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Painting on handloom cotton fabric with colourants extracted from natural sources

Sankar Roy Maulik* & Khusbu Agarwal
Visva-Bharati University, Department of Silpa-Sadana, Sriniketan-731 236, India
E-mail: s_r_moulik@yahoo.co.in

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Cotton fabric was painted with *Rubia cordifolia*, *Laccifer lacca*, *Acacia catechu*, *Punica granatum*, *Terminalia chebula*, *Curcuma longa* and *Camellia sinensis* in presence of aluminum sulphate, ferrous sulphate and copper sulphate as mordants employing a simultaneous mordanting technique followed by steaming of the painted fabric at 102^0C for 30 min, whereas *Indigofera tinctoria* was applied in absence of any such salts. Such painting technique appears to be superior as compared to traditional process in respect to ease of application, storage stability of paste, colour fastness to light, rubbing and wash. It appears that such hand painted fabric has the potential for giving a crafty look to various handloom fabrics used for apparel and home furnishing purpose. In fact, it can also be used for embellishing finished garments such as t-shirt, jackets, etc. as also many other products like bags, pillows, cushion cover or anything made up of fabrics just by adding designs and colors to them. In view of use of various salts at concentrations much below their respective maximum permissible limits, such painted cotton fabrics can also be considered as eco-friendly product and is worth as labeled eco-textile.

Keywords*:* Eco-friendly, Handloom textile, Natural dye, Painting

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Production of textiles in general and artistic textiles in particular is one of the oldest professions of our country. Tradition of weaving on handlooms is a part of India's cultural ethos and preserves its heritage and culture and maintains its own identity. It provides largest employment next to agriculture and is a low capital investment sector and occupies prime place in Indian economy. But in the present context of globalization and rapid technological changes, handloom sector is beset with many challenges and the handloom products are being replicated on power looms at much lower cost. Hence, to strengthen this sector, product diversification and creating market demand is utmost essential. On the other hand, India has a rich heritage and mastered the art of decorating textile through dyeing, printing or painting using natural colours[1, 2] and painters of almost all styles of painting in India have used natural dyes to decorate their paintings, whether it be the folk paintings of India, such as *Madhubani, Patachitra*, or those that enjoyed royal patronage or indigenous art forms like batik, tie-dye, block printing, *Kalamkari*, the use of natural dyes is ubiquitous. But with the advent of synthetic dyes in the mid of 19^{th} century and its subsequent commercialization the use of natural dyes for colouration of textile receded. But in the recent past growing consciousness about environmental preservations and control of pollution had renewed interest for use of natural dyes and it provides an important alternative to petrochemical based dyes in view of growing emphasis and globally nurtured concept of sustainable product and process. Eco-friendly fabric and clothing is the buzz words now-a-days. Designers, manufactures and retailers are busy to develop 'green' product range for the mass market. However, the mass market cloths are yet to get touched by natural dyes and the retailers except few are yet to display and sell natural dyed range in their stores because of the known limitations of these dyes[3-5]. But today's consumer understands the value for money and therefore organic non-toxic products in every field have created a new horizon.

Silpa-Sadana under Visva-Bharati University is a premier institute working in the field of natural dyes on handloom textiles. Traditionally textile decoration techniques with natural dyes involves painting or printing with dyestuffs on the fabric either pre-treated with mordants or painting or printing with mordants on the dyed fabrics. Those processes have their own limitations, viz. time consuming, poor colourfastness

*Corresponding author

to washing, difficult to use print paste containing metal salts in presence of gum after 2-3 hrs, etc. Hence, the present article depicts the process of painting on handloom cotton fabric with some selected natural dyestuffs in a more scientific and technological manner making them higher performing and scope for producing value added diversified handloom textiles in view. It is also the fundamental requirement that coloured textiles should withstand the conditions encountered during processing and subsequent usage and hence assessment of colourfastness properties of cotton fabric dyed and/or painted with selective natural dyes in presence of inorganic salts are also assessed and reported in this study.

