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Review on Extraction, Mordanting and Application of Natural Dyes on Jute

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Abstract

This review paper deals with types and classification of natural dyes and their chemistry of colour component and extraction method and conditions for different popular natural dyes used in Textile sector. There is also a short coverage on review on types of maordants and mordanting methods mostly used for dyeing cotton and jute textiles in particular with traditional processes of mordanting followed by natural dyeing of different cellulosic and ligno-cellulosic natural textiles like cotton and jute. Advantages and disadvantages of natural dye application are also mentioned. Along with mention of eco-safe metallic mordant, some sources of natural bio-mordants like natural alum or tannin rich natural mordanting assistants like harda or gall nut or wall nut etc, are also discussed. Some specific optimized conditions of extraction, mordanting with different types of mordanting and mordanting methods and dyeing methods and principles of fixing natural dyes on such jute or cotton textiles are discussed briefly with further references to read and understand. Recent trend of research on natural dyeing and natural finishing with bio mordant to produce fully eco-safe natural fibre based niche textiles are also reffered and briefly discussed.

Introduction

Natural dyeing is considered as a complex phenomenon than dyeing with synthetic dyes, as no natural dyes are generally substantive to Cellulose or lignocellulosic fibres like cotton and jute respectively. Again mordanting and subsequent natural dyeing of textiles is a specialized science, as it involves so much of chemistry and chemical interactions, which need to be understood well.

Nearly a lion shares of dyestuff used in common textiles are currently produced from synthetic dyes and auxiliaries compounds. Though Synthetic dyes always are not eco safe, cause chemical hazards, contribute in pollution enhancement, but easy to get in pure form as synthetic dyes and easy to standardize the process of dyeing and colour matching with standardized process of dyeing resulting much uniform dyeing at low cost even,. This means that when costs involved in synthetic dyeing of textiles have been found to be lower than natural dyeing, then question arises that why natural dyeing. Natural dyes are eco safe, bio degradable, agro -renewable and for certain applications of natural dyeing colour or shade is found to be enhanced with time giving some uncommon shades [1-6].

The answer in favour of enhancing use of natural dyes in recent time is many-fold that is the market of textile products is gradually changing towards eco concern-ness. Present Customers are more aware of environmental issues are now demanding natural products and natural dyes and even natural finishes for natural fibre based textile decorative fabrics and garments, to be, naturally sourced. If a Textile or garment or fashion company introduces a new line of clothes produced with a natural fibres/ organic fibres, the naturally sourced dye is needed to complete its green label. Natural dyes can offer not only a rich heritage of un common colour from varied natural source of plant based dyestuff, but also supports economy of small scale decentralized sector of textile dyeing by income generation of local area's farmer and dyers in volved in natural dyeing since long.

India being mainly agri-culture economy based country having mostly large nos. of decentralized sector for handloom products for textiles and also the nature provided India a huge wealth of plants sources of variety of natural colours, most of the parts of which yield their own colour and therefore more use of natural dyeing of

textiles in decentralized sector boost up rural and village economy with more employment potential and this is why natural dyeing should be promoted for this reason also besides its environment friendliness too. Natural dyeing in combined colours also need to be applied on textiles for the purpose of compound shade dyeing, standardizing of which is still lacking. The knowledge required for sourcing and extracting such colours and their exact chemistry however is often not available and hence an extensive research work is required to identify suitable plants sources of different natural dyes and to know the chemistry of their colour components and compatibility between any pair of binary mixture of such natural colours to apply on textiles for compound shades.

Growing consciousness for eco-friendly products (food/ textiles / paper has caused more interest to the consumers for using natural dyes. Production of synthetic dyes are dependent on petrochemical source and some of the synthetic dyes contain toxic / carcinogenic amines, and are not eco-friendly. Contrary to this, most of the natural dyes with few exceptions are based on vegetable/ animal origin and are renewable, biodegradable, energy-efficient and eco friendly. Natural dyes can produce uncommon and soothing shades, and in some cases the shades are enhanced with age during use. They are usually non-toxic/ non-carcinogen and non allergic (but not all natural dyes are in-toxic). However the common drawbacks of natural dyes are its difficult reproducibility, non-uniform shade, poor to moderate fastness and non-availability of standard application methods [1-6]. For producing eco-friendly natural products using natural dyes are being preferred in Japan, UK and USA market and it can fetch high price as value added products.

