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Dyeing of cotton using flower of *Cordia Sebestena*: Effects of mordanting and fastness properties

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Abstract

Ethanol extract of natural dye obtained from the flower of *Cordia Sebestena* applied on bleached cotton fabric have been subjected to pre, post and simultaneous mordanting with selective mordants using myrobolan (harda) and other mordants (metallic salts). It is observed that the application of 1-3% of $FeSO_4$,$Al_2(SO_4)_3$ and $SnCl_2$ have been identified as three most prospective mordanting system. The study on the effect of dyeing process variables on surface colour strength indicates that the 60 min. dyeing time, 60°C dyeing temperature, 1:20 material-to-liquor ratio, 3% mordant concentration, 5% dye concentration and 5gpl common salt are the optimum values among the different fibre- mordant system studied. This study also includes the comparison of mordanting techniques as well as dying properties and visualizes the effect of myrobolan and metallic mordants, colour fastness to washing, rubbing, light fastness and perspiration of cotton fabrics dyed with and without mordants have also been studied.

Introduction

With the world becoming more conscious towards ecology and environment, there is grater need today to revive the tradition of natural dye(Anitha K et al., 2007) and dyeing techniques as an alternative of hazardous synthetic dyes is an extremely crude. Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes (Ashis Kumar Samanta et al.,2007 and Bains S et al.,2003) There are several plants/plant parts that provide natural dyes which are used in the textile industry. Many reports are available on application of natural dyes on cotton (Gulrajani M L et al.,1992 and Gulrajani M L.,1992).

The aim of present work has been carried out to prepare eco-friendly natural dyes from the flower extract of *Cordia Sebestena* and dying on cotton fabric. *Cordia Sebestena* grows in all warm and damp parts of India and is considered to be one of the most useful trees in the world. The flower extract of *Cordia Sebestena* produces a brown solution. In the present work an attempt has been made to study the effect of mordanting (Katti M.R et al.,1996) and dyeing properties of cotton fabrics such as, washing, rubbing, light fastness and perspiration (Mahale G Sakshi et al.,2003) and also to visualize the effect of myrobolan (Samanta A.K et al.,2003) and metallic mordants have been undertaken.

Materials And Methods

Materials

Bleached cotton fabric, analytical reagents (AR) grade ferrous sulphate, aluminium Sulphate, nickel sulphate, potassium dichromate, stannous chloride, commercial grade acetic acid, common salt, sodium carbonate and a natural mordant myrobolan (*Terminalia chebula*) powder were used for this study. Depending upon the mordant used, the colour obtained on textiles from the flower of *Cordia Sebestena* extract may give different shades.

Methods

Extraction of colour component

For optimizing (Sandeep Bains et al.,2003), the extraction method the ethanol extraction of dye liquor was carried out under varying conditions, such as time of extraction, temperature of extraction bath and material-to-liquor ratio. In each case, the optical density or absorbance value at a particular maximum absorbance wavelength (λ_{420nm}) for the ethanol extract of the flower of *Cordia Sebestena* was estimated using Hitachi-U-2000 UV-VIS absorbance spectrometer. The values extraction variable 60min., temperature 60^0C and material-to-liquor ratio 1:20 indicate the optimum conditions for the extraction of colour component from the flower of *Cordia Sebestena.*

Dyeing of cotton fabric with the extract of Cordia Sebestena flower

The wetted out cotton samples were entered into dye baths containing required amount of dye extract and water. After 10 minutes, required amount of sodium carbonate and sodium chloride were added. The dyeing was carried out for one hour at 60°C. The dyed samples were dried in air without washing to make them ready for pre, simultaneous and post-mordanting using myrobolan and metallic salts.

Pre-Mordanting of cotton fabric with myrobolan and metallic salts

Conventionally bleached (H_2O_2) cotton fabric with or without pre-mordanting were further mordanted prior to dyeing using 1-3% of any one of the chemical mordants and the myrobolan, at 60°C for 30 min with material-to-liquor ratio of 1:20. The samples treated with metal salts were dyed with the dye extract.

Simultaneous Mordanting of cotton fabric with myrobolan and metallic salts.