Methodology

Cotton fabric

Plain weave loom state handloom cotton fabric with yarns of $2/80^s$ Ne (15 tex) warp and $2/80^s$ Ne (15 tex) weft, having 260 ends/dm and 230 picks/dm and weighing 75 gm/m^2 on the average obtained from Silpa-Sadana Emporium, Visva-Bharati, India were used in the present study.

Chemicals

Laboratory reagent (LR) grade sodium hydroxide, sodium meta-silicate, sodium carbonate, hydrogen peroxide (50% w/v), acetic acid, hydrochloric acid, sodium nitrite, aluminium sulphate, ferrous sulphate, copper sulphate obtained from M/s Loba Chemie Pvt. Ltd., Mumbai, India, and gum *indulka*, anionic wetting agent (T R oil, i.e. sulphonated castor oil), non-ionic detergent of commercial grade obtained from local market were used in this study.

Natural dyes

Rubia cordifolia, *Laccifer lacca*, *Acacia catechu*, *Indigofera tinctoria*, *Punica granatum*, *Terminalia chebula*, *Curcuma longa* and *Camellia sinensis* were used as natural dyes for painting purpose. *Laccifer lacca*, *Curcuma longa* and *Indigofera tinctoria* were obtained from M/s ECO-N-VIRON, India, in paste form and were used without any further extraction, whereas *Rubia cordifolia*, *Acacia catechu*, *Punica granatum*, *Terminalia chebula* and *Camellia sinensis* purchased from local market were extracted using water as the solvent, filtered and filtrates were then used as natural colourant for the painting purpose (Table 1).

Methods

Desizing, scouring and bleaching

In order to remove size and other natural and added impurities from the loom state handloom cotton fabric, the latter was desized, scoured and bleached prior to dyeing and/or painting in the manner as described below:

Desizing of grey cotton fabric was performed using hydrochloric acid solution (4ml/l) at a temperature of 40^0C for 2 hrs at a fabric to liquor ratio of 1:20 (w/v). The desized cloth was washed thoroughly using hot water, which was followed by a cold wash prior to the conventional process of combined scouring and bleaching.

Combined scouring and bleaching treatment of the desized cotton fabric was performed by conventional tub method. In this method, a solution was made with sodium hydroxide (3%), sodium carbonate (2%), anionic detergent (0.5%), Turkey Red Oil (1%) and sodium meta-silicate (2%) and the liquor was heated up to a temperature of 60^0C. At this temperature the desized fabric was immersed into the solution and boiled for 2 hrs. At the time of boiling hydrogen peroxide solution (2%) was added in two installments and the process was further continued for another 1 hr. The scoured and bleached fabric was then washed thoroughly with hot water, followed by cold wash and neutralized with dilute acetic acid, washed again with cold water and finally dried in air.

Extraction of natural dyes

Aqueous solution of natural dyes, viz. *Rubia cordifolia*, *Acacia catechu*, *Punica granatum*, *Terminalia chebula* and *Camellia sinensis* were prepared by adding 20 gm of crushed vegetable matters to 100 ml of water. The mixture was stirred, heated and kept at boiling point for 60 min in a thermostat control beaker dyeing machine, allowed to stand for 15 min and finally filtered. Such filtrate was used for dyeing and painting purpose after diluting it to the specified level, if required.

Preparation of painting paste

Painting pastes of all the dyestuffs except *Indigofera tinctoria* and *Curcuma longa* were prepared by adding appropriate quantity of *gum Indulka* in 100 ml of aqueous extraction of vegetable colourants, followed by stirring with a high speed stirrer. After preparing the painting paste specific quantity of metal salts either individually or in

Table 1—Plant, animal parts and its chief colouring compound used as natural dyes