Definition of natural dyes

The term natural dye covers all the dyes derived from natural sources like plants, animal and minerals i.e, derived from natural resources [1-2]. Natural dyes with very few exceptions are non-substantive but must be used in consumption with mordants. A mordant [4-6], usually a metallic salt, has an affinity for both the colouring matter and the fibre and combining with the dye in the fibre it forms an insoluble precipitate or lake. Application wise, natural dyes include some vat dyes, a few solvent dyes, some pigments, some direct and acid dyes. Only one natural basic dye is known but natural sulphur, disperse, azoic or ingrain dyes are still not available so far.

Classification and properties of natural dyes

Natural dyes can be classified [1,3,11] in a number of ways. The earliest classification was according to alphabetical order or according to botanical names. Later, it was classified in various ways, e.g. on the basis of hue, chemical constitution, application class etc.

In "treatise on permanent colours" by Bancroft, published about 160 years ago, natural dyes were classified into two groups:

(i) Substantive Dyes: The dyes such as Indigo, turmeric etc. which dye the fibers directly are classified as substantive dyes.

(ii) Adjective Dyes: Dyes such as logwood, madder etc. which dye material mordanted with a metallic salt.

Humme [1-2] classified the Natural colouring matter as follows:

(i) Monogenetic Dyes: They produce only one colour irrespective of the mordant present on the fibre or applied along with the dye.

(ii) Polygenetic Dyes: The colours produced by them vary with the mordant applied, e.g., Alizarin.

In the colour index the natural dyes are classified according to the hue. The number of dyes in each hue are given in Table 1.

On the basis of origin, natural dyes are broadly classified into three categories:

(i) Vegetable Origin: The colouring matter is derived from root, leaf, bark, trunk or fruit of plants. It is believed that there are at least 500 plants from which colouring matter can be extracted. Some of the natural dyestuffs of vegetable origin are shown in Table 2.

(ii) Mineral Origin: These colourants derive their name from the natural source which was at one time used to produce these colourants. Later, the so-called mineral colours were produced from purified inorganic compounds. Some of the important mineral colourants were chrome-yellow, iron-buff, narkin-yellow, Prussian-blue and manganese brown. They are now of historical importance with the exception of mineral khaki. This class of colourants is applied by impregnating the fabric with soluble metal salts, just like mordanting process, followed by reaction to produce insoluble salts or hydroxides, *in situ.* Many mineral colourants make the fabric rough and have been found to be poisonous and hence their use has been discontinued.

(iii) Animal Origin: Lac, cochineal and kermes have been the principal natural dye yielding from the insects.

On the basis of hues1, natural dyes can be classified as:

(i) Red colour dyes: Unlike the wide abundance of yellow colour in nature, most red dyes are hidden in roots or barks of plants or camouflaged in the bodies of dull grey insects. Although these sources are limited, they occur in large groups in a single plant. They are almost invariably based on anthraquinone and its derivatives. These dyes are stable to light and wash.

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(ii) Yellow colour dyes: Yellow is the liveliest and perhaps the most abundant of all hues in nature. About 90% of the yellow dyes are flavenoids. Generally, they give pale shade, so the fading is quicker. Exception is turmeric, which produce dull deep shade but considered to be susceptible to light as they emit fluorescence. Wash fastness of yellow dyes range from fair to excellent, e.g. tesu, turmeric, kapila.

(iii) Blue colour dyes: Examples are indigo and woad. These dyes give excellent fastness to light and washing.

(iv) Black colour dyes: Black shades are generally obtained from plant sources which are rich in tannins. Tannin due to its chemical nature has appreciable substantivity towards cellulosic and protein fibre thus imparting good overall fastness properties. Examples – logwood, harda, custard apple.

Natural dyes can also be classified on the basis of their chemical constitution [1-6].

(i) Indigoid dyes: Indigo and tyrian purple are the most common examples of this class. Another blue dye, woad also possesses indigo as the main dyeing component.

(ii) Anthraquinone dyes: Almost all the red natural dyes are based on the anthraquinoid structure having both plant and mineral origin. Madder, lacs, kermes, cochineal are some of the dyes possessing this type of structure. These are generally mordant dyes.

(iii) Alphanaphthoquinones: Typical example of this class is lawsome (henna), cultivated mainly in India and Egypt. Another similar dye is juglone, obtained from the shells of unripe walnuts. These dyes are generally disperse dyes and give shades of orange.

