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Batik on handloom cotton fabric with natural dye

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Handloom forms a precious part of the generational legacy and exemplifies the richness and diversity of culture and artistry of the weavers. Tradition of weaving by hand is a part of the country's cultural ethos. However, in the present context of globalization and rapid technological changes, handloom sector is beset with many challenges and the handloom products are being continuously replicated on power looms at much lower price. Hence, there is a need to strengthen this sector given the employment potential and market demand for handloom products. On the other hand environmental considerations are now becoming additional important factors during the selection of consumer goods including textiles all over the world. Affairs related to environmental preservation and control of pollution have renewed interest for use of natural dyes for the colouration of textile materials all over the world, particularly in the developed countries. In the past few decades, batik work on textile materials has gained popularity among the young generations who quickly adapted the easy-to-do method for individualizing their shirts, trousers, jeans and casual clothing. Therefore, product diversification through *batik* work with natural dyes is one of the ways to create fancy effect on the handloom products for the ever changing fashion market. A greater emphasis on using natural dye in the textile industry could make a valuable contribution to environmental sustainability in the 21st century.

Keywords: *Batik*, Colour fastness, Eco-friendly, Handloom, Natural dye

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Batik is a method of creating patterns/designs on the fabric surface using wax resist techniques. The origin of the word *batik* is thought to be derived from the Javanese *amba* (to write) and *titik* (dot or point), which also envisages the whole operation. The word *batik* was first recorded in English in the Encyclopedia Britannica of 1880 where it was spelt as *battik*. This very old technique originated in Indonesia and the island of Java still produces exquisite materials and wall hangings decorated by this process, richly ornamented and very often of the highest artistic merits. During the twentieth century the revival of *batik* in India began at Santiniketan[1].

The dyeing and printing of textiles with natural dyes is one of the oldest known to man and was practiced dates back to the dawn of human civilization[2]. In earlier days natural dyes extracted from vegetable sources were used for batik work, but after the advent of synthetic dyes and its subsequent commercialization the use of natural dyes receded and presently the batik work is mainly done with naphthol (azoic) and solubilised vat dye, because both of them can be applied under cold condition. But in the recent past due to growing consciousness about environmental preservations and control of pollution the use of natural dyes are gaining momentum for the colouration of textiles all over the world particularly in the developed countries.

Tea is a beverage produced from leaves of the tea plant *Camellia sinensis* var *assamica* (Masters) Kitamura. The chief biochemical colouring compounds present in the tea liquor are theaflavin and thearubigins[3–5]. The Indian madder (*Rubia cordifolia*) consists of short rootstocks with numerous cylindrical smooth and straight roots. It is an anthraquinonoid based red dyes and the main colouring matter present in the roots of *Rubia cordifolia* is a mixture of purpurin[6]. *Rubia cordifolia* is one of the well known drugs being used since ancient time[7] and it has wide range of pharmacological properties. It is also one of the highly reputed drugs used in the indigenous system of medicine as an antiflammatory, to treat urinary disorder, tuberculosis and intestinal ulcer[8-9]. Myrobolans, locally known as *harda*, (*Terminalia*

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chebula) is popularly referred to, is the source of one of the most important vegetable tanning materials and has been used in India for a long time as a tanning, mordanting and dyeing material. It is also of great importance in Ayurvedic medicine and is one of the three key ingredients in triphala, a natural compound that provides overall support for digestive function. It can also be used to treat gastrointestinal and respiratory disorders. The tannin of myrobolan is elagitannic acid[10]. Lac is a resinous secretion of tiny scale insect and is probably the most ancient of the animal dyes and has been used in India as a skin cosmetic and also to dye silk and wool fibre. In China it is a traditional dye for leather goods. The principle colouring component has been identified as laccaic acid[10]. The commonest and the most widely occurring species of the lac insects in India is *Laccifer lacca*. There are over a hundred species of plants on which lac insects have been recorded, but from the point of view of large scale production *Palas* (*Butea monosperma*), *Khair* (*Acacia catechu*) are of most important[10]. *Acacia catechu* is a deciduous, thorny tree which grows up to 15 m (50 ft) in height and in Hindi the plant is called *khair*. The principle colouring compound present in khair is catechin [11]. Catechu or Cutch obtained from *Acacia catechu* is mainly used in cotton and silk dyeing and also in Calico Printing. An astringent substance obtained from the bark and wood has been traditionally used medicinally for the purpose of sore throats, diarrhea, etc. and also for tanning purpose[12]. Turmeric is a spices derived from the rhizomes of *Curcuma longa*. The bright yellow colour of turmeric comes mainly from fat soluble, polyphenolic pigments known as curcuminoids. Curcumin the principle colouring compound present in turmeric[13] is generally considered as its most active constituent and used for dyeing wool, silk and unmordanted cotton to which it imparts a yellow shade in an acidic dye bath. It is also used as a colouring agent in pharmacy and food industry and also used on ceremonial occasion. Onion (*Allium cepa*) used as vegetables all over the world. The outermost dry papery scale of onion bulb yields the dye C I Natural yellow 10. Wool and silk can be dyed with this dye to form various shades ranging from golden yellow to copper red in presence of different inorganic salts or mordants. The main colouring component found in the scale of onion bulb is quercetin[14].