Bleached cotton was treated with both dye extract and metal salts simultaneously, using 1-3% of any one of the chemical mordants and the myrobolan, at 60°C for 30 min with material-to-liquor ratio of 1:20.

Post-Mordanting of cotton fabric with myrobolan and metallic salts.

Bleached cotton was dyed with dye extract. The wetted out cotton samples were entered into different dye baths containing required amount of dye extract and water. After 10 minutes required amount of sodium sulphate was added. After 20 minutes required amount of sodium chloride was added. The dyeing was carried out for one hour at 50°C. The dyed samples were taken out, squeezed and used for treatment with metal salts process without washing. The dyed cotton samples were treated with different metal salts using 1-3% of any one of the chemical mordants and finally myrobolan, at 60°C for 30 min with material-to-liquor ratio of 1:20.

In each case, for general study of dyeing behaviour using different mordants, a prefixed normal dyeing condition (ethanol extract of *Cordia Sebestena* flower, 5%; mordant, 1-3%; MLR, 1:20; common salt 5gpl with requisite amount of NaOH; dyeing temperature, 60°C and dyeing time, 60min) was used.

In all the above three methods, after the dyeing is over, the dyed samples were repeatedly washed with water and then dried in air. Finally, the dyed samples were subjected to soaping with 2gpl soap solution at 50°C for 10 min, followed by repeated water wash and drying under sun.

Determination of K/S value (Shilpa Mudgal et al.,2002) The K/S value of the undyed and dyed cotton fabric was determined by measuring surface reflectance of the samples using a computer-aided Macbeth 2020 plus reflectance spectrophotometer, using the following Kubelka Munk equation with the help of relevant software:

$$K/S = \frac{(1- R\lambda_{max})^2}{2R\lambda_{max}} = \alpha C_d$$

Where K is the coefficient of absorption; S the coefficient of scattering; C_d, the concentration of the due and $R\lambda_{max}$ the surface reflectance value of the sample at a particular wavelength, where maximum absorption occurs for a particular dye/colour component.

Evaluation of Colour Fastness:

Colour fastness (Thomas Bechtold.,2006) to washing of the dyed fabric samples was determined as per IS: 764 – 1984 method using a Sasmira launder-O-meter following IS-3 wash fastness method. The wash fastness rating was assessed using grey scale as per ISO-05-A02 (loss of shade depth) and ISO-105-AO3 (extent of staining) and the same was cross-checked by measuring the loss of depth of colour and staining using Macbeth 2020 plus computer-aided colour measurement system attached with relevant software.

Colour fastness to rubbing (dry and wet) was assessed as per IS: 766-1984 method using a manually operated crock meter and grey scale as per ISO-105-AO3 (extent of staining).

Colour fastness to exposure to light was determined as per IS: 2454-1984 method. The sample was exposed to UV light in a Shirley MBTF Microsal fade-O-meter (having 500 watt Philips mercury bulb tungsten filament lamp simulating day light) along with the eight blue wool standards (BS1006: BOI: 1978). The fading of each sample was observed against the fading of blue wool standards (1-8).

Colour fastness to perspiration assessed according to IS 971-1983 composite specimen was prepared by placing the test specimen between two adjacent pieces of fabrics of silk and cotton and stitched all among four sides. The sample was soaked in the test solution (acidic /alkaline) separately with MLR 1:50 for 30 minutes at room temperature. The sample was then placed between two glass plates of perspirometer under load of 4.5kgs (10 lbs). The apparatus was kept in the oven for four hours at 37±2˚C. At the end of this period the specimen was removed and dried in air at a temperature not exceeding 60˚C. The test samples were graded for change in colour and staining using grey scales.

Results And Discussion

Bleached cotton fabrics mordanted with varying concentration of mordants have been subsequently dyed by using pre, simultaneous and post-mordanting methods as reported. All the dyed fabrics have been assessed for their colour strength (K/ S) value as reported in table 1, 2 and 3. All the dyed fabrics have been assessed for their colour fastness behaviour to washing, rubbing and exposed to light and perspiration and the results are given in table 4.

All the treated samples subjected to light which show fairly good (4) to light fastness and excellent grade to washing fastness and all the treated samples no colour staining to washing fastness. The colour change to dry and wet rubbing for all the treated samples was excellent (5) and there was slight colour staining except for simultaneous mordanting method where it was negligible staining (4-5).