(iv) Fluvonoids: Flavonoids, which yield yellow dyes can be classified under flavones, isoflavones, aurones and chalcones. Flavones are color less organic compounds. Most of the natural yellows are derivatives of hydroxyl and methoxy substituted flavones and isoflavones. Common example is weld (containing luteolin pigment) giving brilliant and fast colours on both wool and silk.

(v) Di-hydropyrans: Closely related in chemical structure to the flavones are substituted di- hydropyrans, *viz.* haematin and its leuco form, haematoxylin. These are important natural dyes for dark shades on silk, wool and cotton. Logwood, brazil wood and Sappan-wood are the common example.

(vi) Anthocyanidins: The naturally occurring member of this class includes carajurin, a direct orange dye for wool and cotton. It is obtained from the leaves of Bignonia chica.

(vii) Carotenoids: The class name carotene is derived from the orange pigment found in carrots. In these, the colour is due to the presence of long conjugated double bonds. The prominent.

Classifying natural dyes on the basis of the method of application [1-6].

(i) Mordant dyes: These are dyestuffs which require a mordant in their application as they have no affinity for the fiber being dyed. A mordant dye should have electron denating groups capable of forming a complex with the transition metal salt, e.g., madder, fustic, Persian, berries, kermes, cochineal etc.

(ii) Vat dyes: These are water insoluble dyes which are first converted to their water soluble form (reducing with Na-hydrosulphite and then solubilising it with alkali) and then applied to the fibres. The true colour is produced only on treatment with a hot soap solution. The soaping treatment completes the oxidation process, e.g., Indigo.

(iii) Direct dyes: Direct dyes are those dyes that have tremendous affinity for the cellulosic fibres. They are dyed from a boiling dye bath. Turmeric, Harda, pomegranate rind *etc.* are a few of the direct natural dyes.

(iv) Acid dyes: These dyes are applied from an acidic medium. The dye molecules have either sulphonic or carboxylic group (s) which can form an electrovalent bond with amino groups of wool and silk. An after treatment with tanic acid and tartaremitic, known as back tanning improves the fastness of these type of dyes, e.g., Saffron.

(v) Disperse dyes: A disperse dye has a relatively low molecular mass, low solubility and no strong solubilizing groups. These dyes have hydroxyl and/or amino groups which impart same solubility to the dye molecule. Disperse dyes can be applied on to hydrophobic synthetic fibre from neutral to mildly acidic pH. They can also be applied to silk and wool. These dyes can be post-mordanted with chromium, copper and tin salts, e.g., Lawsone and many other flavone and anthroquinone dyes.

(vi) Basic dyes: Basic or cationic dyes on ionization give coloured cations and form an electrovalent bond with the –COOH group of wool and silk. These dyes are applied from neutral to mildly acidic pH. These dyes have poor light fastness, *e.g.,* Berberine (Tables 1-4).

Scientific research has evidenced a wealth of extraordinary properties on behalf of dyestuff producing from plants, making them available for use in new and differentiated production fields particularly for textile , which can provide farmers a valuable economic resource [1,2,4,9-15]. Production of synthetic dyes is dependent on petrochemical source and some of the synthetic dyes contain toxic / carcinogenic amines and are not eco-friendly. Contrary to this, most of the natural dyes (with few exceptions) are usually based on vegetable/ animal/ mineral origin, renewable, biodegradable, and ecofriendly. Most of them are usually non-toxic/ non-carcinogen and non-allergic. However, the practical drawbacks of natural dyes are its non-reproducibility, non-uniform shades, poor to moderate colour fastness (not in all cases)

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and non-availability of standard application methods [1-6].

Natural dyed products have a special niche market particularly in export market as eco-friendly products and hence are its importance. Many small scale export textile houses for cotton, silk and woolen textiles are regularly using natural dyes for manufacturing their speciality eco-friendly textile products. For exportable decorative jute furnishings, convertible jute diversified decorative products, use of natural dyes is recently gaining high impetus for creating newer strata of market potential in niche market for value added eco-friendly jute products after dyeing with natural dyes [7-8]. Similarly natural dyes are equally important for dyeing niche products of cotton textiles dyed with natural dyes [9-15]. Natural dyes are also used for food, paint. leather, cosmetic and paper (hand made paper and hence the importance of natural dyes are immense (Table 5).

Table 1: Table showing the number of natural dyes in each hue as per the colour index[1,12].