On the other hand handloom being the traditional device of manufacturing simple and decorative fabrics meant mostly for apparel and home furnishing in our country, has been playing a major role for the economic development of rural areas by the way of generating employment potential. However, in the present context of globalization and rapid technological changes, handloom sector is beset with many challenges and the handloom products are being continuously replicated on power looms at much lower price. Hence, product diversification through printing, stitching, embroidery, innovative design development, etc. is very much essential for the survival of this rich cultural heritage of India.

The present work is aimed at to apply the above mentioned natural dyes on handloom cotton fabric through *batik* techniques in order to produce diversified value added handloom cotton fabric used for apparel. It is the fundamental requirement that coloured textiles should withstand the conditions encountered during processing and subsequent usage and hence assessment of colour fastness properties of the dyed cotton fabrics is also assessed and reported in this article.

Materials

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, 50% (w/v) hydrogen peroxide, acetic acid, hydrochloric acid, aluminium sulphate, ferrous sulphate, copper sulphate obtained from M/s Loba Chemie Pvt Ltd, Mumbai, India, and paraffin wax, bee wax, anionic wetting agent (TR Oil, i.e. sulphonated castor oil), non-ionic detergent of commercial grade obtained from locally available sources were used as and when required.

Natural dyes

Laccifer lacca and *Curcuma longa* obtained from M/s ECO-N-VIRON, India, in paste form were used as natural dyes without any further extraction, whereas *Rubia cordifolia*, *Allium cepa*, *Acacia catechu*, *Terminalia chebula* and *Camellia sinensis*

Table 1—Plant and animal parts used as natural dyes

Botanical name	Common name	Parts used
Rubia cordifolia L.	Indian madder	Root
Acacia catechu (L.f.) Willd.	*Khair*	Stem bark
Curcuma longa L.	Turmeric	Rhizomes
Terminalia chebula Retz.	*Haritaki*/Myrobolan	Fruit
Camellia sinensis var *assamica* (Masters) Kitamura	Tea	Leaves
Laccifer lacca Kerr	Lac	Resin
Allium cepa L.	Onion	Bulb scale

var *assamica* (Masters) Kitamura obtained from locally available sources were used after extraction (Table 1).

Methods

Desizing, scouring and bleaching

In order to remove size and other impurities from the grey cotton fabric, the latter was desized, scoured and bleached prior to batik work in the manner as described below:

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

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 ^{0}C. At this temperature the desized fabric was immersed and boiled for 2 hrs. At the time of boiling (50% w/v) 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

Rubia cordifolia, *Acacia catechu* and *Terminalia chebula* were dried in absence of direct sunlight and crushed in powder form with the help of pulverizer grinder (crusher) before the extraction process. Aqueous solution of *Rubia cordifolia*, *Acacia catechu, Allium cepa*, *Terminalia chebula* and *Camellia sinensis* var *assamica* (Masters) Kitamura was prepared by adding 200 gm of each vegetable matter separately to 1 L of water. The mixture was stirred, heated and kept at boiling point for 60 min, allowed to stand for another 15 min and finally filtered through nylon bolting cloth having 140-200 mesh size in order to separate aqueous solution of colouring components present in the vegetable matters and roughages. Such filtrate was then used as natural colourants after necessary dilution, whereas *Laccifer lacca* and *Curcuma longa* were used without any further extraction.

Batik with natural dyes

Batik technique involves four steps of drawing, waxing, dyeing and wax removing.

Waxing

At first design was traced out on a piece of fabric. The waxing process was done in steps from the lightest shade to the darkest one (Figs. 1 & 2). If the design consists of four colours, viz. white, yellow, red and black then the wax was applied to the white portion first and the cloth was immersed in yellow dye. Then yellow portion was waxed and dipped in red and finally red portion was waxed and the cloth was finally dipped in black colour. A mixture of about 1:1 paraffin wax and bee wax is easiest to work with, but 100% paraffin wax can also be used. A higher concentration of paraffin wax results in more cracks because it is more brittle than bee wax. In this study, for the portions where only cracks were desired paraffin wax was used along with a natural resin obtained from the stem of *Pinus roxburghii* Sarg in the ratio of 60:40, and for design portion paraffin wax along with bee wax (60:40) was used, otherwise the procedure was same. This proportion may change according to the fabric construction and design requirement, etc.

