the cotton fabric. The solution was prepared by taking 0.75% chitosan and dissolved it in 1 % acetic acid. This process was carried out at room temperature and left overnight. Then the chitosan solution was padded on cotton fabric using padding mangle. The padded sample was dried at 100°C for 5 min [7] .

1) Dyeing of cotton fabric

The padded fabric was dyed with Indian madder root dye powder of 50% concentration. The dyed fabrics were rinsed with tap water, squeezed and dried at room temperature. Depth of shade expressed as K/S, was measured on the dyed fabric.

2) Washing of cotton fabric

The dyed samples treated with chitosan and stannous chloride were washed with the solution containing 2% soap and 1% sodium carbonate at 60°C for 15 minutes with the M:L ratio of 1:50 and dried.

3) Wash and Light fastness propertys

The dyed samples with and without mordants were subjected to testing for wash and light fastness property. Color fastnesses of dyed samples were assessed according to the standards IS 765:79 and IS: IS: 2454:1985 respectively [8].

4) UV analysis

UPF of fabric samples was measured in vitro using Labsphere UV-100 F Ultraviolet Transmission Analyser according to standard AZ/NZS 4399:1996 with a sample size of 4cm*4cm and the UPF values were identified.

UPF can be calculated using the following equation [9]:

$$\mathrm{UPF} = \frac{\sum_{290}^{400} E_\lambda \cdot S_\lambda \cdot \Delta_\lambda}{\sum_{290}^{400} E_\lambda \cdot S_\lambda \cdot T_\lambda \cdot \Delta_\lambda}$$

where,
Eλ is the solar UVR spectral irradiance in W·m-2·nm-1
Sλ is the relative erythemal effectiveness according to the CIE
Δλ is the wavelength interval of the measurements
Tλ is the spectral transmittance at wavelength λ
λ is the wavelength (in nm)

IV. RESULTS AND DISCUSSION

A. Dye concentration

Dyeing of cotton fabric done at 10% mordant concentration and at varying dye concentrations of 10%, 20%, 30%, 40%, 50% and 60% shows the K/S values in the figure for all the samples. From the below figure, it is clear that the dye absorption increases with increase in dye concentration upto 50% after which it starts decreases. Hence the maximum depth of shade can be obtained at 50% dye concentration.

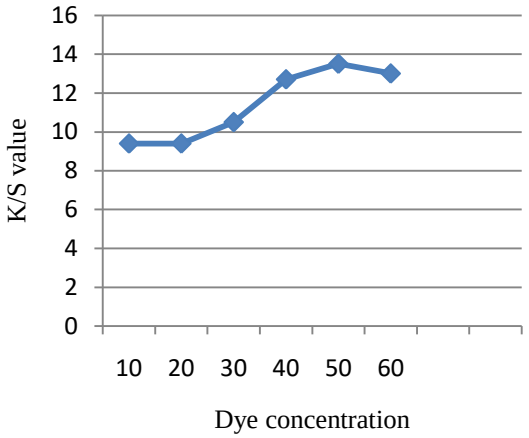


Fig.2. Color strength k/s value for various dye concentrations

B. Wash and Light Fastness Property

Wash fastness and light fastness results of the dyed fabrics with and without chitosan treatment and stannous chloride treatment are shown in the figure below.

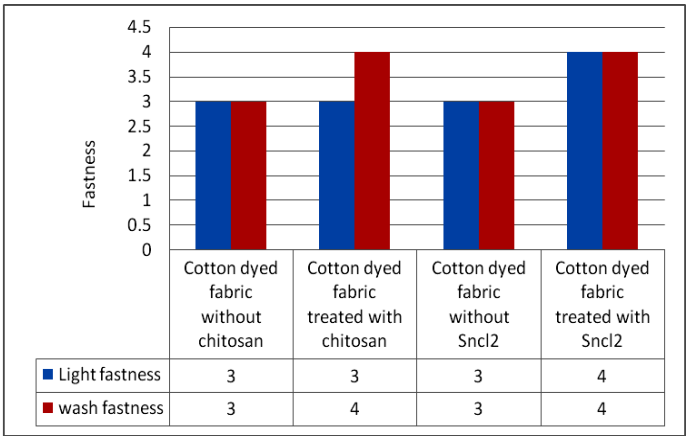


Fig.2. Wash and Light fastness property of cotton fabrics with and without mordants

The wash and light fastness of cotton samples shows higher value when treated with mordants compared to untreated samples. Thus the dye uptake of cotton fabric samples has been improved by the application of stannous chloride and chitosan which shows better fastness property in the fabric.

C) Ultraviolet Protection factor

In this study UPF values are measured for SnCl2 treated and chitosan treated cotton fabric and the results are compared.

TABLE I ULTRAVIOLET PROTECTION OF COTTON TREATED SAMPLES

Samples	UPF	T(UVA)	T(UVB)	UPF Rating	Protection category
Cotton fabric with Sncl2	72.07	1.68%	1.35%	60	Excellent
Cotton fabric with chitosan	62.00	1.78%	1.61%	50	Excellent

From the above table it is observed that both the fabrics shows excellent UV protection as the UPF > 50[10]. The fabric dyed with Sncl2 treated fabric has a high level of UV protection compare to Chitosan treated sample. As the stannous chloride increase the dye uptake of Indian madder deep into the fibres, it provides more protection from ultraviolet radiation.

V. CONCLUSION

As the Indian Madder root powder has ultraviolet protection property in nature, it is applied on cotton fabrics for protecting the skin from severe sun burns. The sun protection property of the fabric is enhanced with the application of mordants like Chitosan and Stannous chloride where the dye uptake of fabrics has been improved. Both these treated samples show higher depth of shade which results in good light and wash fastness property of treated sample when compared to untreated sample.

UV protection property analysed for both the samples shows that Stannous chloride ($SnCl_2$) treated sample shows high UPF when compared to Chitosan treated sample. Stannous chloride used as mordant helps to uptake the dyes deep into the fibres whereas in Chitosan treated sample, Chitosan is coated on the fabric surface and then dyed with natural extract. Hence the coating may hinders the dye absorption deeply into the fibre which results in low UPF value than stannous chloride treated sample.

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