CI Natural	No. of Dyes	Percent
Yellow	28	30.4
Orange	6	6.5
Red	32	34.8
Blue	3	3.3
Green	5	5.5
Brown	12	13
Black	6	6.5

Table 2: Table showing some common natural dyestuffs obtained from different vegetable origin.

Part of the Plants	Dyestuffs
Root	Turmeric, Madder, Onions, Beet-root
Bark/ Branches	Purple bark, Sappan wood, Shillicorai, Khair, Red, Sandalwood
Leaf	Indigo, Henna, Eucalyptus, Tea, Cardamon, Coral Jasmine, Lemon Grass
Flowers (Petals)	Marigold, Dahlia, Tesu, Kusum
Fruits/Seeds	Latkan, Pomegranaterind, Beetle nut, Myrobolan

Table 3: Chemical nature of colour components of natural dyes and their colouring principles.

Colouring principle	Natural occurrence		
	Yellow /Orange/ Brown Dyes		
Flavonoids		**Aurones**	
Flavones		Sulfuretol	Dahlia, Palas
Chrysol	Wood of pines	Leptosidol	Coreopis
Luteolol	Guade, dalia	**Carotenoids**	
Luteolin	Weld	Crocin	Saffron, Harshingar
Fustic	Jackfruit	Bixin	Annato
Flavonols		**Diaroyl Methane**	
Galangeol	Pine wood	Curcumin	Turmeric
Kaempferol	Gaude, mariegold, tea	**Alkaloids**	
Quecetrol	Sunflower, Chrysanthemum	Berberine	Bayberry or Barberry
Fisetol	Fustic	**Quinones**	
Rhamnetol	Nerpruns	**Napthoquinone**	
Gossypetol	Cotton , Chrysanthemum	Lawsone	Henna
Myricetol	Myrica rubra, nagi	Juglone	Walnut Shells
Isoflavones		Lapachol	Taigu wood
Daidzeol	White rose	**Anthraquinione**	
Genisteol	Ajonc, trefles	Chrysophanol	Rhubarb
Angolensol	Sandal, barwood	Emodin	Rhubarb, Purging Backthorn

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Chalcones		Rhein	Cassis, Rhubarb
Buteol	Palas, Dahalias		
Coreopsidoside	Coreopsis, Butea frondosa		
Mareoside	Dahlia		
Rottlerol	Kamala		
For Red Dyes		**For Blue Dyes**	
Flavonoids			
Liquiritigenol	Sandal wood	Indigoid	Indigo
Emodin	Al root	Dihydropyran	Logwood
Rhein	Al root		
Purpurin	Manjistha	For Black Dyes	
Purpuroxanthin	Manjistha		
Alizarin	Manjistha, Chay Root	Anthraquinone	Limawood
Pseudopurpurin	Manjistha	Tannins	Cochineal
Benzoquinione		Dihydropyran	Pomegranate
Carthamin	Safflower		

Table 4: Comparison of natural dyes Vs Synthetic dyes.

Natural Dyes	Synthetic Dyes
Use of renewable resources	Consumption of non-renewable resources such as oil and by-products
Lack of toxicity during production and reduction of work hazard	Work hazard during production
Full biodegradation and reduction of the environmental impact	High environmental impact during production and waste disposal
Lack of toxicity of the end products	Danger of allergies (dermatitis by contact) for the consumers

Table 5.

Application and Production fields of Natural dyes

The main field of application is represented by the green textile industry and the eco-fashion trade where natural dyes are employed to dyeing natural fibres such as jute, cotton, wool, silk, linen, hemp and nettle etc .

Besides Application of Natural dyes in Textiles, Further fields of use are:

- Foods
- Papers
- Paints and varnishes of natural origin to be used in the eco-building industry;
- Paints and pigments for artists and restorers willing to employ original materials and techniques;
- Dyeing of vegetable tanned leather;
- Natural cosmetics industry.

