

Printing of Cotton Fabric with Natural Colors vis-à-vis Effects of Metal Ions

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Abstract: Anciently, textile coloration was mainly carried out with natural colorants and components obtained from natural resources. However, with the invent of synthetic dyes, use of natural colors for coloration of textile declined tremendously. The manufacturers and end users of synthetic dyes suffered certain constrains such as non-biodegradability, disposal problem, toxicity of some dyes, allergenic reactions, increasing price of coal tar and others. Green dyes, popularly known as natural colors, are gaining increasing popularity amongst the textile dyers and printers and end users. Natural color dyeing on natural fibers has been well established commercially. Very few literatures pertain to printing of natural colors are available. Two, the most popular natural colors, turmeric and catechu, have been printed on cotton fabric using various techniques of mordanting. The optimal route of mordanting with print compositions for cotton fabric was derived. Further, the effects of printing of natural colors using various mordants, namely, sodium sulphate, copper sulphate, ferrous sulphate and aluminum sulphate, are compared on cotton fabric. All these mordants consists common negative ion (sulphate), but different metallic ions. The effects of metallic ions on color co-ordination values (L,a,b,C and H) are compared. Finally, the fastness properties are also determined and found good to very good.

I. INTRODUCTION

In every civilization, colour has played a vital role in human life. Colour is an important aspect for textile aesthetic and personal appearance. In ancient time natural colorants were the only sources of textile coloration^{1,2}. With the invention of synthetic dyes in 1856 by H. Perkin from coal tar, the use of natural colors in textile application declined tremendously. The major advantages of synthetic dyes are their cost, fastness properties, reproducibility, wide shade ranges and others. However, many synthetic dyes are found carcinogenic or allergenic to skin as their manufacturing process involves certain toxic chemicals. German government and European nations have banned many synthetic dyes because they are produced from carcinogenic amines since 1992. Further, some of the synthetic dyes are either non – biodegradable or liberated heavy metals or chemicals on the discharged and ecological balance of the nature has been disturbed to great extent. The stringent environmental standard imposed in many countries, the increasing price and non-renewable nature of raw oil from which fraction of the synthetic dyes are originated, toxic and allergic reactions associated with

synthetic dyes are some of the prime factors for increasing uses of natural colours not only for textile, but also for ancillary industries^{3,4}. In spite of their inferior fastness, natural dyes exhibit better biodegradability and are generally more compatible with the environment and hence are more readily acceptable to the environmentally conscious users.

Many scientific researches pertaining to dyeing with natural colorants to different textile fibers (mainly on natural and to some extent on synthetic) using different techniques with or without mordanting are available^{5,6}. Very few literature available with respect to printing with natural colorants⁷⁻⁹. However, no reports on the effects of metal ions as mordants on the printing of natural colorants on any textile materials were reported. For successful commercial use of natural dyes for any particular fibers, the appropriate and standardized techniques of printing for that particular fiber-natural dye system need to be adopted so that the shade with acceptable colour fastness and reproducibility can be obtained. In the present study, two important natural colorants, the most abundance tried by the researchers, namely turmeric and catechu are selected for their printing behavior on cotton fabric. Mordants are mainly used to impart better dye absorption on cotton fibers. Therefore, four different metallic salts with different metal ions (cationic ion) were evaluated for their efficiency of printing of natural colorants on cotton fabric as mordants. Further, different techniques of mordanting are used and the best one on the basis of colour strength, fastness properties and consistency are tried to develop for printing.

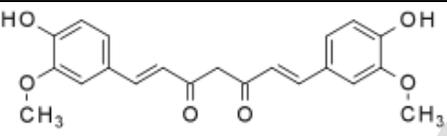
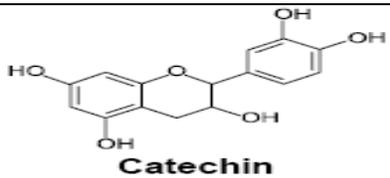
II. EXPERIMENTAL

2.1 Material:

Plain woven cotton fabric with 114 gsm and 89 HUNTER whiteness, in ready for dyeing form, is procured from the local textile industry and used through the study. Two natural colorants, namely, curcuma longa and acacia catechu, extracted by standard prescribed methods¹ are used in the present study (table I). Four different mordants, namely, sodium sulphate (SS), copper sulphate (CS), ferrous sulphate (FS) and aluminium sulphate (AS) are used in the form of laboratory grade reagents.