Botanical name	Common name	Parts used	Chief colouring compound
Rubia cordifolia L.	Indian madder	Root	Purpurin[3]
Acacia catechu (L.f.) Willd.	*Khair*	Stem bark	Catechin[6]
Curcuma longa L.	Turmeric	Rhizomes	Curcumin[7]
Terminalia chebula Retz.	*Haritaki*/Myrobolan	Fruit	Elagitannic acid[8]
Camellia sinensis var *assamica* (Masters) Kitamura	Tea	Leaves	Theaflavin and Thearubigins[9]
Laccifer lacca Kerr.	Lac	Resin	Laccaic acid[8]
Indigofera tinctoria L.	Indigo	Green crop	Indigotin[6]
Punica granatum L.	Pomegranate	Fruit rind	Ellagi-tannin-flavogallol[10]

combinations were mixed, kept for 15-20 min so that complete lake was formed by reacting with the colouring component present in the dyestuffs and the metal.

In case of *Indigofera tinctoria* painting paste was prepared by mixing 20 gm of *Indigofera tinctoria* with 10 gm of sodium nitrite and 70 gm of gum *Indulka* (10 % paste), whereas in case of *Curcuma longa* painting paste was prepared by adding 10 gm of *Curcuma longa* with 2 gm aluminium sulphate and 2 gm tartaric acid along with 70 gm of gum *Indulka* (10 % paste) and 16 ml water**.**

It is to be noted that the viscosity of the painting paste may vary depending on various factors, viz. type of fabric, design, type of brush, etc.

Painting with natural dyes (Fig. 1)

Traditional process

1. Scoured and bleached cotton fabric was dyed with aqueous solution of natural dyes at a temperature of 80 ^{0}C for 30 min and dried in air, followed by painting with different inorganic salts mixed with gum *Indulka* at different proportions for getting various shade. Alternately the fabric was treated with different inorganic salts at 70 ^{0}C temperature for 20 min and dried, followed by painting with thickened solution of natural dyes. In both the cases, after painting the fabric was kept for 3-4 days or sometimes even for one month for fixation of the dyes.

2. In another process scoured and bleached cotton fabric was treated with an aqueous solution of *Terminalia chebula* for sometimes and squeezed, followed by soaking in buffalo milk for 2-3 hrs. Because of high tannin content, *Terminalia chebula* was used as the colourant and high fat content in buffalo's milk prevents dye from spreading on the cloth. After that designs were drawn on the surface of the fabric by using black ink separately prepared by adding 250 gm iron dust in 1 L of water along with 1 kg molasses (*chite gur*) and kept for one month. Painting on *Terminalia chebula* treated fabric was done with this black ink and was kept for 2-3 months followed by washing in flowing water.

Modified process

1. In the modified process the fabric was padded with an aqueous solution of *Terminalia chebula* at 100% wet pick up in a miniature lab model two bowl padding mangle and dried in air. This was followed by painting with a paste consists of ferrous sulphate 2 gm, gum *Indulka* 80 gm and water 18 gm. After painting, the fabric was steamed at 102 ^{0}C for 30 min and washed thoroughly with 2 gm/l non-ionic detergent, followed by cold wash and finally dried in air.

2. In another process inorganic salts of specified dose level were mixed with the aqueous solution of natural dyes and kept for 15 min in order to form lake or complex. Appropriate amount of gum *indulka* was then mixed with the help of high speed stirrer to prepare the painting paste. Painting on bleached or dyed cotton fabric was performed with this paste and the fabric was dried in air, followed by steaming at 102^{0}C for 30 min and washed thoroughly with 2 gm/l non-ionic detergent, followed by cold wash and finally dried in air.

In case of *Indigofera tinctoria*, painting paste was prepared by mixing 20 gm of *Indigofera tinctoria* with 10 gm of sodium nitrite and 70 gm of gum *Indulka* (10 % paste). The colour was developed in a bath containing 30 gm/l hydrochloric acid and 20 gm/l sodium chloride at a temperature of 60 ^{0}C for 10 min.