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Advantages and Disadvantages of Natural Dyes

In the recent years, there has been a trend to revive the art of natural dyeing. This is mainly because in some aspects natural colourants are advantageous against synthetic dyes. Some of these advantages are listed below:

Advantages of natural dyes

i. The naturally dyed shades are soft, lustrous and soothing to the human eye.

ii. They produce a wide range of colours [9-15]. A small variation in the dyeing technique or the use of different mordants with the same dye can create totally new colours, which are not possible with synthetic dyestuffs.

iii. Natural dyestuffs produce rare colour ideas and are automatically harmonizing.

iv. Unlike the non-renewable which forms the basic raw materials for synthetic dyes, the

vegetable based natural dyes are replaceable and at the same time biodegradable [1,2].

a. In some cases like harda, indigo *etc.,* the waste in the process becomes an ideal fertilizer for use in agricultural fields.

b. Many plants thrive on waste lands [1-4]. Thus, wasteland utilization is an added merit of the natural dyes. Dyes like madder grow as host in tea gardens. So there is no additional cost or effort required to grow it.

c. This is a labour intensive industry, thereby providing job opportunities for all those engaged in cultivation, extraction and application of these dyes.

d. It can increase the textile exports and thus help India in earning foreign exchange.

e. Most of the constituents including colouring component of natural dyes are anti-allergens, hence

f. It is safe for skin contact and are mostly non-hazardous to health [1-6].

g. Some of the natural dyes are enhanced with age, while synthetic dyes fade with time.

h. There are few metallic mordants objectionalble for chemical toxic hazards like Chromium or copper etc, and hence these metallic maordants are avoided and eco safe mordants are used only. Newer bio mordant /green mordants are identified recently to avoid such metallic mordants [9-15].

i. Natural dyes bleed but do not stain other fabrics, turmeric being an exception.

j. They are moth proof and can replace synthetic dyes in food-stuffs for safety.

k. Despite the above said advantages of natural dyes, they carry some inherent disadvantages [1,2,4,9-15], which were responsible for the decline of this art of natural dyeing and hence immense research are necessary either to partally eliminate or to completely to do away with these disadvantages.

Disadvantages of Natural Dyes

i. It is difficult to standardize a recipe for the use of natural dyes. There is complete uncertainty of results which vary from time to time, place to place and also from one crop to another.

ii. The process requires skilled craftsmanship and is expensive. Use of expensive mordants and low colour yield thus necessitates the use of more dyestuffs and larger dyeing time, sharply increase most of the overall process.

iii. Poor scientific back up of a large part of this branch of science is still being explored.

iv. Lack of availability of precise technical knowledge on extraction and dyeing techniques.

v. The dyed fabric may change colour when exposed to the sun, sweet and air. This cannot be changed as the exact chemicals present in any part at any particular time are not yet fully known.

vi. Nearly all-natural dyes with a few exceptions require the use of mordants to fix them on to the fabric substrate. While dyeing, a substantial portion of the mordant remains unexhausted in the residual dye bath and may pose serious effluent disposal problem.

vii. With a few exceptions, most of the natural dyes are fugitive even when applied in

viii. conjunction with a mordant. Therefore, their fastness performances are generally not adequate for modern textile usage.

Types of Mordants

Different types of mordants yield different colours even for the same natural dye [16]. Therefore, final colour, their brilliance and colour fastness properties are not only depend on the dye itself but are also determined by varying concentration and skillful manipulation of the mordants including bio -mordants or green mordants /dual mordants etc [16]. Thus, a mordant is more important than the dye itself. Mordants can be classified into the following categories [1-4, 16].

Metallic mordants:

Common examples are metal salts of aluminium, chromium, iron, copper and tin. The metallic mordants are of two types.

Brightening mordants

[i] **Alum:** It is a cheap, easily available and safe to use mordant. It usually produces pale versions of the prevailing dye colour in the plant.

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[ii] **Chrome(potassium dichromate):** It is also referred to as red chromate. It is relatively more expensive. However, Cr^{3+} or Cr^{6+} is considered to be harmful for human skin as objectionable heavy metal beyond a certain limit of its presence. Its use has been limited as per the norms of the eco-standards. The dichromate solution is light sensitive and therefore it changes colour under light exposure.

[iii] **Tin (stannous chloride)**: It gives brighter colours than any other mordant. However, they are oxidized on exposure to air and may impart a stiff hand to the fabric. Stannous chloride also causes higher loss of fabric tenacity if applied beyond a certain concentrations.

Dulling Mordants:

[i] Copper (cupric sulphate): Known as blue vitriol, it is readily soluble in water and easy to apply. It gives some special effects in shades, which other wise cannot be obtained. However, copper beyond a certain limit is also under the eco-standard norms as objectionable heavy metals.

[ii] Iron (ferrous sulphate): It is also known as green vitriol and is readily soluble in water. It is used for darkening /browning and blackening of the colours/ shades. It is easily available and one of the oldest mordants known. It is extensively used to get grey to black shades.