Table – 1

Details of natural colourants used

C I Name	Commercial Name (Colour)	Botanical Name	Chemical Structure	Obtained From
C I Yellow – 3	Turmeric (Yellow)	Curcuma Longa		Rhizome
C I Brown – 12	Catechu (Brown)	Acacia Catechu	 Catechin	Wood

2.2 Application of mordant on cotton fabric :

Conventionally used, three methods of mordant application, namely pre (first mordant and print), meta (mordant added in print paste) and after (first print and mordant) are used for cotton fabric. Mordants are applied in three levels of concentrations (5, 10 and 15 % w/v), dried and cured at 110°C for 5 minutes (for meta mordant process no separate curing was performed).

2.3 Preparation of printing paste :

Print paste of the natural colorants are prepared (table – 2) and applied on cotton fabric as per the methods of mordanting prescribed previously. After printing and drying at 100°C for 10 minutes, fabric is cured at 150°C for 7 minutes followed by rinsing with water, soaped with non ionic detergent (1 % w/v) at 50°C for 10 minutes, washed and dried.

2.5 Analytical procedure:

For the evaluation of print color efficiency, the CIE color coordinates, L*, a* and b* values and color strength in terms of K/S of printed samples are obtained by Spectra Scan 5100 Spectrophotometer (Premier Colour Scan Made, India). The average of three readings is reported in the results.

Table – 2 : Print paste formulation

Name of Ingredients	Parts
Dye Extract	X
Sodium carbonate	0.5
Thickener	60
Mordant (only in meta process)	5, 10 & 15
Water	15 Parts
Total	100 Parts

The second important property to evaluate print efficiency is the fastness properties. For this purpose, washing (ISO 105 – C01), rubbing (ISO 105 – X12), perspiration (ISO 105 – E04) and light (ISO 105 – B02) fastness properties of printed samples are also assessed.

III. RESULTS AND DISCUSSION

3.1 Standardization of mordant application process:

Cotton fabric was printed with two natural colorants (turmeric and catechu) using pre, meta and post mordanting methods. In the first part of the study with single mordant, namely, copper sulphate (5, 10 and 15 % w/v), three methods of mordanting for print effects are evaluated in terms of color strength (K/S) and results obtained are reported in table – 3.

It has been well known that natural colorants have low substantivity for cotton fibers and therefore, application of mordant i.e. an intermediate chemical, having an affinity for fiber and colorant is required. This has been confirmed from the results (table – 3) i.e. with mordant, irrespective of any methods, the color strength values are higher than without mordant. Further, the comparison of three methods of mordanting, namely, pre, meta and post, shows that the colour strength (K/S) values of post is better followed by pre and meta mordanting method. The best print effects of all the three level of concentrations of turmeric and catechu dyes on cotton with copper sulphate mordant was found with post mordant technique. This may be because interaction of mordant and colorant (which is printed first) on the surface of fabric is in better condition in post mordant method. In the other two methods, the interference of mordant either previously or along with color, hinders the process of interaction of colorant and mordant and simultaneously fixation.

Table – 3 : Print effects of turmeric and catechu colors on cotton fabric using various mordant application techniques

Mordant (Conc. % w/v)	Mordant application method	K/S Values	
		Turmeric	Catechu
-	Without	4.2	3.7
5	Pre	4.9	4.8
	Meta	4.8	4.6
	Post	5.8	5.4
10	Pre	5.9	5.6
	Meta	5.2	4.8
	Post	7.8	6.9
15	Pre	6.3	6.4
	Meta	5.9	5.8
	Post	8.5	8.2

3.2 Printing of cotton fabric with turmeric natural colorant by post mordanting technique :

From the foregoing experiment it has been found that print effects by post mordant application method on cotton fabric gives superior results. Therefore, cotton fabric was printed using four different mordant (metallic salts), namely, sodium sulphate (SS), copper sulphate (CS), ferrous sulphate (FS) and aluminum sulphate (AS), in three different concentration levels (5, 10 and 15 % w/v). The print efficiency after washing and drying are evaluated in terms of colour strength (K/S) and CIE colour values and results obtained are reported in table – 4.