Assessment of colourfastness to washing

Colourfastness to washing of cotton fabrics painted with natural dyes was assessed in a launder-o-meter in accordance with a method prescribed in IS: 3361-1984 (ISO-II) [11]. Washing was done for 45 min at 50 ± 2^{0}C at a fabric-to-liquor ratio of 1:50 employing a non-ionic detergent (5 gm/L), washed in cold tap

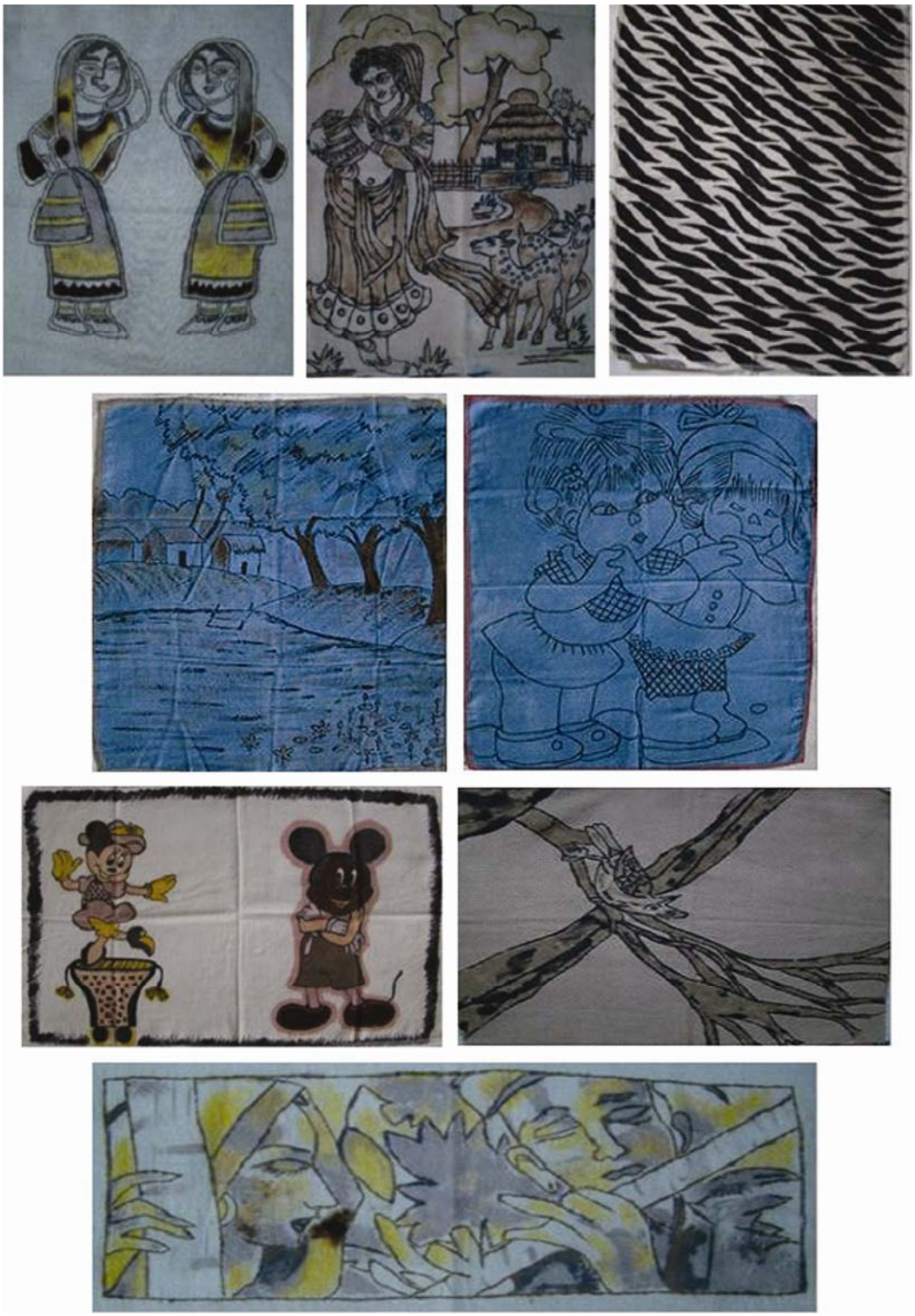

Fig. 1—Painting with natural dyes on handloom cotton fabrics (modified process)