Tannins - The term 'tanning agent' was given initially[3] to those water-soluble cellulosic materials that predicated gelatin from solution. But all gelatin precipitation did not identified as tanning agent. Tannins are polyphenolic compounds having capacity of gelling under certain conditions. (a) It may be hydroysable pyrogallol tannins exemplified by 'tannic acid', by Chinese or Turkish gallotannins (galls) and by Sicilain and Stagshorn sumac, (b) hydroysable ellagitannins that give ellagic acid or similar acids on hydrolysis, exemplified by valonea, chestnut, and (c) condensed or catechol tannins that contain little or no carbohydrates and are converted to acids to insoluble amorphous polymers. Among the tannins, myrobalan (harda) and galls/ sumach are most important.

Oils or oil type mordants- Vegetable oils or Turkey Red oil (TRO) are such type of mordants. TRO as mordant is mainly used in the dyeing of deep red colour from madder. The main function of the TRO as oil mordant is to form a complex with alum when used as a main mordant. Sulphonated oils posses better binding-capacity than the natural oils. Oil mordanted samples exhibit superior fastness and hue.

Principle of Natural Dyeing:

Most of the natural dyes have no substantivity on cellulose or other textile fibres without the use of a mordant compound. The majority of natural dyes need a mordanting chemical (preferably metal salt or suitably co-ordinating complex forming agents) to create an affinity between the fibre and the dye or the pigment molecules of natural dyes. These metallic salts as mordant form metal complexes with the fibres and the dyes. After mordanting metallic salts on the fibres, the metal salts anchoring to the fibres, attracts the dye/organic pigment molecules to be anchored to the fibres and finaaly creates the bridging link between the dye molecules and the fibre by forming co-ordinating complexes in cotton and jute textiles [16-20].

Aluminium sulphate or other metallic mordants anchored to any fibre, chemically combine with certain mordantable functional groups present in the natural dyes and bound by co-ordinated/ covelent bonds or hydrogen bonds and other interactional forces as shown below: Figure 1. Thus, for proper fixation of natural dyes on any textile fibre, mordanting is essential in most of the cases. The said mordanting can be accomplished either before dyeing (Pre-Mordanting), or during dyeing (Simultaneous Mordanting) or after dyeing (Post-Mordanting). Unlike cotton, jute has some extent of affinity for some of the natural dyes, due to presence of a little extent of free carboxylic acid group in jute. So, mordanting is essential in cotton for creating affinity for natural dyes, which may be sometimes optional for jute in some cases. However, mordanting (pre, simultaneous or post) usually deepens surface colour strength and also strengthens colour fastness properties, in case of pre-or simultaneous mordanting. While, post-mordanting also may improve colour fastness, but may change the tone of colour [16].

Extraction of dye liquor from different natural dyes

The natural dyes sourced from either flowers, stem or wood, roots, bark, animals or minerals need to be extracted in any fluid medium so that it can be applied suitably on textiles. Natural dyes of different origin has to be extracted using aqueous media with or without addition of acid/ alkali/ alcohol or using supercritical fluid extraction or alcoholic /organic solvent and finally need to be to filtered, evaporate and to dry. Now a days, there has been commercially viable industrial methods available for extracting colour components/ purified colour substances from natural dyes for their ready and easy applications on textiles

As per few research reports [5-8,16-21] of IJT/DJFT, the optimised conditions of aqueous extraction of few selective natural dyes applicable for jute are as follows: MLR-1:20 at 80ºC for 90 mins for extraction of Red sandal wood in aqueous medium

- MLR-1:10 at 100ºC for 30 mins for extraction of Jack fruit wood in aqueous medium
- MLR-1:20 at 80ºC for 45 mins for extraction of mariegold in aqueous medium
- MLR-1:20 at 90ºC for 45 mins for extraction of manjistha in aqueous medium
- MLR-1:20 at 100ºC for 120 mins for extraction of babool bark in aqueous medium
- MLR-1:20 at 100ºC for 120 mins for extraction of sappan (Red) wood in aqueous medium