The perspiration fastness grades ranged between 4 and 5 for all samples in both acidic and alkaline media. There was no colour staining (5) for all the treated samples in both acidic and alkaline media. It is interesting to note that harda, being a natural light yellow mordantable dye, shows a steady increase in K/S value on cotton fabrics. It is observed from the figures 1, 2, 3 that among the three mordanting techniques, simultaneous mordanting gave excellent results (*K*/S value) as compared to other mordanting system.

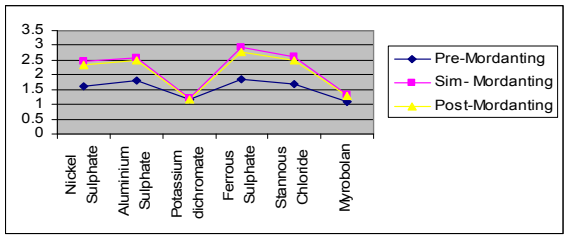

Fig: 1 Surface colour strength of dyed cotton fabrics after pre, simultaneous and post –mordanting methods by using 1% mordant concentration (K/S value without mordant: Cotton- 1.47)

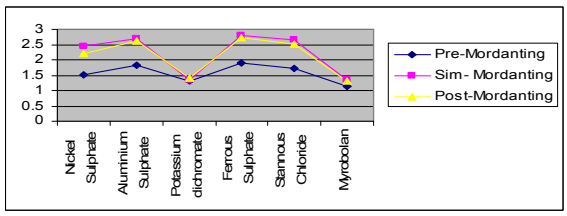

Fig:2 Surface colour strength of dyed cotton fabrics after pre, simultaneous and post –mordanting methods by using 2% mordant (K/S value without mordant: Cotton- 1.56)

It is observed that among differently mordanted bleached cotton subsequently dyed with 5% ethanol extract flower of *Cordia Sebestena* with 3% ferrous sulphate by simultaneous mordanting technique, renders the fabric relatively higher K/S value (~2.94) as compared to other mordanting system .The use of 3% aluminium sulphate by simultaneous mordanting technique followed by further dyeing with comparable dose of 5% ethanol extract flower of *Cordia Sebestena* colour shows the K/S value of 2.75 and thus is considered as next good performer 3% stannous chloride and 5% ethanol extract flower of *Cordia Sebestena* colour shows the K/S value of 2.71 is the next good performer (Fig.1,2 and 3).

Among all the mordants used, the increase in K/S value is found to be the highest for ferrous sulphate mordant due to the inherent colour of ferrous sulphate salt.

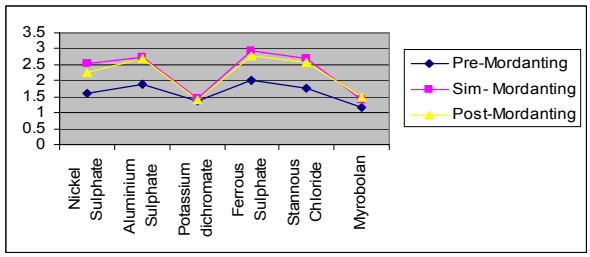

Fig: 3 Surface colour strength of dyed cotton fabrics after pre, simultaneous and post –mordanting methods by using 3% mordant concentration (K/S value without mordant: Cotton- 1.62)

The increase in colour strength K/S values after pre, simultaneous and post-mordanting with selective mordants (1-3%) on cotton fabric are in the following order:

$FeSO4>Al_2(SO_4)_3>SnCl_2>NiSO_4>K_2Cr_2O_7>$Myrobolan

This increase in K/S value to a different extent after pre, simultaneous and post-mordanting may be due to the changes in scattering because of the chemical interaction between fibres and harda or metallic salts along with the additional inherent colour input of the corresponding mordants.

Hence ,considering the dyeing results, the sequential mordanting systems using 3% $FeSO_4$+ 5% ethanol extract of flower of *Cordia Sebestena*, 3% $Al_2(SO_4)_3$ + 5% ethanol extract of flower of *Cordia Sebestena* and 3% $SnCl_2$+ 5% ethanol extract of flower of *Cordia Sebestena* are found to be more prospective, rendering a higher degree of increase in surface colour strength. These three systems of mordanting have therefore been chosen for further study of dyeing process variables for cotton fabrics.