water and finally dried in air. The change in colour of the original dyed sample and staining on adjacent fabrics were rated between 1–5 using five step grey scales (including half step) for evaluating change in colour and for evaluating staining on adjacent fabric respectively, where a rating of 5 indicates excellent and a rating of 1 indicates very poor fastness properties. The grey scale used for assessing change

in colour and for assessing staining were having the numbers ISO 105-A03:1993 and ISO 105-A03:1993, respectively.

Assessment of colourfastness to light

Colourfastness to light was assessed on a Mercury Bulb Tungsten Filament (MBTF) lightfastness tester following a method prescribed in IS: 2454 -1984[12]. One half portion of each sample measuring 1 x 4.5 cm was appropriately covered with a piece of opaque black paper before placing the same in the light fastness tester. Eight blue wool standards with numbers (1-8) similarly covered and having progressively lower fading rate with increasing standard numbers were also exposed along with the test specimen. The rate of fading of the test specimen was visually compared with that of the standard samples for determination of colourfastness rating. Blue wool standard fabrics used for such purpose were having number ISO 105: BO1C LFS1 – LFS8.

Assessment of colourfastness to rubbing

This was determined employing a Crockmeter following the method prescribed in IS: 766-1984[13]. The staining on adjacent fabrics was rated between 1–5 using 5 step grey scale (including half step) for evaluating staining, where a rating of 5 indicates excellent and a rating of 1 indicates very poor fastness properties. The grey scale used for assessing staining was made in accordance with International Standard Organization (ISO) and was having the number ISO 105-A03:1993.

Results and discussion

Assessment of colourfastness to light, washing and rubbing

Data for colourfastness to light, wash and rubbing of cotton fabric painted with specified natural dyes in presence of aluminium sulphate, ferrous sulphate and copper sulphate by following modified process as described earlier are presented in Table 2. Use of inorganic salts caused a good light fastness rating of the dyed substrates for all the natural dyes except *Curcuma longa*. *Curcuma longa* is very much susceptible to light because they emit fluorescence[8] and also from the structure of curcumin[7] one can say that this dye is not forming metal-complex with the mordants and hence shows poor light fastness and the samples are substantially faded within first 3-4 hrs of exposure time in MBTF fastness tester. The wash fastness of this dye on cotton is also moderate. Moderate wash fastness rating may be attributed due to weak dye fibre interaction and change in hue during washing. In spite of such drawbacks like poor light fastness, moderate wash fastness and *p*H sensitivity, *Curcuma longa* remains the most favoured natural colour for obtaining bright yellow shades and is commonly used in painting. On the other hand aluminium, iron and copper with their good complex forming ability[14] can hold two or more suitable dye molecules together to form insoluble large complex, which enhanced the light fastness of the dyed substrates[8, 15]. Such complexation of the coloured component within the fibre structure leads to polymerization of the dye molecules which is also responsible for improvement in light fastness of the dyed substrates[16, 17]. The chromophore in those cases may be protected from photochemical oxidation by forming a complex with the metal. The photons sorbed by the chromophoric groups dissipate their energy by resonating within the ring and hence dye is protected. *Indigofera tinctoria* exhibits excellent fastness to washing, light and rubbing. The dye is applied in the soluble leuco form but once it is inside the fibre the dye gets oxidized to the insoluble form and getting firmly held by the fibre.