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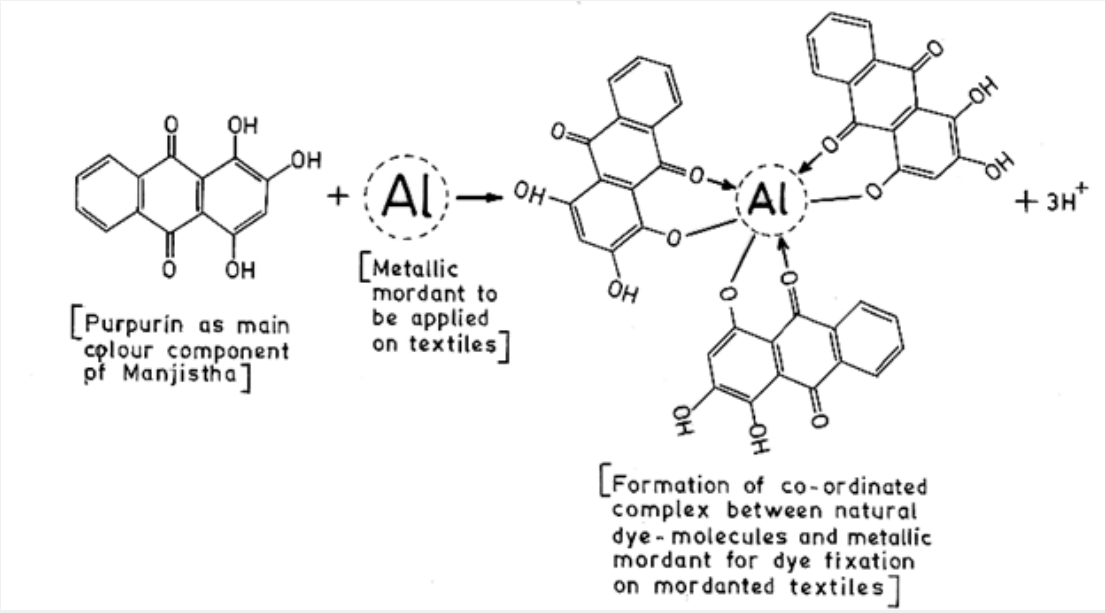

Figure 1: Mechanism of fixation of natural dyes through mordants.

Mordanting methods

For fixation of natural dyes, mordanting is essential in most of the cases. Among different techniques of mordanting, pre-mordanting has been found to be disadvantageous for jute fabrics. Moreover instead of single moradanting, a selective double mordanting has been found to give better dyeability and dyeing performances in jute fabrics. It is reported that either single mordanting with 20 % Al_2SO_4 or preferably double pre-mordanting using 20 % harda(myrobolan) as first mordant followed by 20% Al_2SO_4 or 20 % $FeSO_4$ as second mordant on 3% H_2O_2 bleached jute fabric renders maximum colour yield for red sandal wood, jackfruit wood and their compatible mixtures with other natural dyes.

The methods of such doucble mordanting of jute fabric is as follows:

Myrobolan (Harda) powder (as natural mordanting assistants) need to be presoaked (12 hrs) to obtain aqueous myrobolan gel, which is to be diluted to a desired concn. (20% w/w) and finally is to be filtered before application on bleached jute fabrics by exhaust method using MLR- 1:20, temperature- 80ºC and time - 30 minutes, before final drying in air without washing, to make it ready for either second mordanting and /or dyeing with natural dyes. For further chemical mordanting, the unmordanted or 1st mordanted jute fabrics fabric is to be further treated with aqueous solution of 20% (w/w) selective chemical mordant (20% Al_2SO_4 or 20 % $FeSO_4$) by exhaust method using MLR- 1:20, temperature- 80 ˚C and time - 30 minutes, before final drying in air without washing, to make it ready for subsequent dyeing with natural dyes.

Method of dyeing with natural dyes

Exhaust method of dyeing jute or cotton fabric are almost similar to that applicable for dyeing the same with synthetic dyes. However, it only differs in three ways i. e. (i) necessitating additional process of mordanting, (ii) necessitating additional process of extraction of dye liquor from natural dye sources and (iii) shade application % for natural dyes are expressed on the basis of percentages of solid and dry dye-source material of natural dyes taken for extraction and /or dyeing. As per few research reports [7,8,11,12,16-20] of IJT /DJFT,CU the optimized conditions for exhaust process of dyeing with selectve natural dyes on suitably/ selectively double pre-mordanted bleached jute fabric using above mentioned extracts of natural dyes are as follows: (Table 6).