Dyeing

Dye solution was prepared by adding appropriate quantity of inorganic salts or mordants (5 – 10 gm/l) to the aqueous solution of natural colourants and kept for 30 min at room temperature in order to complete the reaction to form coloured lake. This was followed by the impregnation of wax coated cotton fabrics at room temperature for 5-10 min, dried and steamed at 102 ^{0}C for 30 min in a cottage steamer.

In another method (Fig. 3) cracks were created on the dyed fabric. In this case application of aqueous

Fig. 1-3: 1—Natural dye: *Rubia Cordifolia, Acacia catechu, Terminalia chebula ;* Inorganic salts: Aluminium sulphate, copper sulphate and ferrous sulphate, 2—Natural dye: *Rubia Cordifolia, Curcuma longa, Terminalia chebula ;* Inorganic salts: Aluminium sulphate, and ferrous sulphate and 3—Ground colour: *Allium cepa* and Aluminium sulphate; Crack developed: *Terminalia chebula* and ferrous sulphate

solution of natural colourants in presence of inorganic salts or mordants was done following a pad – dry technique. For the above purpose, the impregnation of the cotton fabric in solution containing *Allium cepa* and aluminium sulphate was performed at nearly 100% wet pick up in a miniature lab model two bowl padding mangle. The impregnated fabric was dried and subsequently coated with paraffin wax. This wax coated fabric was then crushed for creating crack effects and again immersed in another solution containing *Terminalia chebula* and ferrous sulphate for 5-10 min, followed by drying and steaming as described earlier.

Wax removal

Since natural dyes are very much alkali sensitive so conventional wax removing process with detergent and sodium carbonate is not possible for this colour. In this case after completion of waxing and subsequent dyeing process wax was removed by placing the fabric in between two news papers, followed by ironing at around 100^0C temperature. All most 90% of wax was transferred to the paper and rest 10% of wax was removed by boiling with non-ionic detergent along with an emulsifying agent for 5-10 min.

Assessment of colourfastness to washing

Colour fastness to washing of dyed cotton fabric was assessed in a launder-o-meter in accordance with a method prescribed in IS: 3361-1984 (ISO-II) [15]. A 10 x 4 cm sample was cut and sandwiched between two adjacent fabrics and stitched from all the four sides. One of the two adjacent fabrics was made of the same kind of fibre as that of the dyed sample to be tested; the second piece of adjacent fabrics was made of wool. Washing was done for 45 min at 50 ± 2°C at a fabric-to-liquor ratio of 1:50 employing a non-ionic detergent (5 gm/l), washed in cold tap water and finally dried in air. The change in colour of the original dyed sample and staining on adjacent fabrics is rated between 1–5 using 5 steps grey scale (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) light fastness tester following a method prescribed in IS: 2454 -1984[16]. 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 colour fastness 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[17]. For such purpose, dyed fabric sample was placed on the instrument and was rubbed with a piece of white fabric. The white piece of fabric having similar construction as that of the dyed sample and was mounted on the tip of a finger of 900 gm weight which moved to and fro along a track length of 10 cm. The test piece was subjected to the action of such rubbing for 10 cycles in each case, where one complete to and fro movement of the finger over the track constituted one cycle. The staining on adjacent fabrics was rated between 1–5 using five steps 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

Colourfastness to light, washing and rubbing

Data for colourfastness to light, wash and rubbing of cotton fabric dyed with natural dyes in presence of aluminium sulphate, ferrous sulphate and copper sulphate are presented in Table 2. Use of inorganic salts caused a good to very good light fastness rating of the dyed cotton fabrics for all the natural dyes except *Curcuma longa* (turmeric). Turmeric is very much susceptible to light because they emit fluorescence[18] and also from the structure of curcumin, i.e. the colouring component present in turmeric[13] one can say that this dye is not able to form metal-complex with the mordants and hence shows poor light fastness properties and the samples are substantially faded within first 3-4 hrs of exposure time in MBTF light fastness tester. The wash fastness of this dye on cotton is also moderate. Moderate wash fastness rating is the consequence of 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, turmeric remains the most favoured natural colour for obtaining bright yellow shades. On the other hand for all other natural dyes used aluminium, iron and copper exhibit good light fastness rating. Aluminium, iron and copper with their good complex forming ability[18] can hold two or more suitable dye molecules together to form insoluble large complex, which enhance the light fastness of the dyed substrates[18, 20]. 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[21, 22]. 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.