However, the use of ferrous sulphate in any case always renders cotton fabric a deep brownish /grey colour owing to the inherent colour of this transition metal salt anchored to the corresponding fibre, besides the improvement in K/S value due to the natural dye component. The observed slow increase in K/S value in cotton treated with same mordants is only due to the additive colour yield for the additional incorporation of the inherent colour of $FeSO_4$ itself.

Conclusion

It was found from the study that the flower of *Cordia Sebestena*, dye can be successfully used for dyeing of cotton to obtain a wide range of soft, pastel and light colours by using natural and metallic mordants.With regards to colourfastness,test samples exhibited excellent fastness to washing(except pre, simultaneous and post mordanting- $K_2Cr_2O_7$);excellent fastness to rubbing(except pre,simultaneous and post mordanting- $K_2Cr_2O_7$);good to excellent fastness to perspiration in both acidic and alkaline media and fairly good fastness to light.

Among the different fibre-mordanting systems studied, the use of 3% of ferrous sulphate applied by simultaneous mordanting for subsequent dyeing on cotton with 5% ethanol extract of flower of *Cordia Sebestena*, 3% of aluminium sulphate applied by simultaneous mordanting for subsequent dyeing on cotton with 5% ethanol extract of flower of *Cordia Sebestena* and 3% of stannous chloride applied by simultaneous mordanting for subsequent dyeing on cotton with 5% ethanol extract of flower of *Cordia Sebestena* show maximum K/S values as compared to other selective pre, simultaneous and post mordanting systems.

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TABLE-1: Surface colour strength of dyed cotton fabrics after pre, simultaneous and post –mordanting methods by using 1% mordant concentration (K/S value without mordant: Cotton-1.47).

Fabric	Mordant Concn.: 1%	K/S(λ=420 nm)		
		Pre-Mordanting	Simultaneous Mordanting	Post-Mordanting
Cotton	Nickel Sulphate	1.62	2.44	2.32
	Aluminium Sulphate	1.80	2.58	2.51
	Potassium dichromate	1.15	1.21	1.18
	Ferrous Sulphate	1.87	2.92	2.78
	Stannous Chloride	1.70	2.62	2.51
	Myrobolan	1.10	1.32	1.29

TABLE-2: Surface colour strength of dyed cotton fabrics after pre, simultaneous and post –mordanting methods by using 2% mordant concentration (K/S value without mordant: Cotton-1.56).

Fabric	Mordant Concn.: 2%	K/S(λ=420 nm)		
		Pre-Mordanting	Simultaneous Mordanting	Post-Mordanting
Cotton	Nickel Sulphate	1.53	2.45	2.21
	Aluminium Sulphate	1.84	2.69	2.62
	Potassium dichromate	1.32	1.34	1.41
	Ferrous Sulphate	1.91	2.79	2.71
	Stannous Chloride	1.73	2.66	2.51
	Myrobolan	1.13	1.35	1.31

TABLE-3: Surface colour strength of dyed cotton fabrics after pre, simultaneous and post –mordanting methods by using 3% mordant concentration (K/S value without mordant Cotton-1.62).

Fabric	Mordant Concn.: 3%	K/S(λ=420 nm)		
		Pre-Mordanting	Simultaneous Mordanting	Post-Mordanting
Cotton	Nickel Sulphate	1.60	2.52	2.26
	Aluminium Sulphate	1.91	2.75	2.69
	Potassium dichromate	1.35	1.46	1.41
	Ferrous Sulphate	2.01	2.94	2.78
	Stannous Chloride	1.79	2.71	2.58
	Myrobolan	1.17	1.39	1.47

TABLE-4: Colourfastness of dyed cotton fabrics with selective mordants using pre, simultaneous and post –mordanting methods.