The results of SS mordant indicates that at the concentration of 0, 5, 10 and 15 % of mordant the K/S values of turmeric dye are 4.2, 4.8, 5.2 and 6.8 respectively. This indicates the color values of print increases with that of concentration of mordant. The increase in K/S value is at small extent with that of concentration increases from 5 to 10 %. However, significantly high increase in color values with increase in concentration from 10 to 15 %. Exactly, similar trends can be seen with other mordants namely, CS, FS and AS.

Table – 4 : Printing of cotton fabric using turmeric colorant with different mordants by post mordant application technique

Name of mordant	Mordant conc.(%W/V)	L	A	b	C	H	K/S
SS	0	36.1	11.4	22.3	25.3	44.4	4.2
	5	78.8	2.7	28.4	28.5	84.3	4.8
	10	79.6	2.4	23.8	23.9	84.0	5.2
	15	88.2	1.7	24.3	24.4	85.8	6.8
	0	36.1	11.4	22.3	25.3	44.4	4.2

CS	5	57.4	18.3	46.9	50.2	68.6	5.8
	10	58.5	17.8	47.4	50.6	69.3	7.8
	15	59.3	18.5	48.6	52.0	69.0	8.5
FS	0	36.1	11.4	22.3	25.3	44.4	4.2
	5	53.2	16.4	41.0	44.1	68.4	6.8
	10	53.6	17.0	41.1	44.5	67.3	6.9
	15	67.0	16.1	40.0	43.1	67.9	8.0
AS	0	36.1	11.4	22.3	25.3	44.4	4.2
	5	62.9	18.8	56.6	59.7	71.5	7.5
	10	64.8	18.2	59.0	61.7	72.7	8.7
	15	74.6	17.8	58.8	61.4	73.1	10.6

The result also indicates the colour index values of turmeric colorant with different mordant. ‘L’ indicates lighter (positive values) or darker (negative values), ‘a’ indicates greener (negative values) or redder (positive values), ‘b’ indicates bluer (negative values) yellower (positive values), ‘C’ indicates brighter (positive values) or duller (negative values) and ‘H’ quantified the angular measure. The colour co-ordinates values indicate that samples are of the same depth (approximately same ‘L’ value) with different mordant. The positive value of ‘a’ indicates all the samples are redder, but the more redder is with CS followed by AS, FS and SS. The positive values of ‘b’ and ‘C’ show that samples are yellower and brighter. The highest brightness and yellow value of colour is obtained with the AS followed by CS, FS and SS. The angular measured value (H) shows the value between 30 to 90°, means the colour of the samples are red to yellower.

3.3 Printing of cotton fabric with catechu natural colorant by post mordanting method:

Cotton fabric was printed with catechu colorant using four different mordant (metallic salts), namely, SS, CS, FS and AS, in three different concentration levels (5, 10 and 15 % w/v) by post mordant application technique. The print efficiency after fixation is evaluated in terms of colour strength (K/S) and CIE colour co-ordinate values (table – 5).

The effect of concentration of mordant of catechu colorant also shows similar trends as that of turmeric, i.e. with increase in concentration upto 10 % (owf), increases steadily the color value and above that level color value increases drastically. This particular behavior can be seen for all the mordant with catechu colorant print on cotton fabric.

The results of copper sulphate mordant indicates that at the concentration of 5, 10 and 15 % of mordant the K/S values of turmeric dye are 8.5, 8.8 and 9 respectively. This indicates as

the concentration of mordant increases the colour value of print also increases. The increase in K/S value is significantly high from increase in concentration from 5 to 10 %. However, with further increase in concentration from 10 to 15 %, there is much improvement in colour value as observed by K/S value.

Exactly, similar trends can be observed with other mordants namely, ferrous sulphate, aluminum sulphate and sodium sulphate. In the said mordants also with increase in concentration of mordant from 10 to 15 % the significant increase in strength can be observed. With further increase in concentration of mordant there is no much improvement in the colour strength. Table 6 also indicates the colour index values of both different natural dyes on different mordants. ‘L’ indicates lighter (positive values) or darker (negative values), ‘a’ indicates greener (negative values) or redder (positive values), ‘b’ indicates bluer (negative values) yellower (positive values), ‘C’ indicates brighter (positive values) or duller (negative values) and ‘H’ quantified the angular measure. The colour co-ordinates values indicate that samples are of the same depth (approximately same ‘L’ value) with different mordant. The positive of ‘a’ indicates all the samples are redder, but the more redder is with sodium sulphate followed by aluminum sulphate, copper sulphate and ferrous sulphate. The positive values of ‘b’ and ‘C’ show that samples are yellower and brighter. The highest brightness and yellowness is with the aluminium sulphate mordant. The angular measured (‘H’) shows the value between 90 to 180°, means the colour of the samples are red to yellower.