Table 2—Colourfastness to light, wash and rubbing for cotton fabric painted with natural dyes following modified process

Natural dye	Mordant	Lightfastness	Rubbing fastness	Wash fastness
Rubia cordifolia (*Manjistha*)	$Al_2(SO_4)_3$	3-4	4	4
Coccus laccae (Lac)	$FeSO_4$	5	4	4
Coccus laccae (Lac)	$Al_2(SO_4)_3$	4	4	4
Acacia catechu (*Khayer*)	$CuSO_4$	5-6	4	4
Indigofera tinctoria (Indigo)	Nil	6	4-5	4-5
Terminalia chebula (*Haritaki*)	$FeSO_4$	5-6	3	4
Terminalia chebula (*Haritaki*)	$Al_2(SO_4)_3$	4-5	3-4	4
Curcuma longa (Turmeric)	$Al_2(SO_4)_3$ & Tartaric Acid	1-2	3-4	3
Camellia sinensis (Tea)	$Al_2(SO_4)_3$	4-5	4	4
Camellia sinensis (Tea)	$FeSO_4$	4-5	4	4

The rating for colourfastness to washing of painted cotton fabric except *Curcuma longa* in presence of aluminium sulphate, copper sulphate and ferrous sulphate commonly produces good to excellent colourfastness to washing. Improvement in such colourfastness to washing rating may be the consequence of formation of insoluble large complex formed by the colouring component present in the dyes and the metal ions within the fibre.

A common excellent rubbing fastness property of the above natural dyes when applied on cotton fabrics indicates very little deposition of the above colourants on the surface of the fabrics at the end of the painting process.

Traditional significance and recommendations

In the human civilization plants are used not only for the basic needs of life such as food, fibre, fuel, cloth and shelter but also as sources of natural dyes for dyeing, painting and printing purposes. The ancient dyers and painters were not conversant with the modern science and technology of dyeing, painting and printing of textiles with natural dyes. The application of these dyes were receded after the advent of synthetic dyes in the mid of nineteenth century by W H Perkin and the position continued to be much the same until in the recent past the growing demand for eco- friendly product has generated a new awareness at each level of the textile industry. In the present day handicraft industry in many countries has evolved around local talent in the art and craft of dyeing and painting of textile with natural dyes and the eco-fabric thrust has been identified as an area where consumers are prepared to seek out and pay for fabrics that have a 'green' element. Although the percent of the market place is small, the eco-friendly apparel market is definitely growing and the consumer pressure to make environmentally friendly products has had an impact on the textile and other industries. At present consumers are demanding ecologically and social responsible processed textiles and companies are searching for tools to make their supply chains more sustainable. Hence, an effort should be made to promote the use of natural dyes, extend their range of application and encourage commercial use than restricting it to the cottage and craft level. It is also advisable to use only those colour yielding raw materials which are considered as waste or are of low trade value. Researchers and designers may use the described technique in the article for an improved result in respect of colourfastness, durability, ease of application and eco-friendliness.

Conclusion

India has a rich tradition of painting using natural dyes. Dyeing and painting with natural dyes contribute to value addition of textiles and also responses to the increasing demand of compatibility with the environment. Painting on handloom cotton fabric with *Rubia cordifolia*, *Laccifer lacca*, *Acacia catechu*, *Punica granatum*, *Terminalia chebula* and *Camellia sinensis* was effectively accomplished in presence of aluminium sulphate, ferrous sulphate and copper sulphate by following simultaneous mordanting technique, whereas *Indigofera tinctoria* was applied in absence of any such inorganic salts. As compared to traditional process the process as described in the article is superior in terms of ease of application, colourfastness properties, storage stability of painting paste and also for achieving clear white ground. Through this process of painting one can give a crafty look to the handloom cotton fabrics used for apparel and home furnishing purpose. But before selecting the inorganic salts to be used as mordants for painting purpose it is essential to check their maximum permissible limit in the ultimate products for different Eco-marks. It is also essential to maintain proper proportion of colourants and inorganic salts in the painting paste. Excess of dye beyond the limit may cause tinting on the white ground and excess amount of inorganic salts than the desired level will increase in pollution load.

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