Mordants	Method of mordanting	Mordant Concentration (%)	Washing		Rubbing				Sun light	Perspiration			
					Dry		Wet			Acidic		Alkaline	
			CC	CS	CC	CS	CC	CS		CC	CS	CC	CS
Nickel Sulphate	Pre-Mordanting	1	4	4	5	4	5	5	4	5	5	5	5
		2	5	4	5	5	5	5	4	5	5	5	5
		3	5	5	5	5	5	5	4	4	5	4	5
	Simultaneous Mordanting	1	5	4 -5	5	5	5	5	4	5	5	5	5
		2	5	4 -5	5	4-5	5	5	4	5	5	5	5
		3	5	4	5	5	5	5	4	4	5	4	5
	Post-Mordanting	1	5	4 -5	5	5	5	5	4	5	5	5	5
		2	5	4 -5	5	5	5	5	4	5	5	5	5
		3	5	4	5	5	5	5	4	4	5	4	5
Aluminium Sulphate	Pre-Mordanting	1	5	5	5	4	4	5	4	5	5	5	5
		2	5	4	5	5	5	5	4	5	5	5	5
		3	5	5	5	5	5	5	4	4	5	4	5
	Simultaneous Mordanting	1	4	4 -5	5	4	5	4	4	5	5	5	5
		2	4	4 -5	5	4-5	5	4-5	4	5	5	5	5
		3	4	4	5	5	5	5	4	4	5	4	5
	Post-Mordanting	1	5	4 -5	5	5	5	5	4	5	5	5	5
		2	5	4 -5	5	5	4	5	4	5	5	5	5
		3	5	4	5	5	5	5	4	4	5	4	5
Potassium dichromate	Pre-Mordanting	1	4	3	4	4	4	5	3	4	5	4	5
		2	4	3	4	5	4	5	3	3	5	4	5
		3	4	4	4	5	3	5	4	3	5	4	5
	Simultaneous Mordanting	1	3	2	4	4	5	4	3	3	5	3	5
		2	4	2	4	4-5	4	4-5	3	3	5	3	5
		3	4	3	4	5	5	5	4	3	5	4	5
	Post-Mordanting	1	4	3	3	5	5	5	3	3	5	3	5
		2	4	3	3	5	5	5	3	3	5	3	5
		3	4	4	4	5	5	5	4	4	5	4	5
Ferrous Sulphate	Pre-Mordanting	1	5	5	5	5	5	5	4	4	5	4	5
		2	4	5	5	5	5	5	4	4	5	4	5
		3	4	4	5	5	5	5	4	4	5	4	5
	Simultaneous Mordanting	1	5	5	5	4	5	5	4	4	5	4	5
		2	5	4	5	4-5	5	5	4	4	5	4	5
		3	5	4	5	5	5	5	4	4	5	4	5
	Post-Mordanting	1	5	5	5	5	5	5	4	4	5	5	5
		2	5	4 -5	5	5	5	5	4	4	5	5	5
		3	5	4	5	5	5	5	4	4	5	4	5
Stannous Chloride	Pre-Mordanting	1	4	4 -5	5	5	5	5	4	4	5	4	5
		2	4	4	5	5	5	5	4	4	5	4	5
		3	5	3 -4	5	5	5	5	4	4	5	4	5
	Simultaneous Mordanting	1	5	4 -5	5	4	5	4-5	4	4	5	4	5
		2	5	4	5	4-5	5	4-5	4	4	5	4	5
		3	5	4	5	5	5	5	4	4	5	4	5
	Post-Mordanting	1	4	4	5	5	5	5	4	4	5	5	5
		2	5	5	5	5	5	5	4	4	5	5	5
		3	5	4	5	5	5	5	4	4	5	4	5
Myrobolan	Pre-Mordanting	1	3	4	5	5	5	5	4	4	5	4	5
		2	3	3	5	5	5	5	4	3	5	4	5
		3	4	4	5	5	5	5	4	4	5	4	5
	Simultaneous Mordanting	1	3	4	5	4	5	5	4	4	5	4	5
		2	3	3	5	4	5	5	4	5	5	4	5
		3	4	4	5	5	5	5	4	4	5	4	5
	Post-Mordanting	1	3	4	5	5	5	5	4	4	5	4	5
		2	3	3	5	5	5	5	4	4	5	4	5
		3	4	4	5	5	5	5	4	4	5	4	5
Control	-	-	4 -5	4	5	5	5	5	4	4	5	4	5

CC – Colour change, CS – Colour Staining, C – Cotton

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Appendix: At the end of the paper

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