Table – 5 : Printing of cotton fabric using catechu colorant with different mordant by post mordant application technique

Name of mordant	Mordant conc.(%W/V)	L	a	b	C	H	K/S
SS	0	10.1	8.1	6.3	11.4	15.8	1.8
	5	18.1	18.0	14.4	23.1	38.7	4.2
	10	18.3	18.3	15.0	23.4	39.8	4.5
	15	19.8	19.5	15.6	24.5	39.6	5.9
CS	0	10.1	8.1	6.3	11.4	15.8	1.8

Table – 6 : Fastness properties of natural colour printing on cotton fabric with different mordants

Natural Colour	Name of mordant	Washing fastness		Perspiration fastness		Rubbing fastness		Light Fastness
		SS	CC	Alkaline	Acidic	Dry	Wet	
C.I.Yellow-3	UT	3/4	¾	3	3	3	2/3	4
	SS	4	4	3/4	3/4	4	3/4	6
	CS	4/5	4	4	3/4	4	4	6
	FS	4/5	4/5	3/4	4	3/4	4	5
	AS	4	4	4	4	3/4	3/4	5

	5	33.6	13.0	11.5	17.2	40.7	7.5
	10	34.6	13.5	11.6	17.8	41.4	8.1
	15	35.0	14.1	13.0	19.2	42.7	9.8
FS	0	10.1	8.1	6.3	11.4	15.8	1.8
	5	32.5	8.8	9.4	12.9	41.1	7.2
	10	34.6	9.8	11.7	13.7	42.0	7.8
	15	42.9	13.0	19.7	21.9	53.1	8.9
AS	0	10.1	8.1	6.3	11.4	15.8	1.8
	5	20.9	20.9	18.1	31.0	31.4	6.1
	10	21.6	21.6	20.2	33.0	35.4	7.0
	15	26.7	25.7	22.2	43.8	45.7	8.9

In both the natural colors type of metallic ion significantly effected on the hue, chroma and value of final print which can be observed from the L, a, b, C and H values. In the identical conditions of application of natural colorants printing, the color parameters changes with that of mordant. This is because each metallic ion has different ionization energy which effects on bond formation with natural colors.

3.4 Fastness properties of printed sample:

Printing efficiency can be finally judged by determination of important fastness properties, namely washing, rubbing, perspiration and light. The different fastness properties of printed samples are evaluated for 10 % mordanted sample by standard prescribed method and results obtained are reported in table 6.

Various fastness properties of natural colour print without mordant on cotton fabric is poor to average. However, on mordanting the wash fastness becomes good to very good, perspiration and rubbing fastness become average to good and light fastness turns to good. Further, the fastness result indicates that the types of mordant i.e. metallic ion do not much interfere on the fastness properties of print. The fastness properties can be further improved to certain extent by after treatment with cationic fixing agent or special finish softener.

C.I.Brown -12	UT	3/4	3	3	3	3	3	4
	SS	4	4/5	3/4	3/4	4	3/4	6
	CS	4/5	4	4	4	3/4	4	5
	FS	4/5	4/5	4	3/4	4	3/4	6
	AS	4	4	3/4	4	3/4	3/4	6

IV. CONCLUSIONS

Natural colors, namely, turmeric and catechu can be printed on cotton fabric effectively with the help of mordant. The various techniques of mordanting confirm that the post mordant technique i.e. print and mordant application, gives better results of print with natural colors. Further, the types of mordants i.e. metallic ions, also significant effect on the final color of the print. This has been observed with the color coordinates values of various mordant i.e. metallic ions print with the identical conditions. In order to get consistency of the print effect of natural color it is necessary to select proper mordant and conditions of print. The fastness properties after mordanting of natural color print improve to tolerance level or to superior level.

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