In each case, after the dyeing is over, the dyed samples are to be repeatedly washed with hot and cold water and then to be dried in air. Finally, the dyed samples are to be subjected to soaping with 2gpl soap solution at 60 °C for 15 min, followed by repeated water wash and drying under sun. However, recently not only bio-dyeing /natural dyeing is important, natural finishing is also equally being taken care for fully -eco textiles productions for functional finishing like uv resistant finish, antimicrobial finish etc and thus bio mordanting, bio -dyeing and bio finishing are now important areas of current research [9-12, 16, 21]. So, there is an ample research gap on use of different bio mordant or tannin rich mordant along with or without natural metallic mordant with different natural dyes/finishes having potential of fully eco safe dyeing and finishing of textiles with or without post-dyeing after -treatments with natural cationic agents (like chitosan) and natural UV absorbers for improving to acceptable grade (4 or

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more) for both wash fastness and light fastness of such natural dyed and finished natural fibre based textiles. The another aspects in present research on natural dyeing is test of compataibility before producing compound shade for colour matching are now being attracting enhanced interest of researchers.

Table 6.

Name of Natural Dyes	Dyeing Conditions					
	Temp, °C	Time, mins	MLR	pH	Salt, g/l	Sodium carbonate g/l
Red sandal wood	80	60	1:20	4.5-10	10	As required
Jack fruit wood	100	60	1:20	11	10	---
Manjistha	100	60	1:50	4.5	10	---
Mariegold	100	60	1:50	3	10	---
Babool	100	60	1:50	4.5	10	---
Sappan wood	100	60	1:50	4.5	10	---

Concluding Remarks

Since most of natural dyes have low fastness to light and washing, one may surmise that they have a dismal future. But similar is the case with some synthetic dyes like rhodamine and phthalocyanine dyes, which have very bright magenta and turquoise shades respectively, but very poor washing fastness, yet they are much used. Similarly, natural dyes can find much use in spite of poor fastness, especially if innovative methods of improving their fastness are developed. For example, faded blue jeans dyed with indigo are a craze in casual wear due to poor rubbing fastness. Moreover, main drawback of natural dyes are poor light and washing fastness, which may be overcome in future by research on optimization of their dyeing conditions and mordanting processes, using new mordants and dyeing auxiliaries as well as by identifying suitable after-treatments with eco-friendly agents. Above all, with the ever-growing eco-consciousness the natural dyes, being eco-friendly, can be harnessed to play a bigger role in dyeing of eco-friendly textiles particularly from natural fibers.

Materials For Further Reading

Websites and other important sources of information about natural dyes

The following sources given in the tabular form can be major sources of information on natural dyes: (Table 7).

Table 7.

A. US Companies (selling natural dyes through Internet)		B	Indian companies (selling natural dyes)
1	Jane's Fiber Works http://greene.xtn.net/-fibre/dyes.html	1.	Alps Industry http://www.alpind.com
2	The Mannings Catalog http://.the-mannings.com		
3	Carol Leigh's Hillcreek Fiber Studio http://www.hillcreek.com	2.	AMA herbal lab Pvt.Ltd. http://www.amaherbal.com
4	Louet Sales http://www.cybertap.com		
5	Mawia Handprints http://www.maiwa.com	3.	KMA Exports http://www.indiamart.com/Kmaexports
6	La Lana Wools http://www.taaosfiber.com		
7	Misty Mountain Farm http://www.mistymountainfarm.com	4.	NCC Agro Industries http://www.indiamart.com/nccagroindustries
8	The Spinnery http://thespinnery.com		
9	Alexander Textiles http://www.alextex.com	5.	KSG Enterprises http://www.indiamart.com/ksgenterprises

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7. HD Sinnur, AK Samanta, DK Verma and Runali Kaware (2017) Standardization of Mordant and Dyeing Process Variables for Dyeing of Cotton Khadi Fabric with Indian Madder as Natural dyes. Indian J of Natural Fibres 4(1): 21-38.

8. HD Sinnur, Ashis Kumar Samanta and DK Verma (2018) Use of Metallic Fe (Iron) Mordant with or without Harda for Dyeing of Cotton Khadi Fabric with Natural dyes: Madder and Red-sandal wood, Pomegranate Rind and Babul. Indian Journal of Natural Fibres 4(2): 43–62.

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12. AK Samanta, A Hossain, N S Bhaumik, P S Vankar and Dhara Shukla (2018) Organic Colouration and antimicrobial finishing of organic cotton fabric by exploiting distillated organic extraction of organic Tectona Grandis and Azardiracchta indica with Organic Mordanting Compare to Conventional Inorganic Mordants. International Journal of Textile Science and Engieering.

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