From Table 2**,** it is also observed that all the natural dyes except *Curcuma longa* (turmeric) in presence of aluminium sulphate, copper sulphate and ferrous sulphate commonly produce good to excellent colourfastness to washing. Improvement in such colourfastness to washing rating may be attributed to the formation of insoluble large complex by the colouring component present in those colourants and the metal ions within the fibre. A common very good rubbing fastness property of the above natural dyes when applied on cotton fabrics indicates very little deposition of the above dye on the surface of the fibres at the end of the dyeing process.

Traditional significance and recommendations

Artisans, craftsman and ethnic communities are practicing the process of vegetable dyeing generation after generation following old traditional methods of dyeing without any proper scientific documentation. It has been noticed that many communities have shifted

Table 2—Colourfastness to light, wash and rubbing of cotton fabrics dyed with natural dyes

Natural dye	Mordant	Light fastness	Wash fastness	Rubbing fastness
Rubia cordifolia	$Al_2(SO_4)_3$	4	4	4
Laccifer lacca	$FeSO_4$	5	4	4
Laccifer lacca	$Al_2(SO_4)_3$	5	4	4
Acacia catechu	$CuSO_4$	5-6	4	4
Terminalia chebula	$FeSO_4$	5-6	4	3-4
Curcuma longa	$Al_2(SO_4)_3$	1-2	3	3-4
Allium cepa	$Al_2(SO_4)_3$	4	3-4	4
Camellia sinensis var *assamica* (Masters) Kitamura	$Al_2(SO_4)_3$	4-5	4	4
Camellia sinensis var *assamica* (Masters) Kitamura	$FeSO_4$	4-5	4	4

to other profession from their traditional profession of natural colour dyeing and as a result their knowledge has not been documented or transferred for further research and commercial interest. One of the major imperative to the use of natural dyes is the knowledge gap and also non-availability of the dyes in standardized form.

Hence, there is plenty of scope for rapid development in terms of agricultural production, processing and application technique of this colour on textile. If this technology is to be used for generating revenue, employment and for creating a strong base for renewable resources for the dye industry a comprehensive training programme is required on the traditional use of this heritage colour in a more scientific manner for creating exquisite handloom articles without compromising quality and aesthetic appeal.

A survey of indigenous flora should be made in order to determine the availability of dye yielding materials like fruits, flowers and leaves from Indian forest. Dye component separation should also be done to determine their usefulness and utility. Exhaustive chemical screening of most of the plant materials of the Indian forest particularly those which are reported to be vegetable wastes of forest should be undertaken. Some of the dye yielding plants may be tried for cultivation on marginal and wasteland of the country. If small portion of this land which is not generating any revenue can be utilized for dye containing plantations, naturally the final economics of the dyestuff would greatly improve. A scientific and high-tech procedure of extraction, purification and characterization of natural dye will certainly improve the overall quality of dyestuffs as well as the ultimate products. A greater emphasis on using natural dye in the textile industry could make a valuable contribution to environmental sustainability in the 21st century. To promote the use and production of natural dyes more young personnel should be trained in a scientific way and encourage them by providing some employment oriented scheme in rural areas.

Conclusion

In recent years the demand for natural dyed hand *batik* on cotton fabric is gaining momentum due to the fast changing fashion trend and the demand for eco-friendly hand crafted products all over the world especially in European market. Today's artists and designers constantly developing innovative areas for expression, are stimulating new approaches to textile art. Batik work with natural dye as new as they are ancient is capturing tremendous attention and being explored, updated and combined in highly imaginative ways. Most of the natural dyes are polygenetic; hence there is a tendency to use all types of metal salts for achieving variety of shades without considering their toxicity impact on the environment. So, before selecting the metal salt to be used as mordants it is essential to check their maximum permissible limit in the ultimate products for different Eco-marks. However there is no upper limit on aluminium, iron, and tin and the upper limit on copper is also fairly high (50 ppm). Hence the salts of those metals could safely be used for mordanting purpose in the *batik* process. However, there quantities should be optimized so as to minimize the pollution load.

In view of good overall colourfastness properties of handloom cotton fabric dyed with *Laccifer lacca*, *Rubia cordifolia*, *Acacia catechu*, *Terminalia chebula, Allium cepa* and *Camellia sinensis* var *assamica* (Masters) Kitamura the application method described in the present article for creating design through resist techniques (batik) can suitably be used for producing value-added environment friendly apparel and other textile products made from those fabrics. The only problem faced during the entire process is the wax removal and recycling of wax, since conventional process of removing wax with detergent and sodium carbonate is not suitable for this colour.

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