

A Review Paper on Natural Dye

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Abstract

Natural dyes are most eco-friendly option for dyeing as they are non-toxic, biodegradable and derived from renewable sources like plants, minerals, and insects. These natural dyes are hypoallergenic and contain medicinal properties and provides antimicrobial, antifungal and antioxidant benefits to skin. These dyes produce very soft and stable colour, using this dyes can reduce water pollution. In this review paper extraction process, history of dyes and they tests are given.

1. Introduction

Textile materials (natural and synthetic) used to be coloured for value addition, look and desire of the customers. Anciently, this purpose of colouring textile was initiated using colours of natural source, until synthetic colours/dyes were invented and commercialized. For ready availability of pure synthetic dyes of different types/classes and its cost advantages, most of textile dyers/ manufacturers shifted towards use of synthetic colourant. Almost all the synthetic colourants being synthesized from petrochemical sources through hazardous chemical processes pose threat towards its eco-friendliness.

Natural dyes are known for their use in colouring of food substrate, leather as well as natural fibres like wool, silk and cotton as major areas of application since pre-historic times. Although this ancient art of dyeing textiles with natural dyes withstood the ravages of time. Therefore to obtain newer shade with acceptable colour fastness behaviour and reproducible colour yield, appropriate scientific dyeing techniques/procedures are to be derived. Thus, relevant scientific studies and its output on standardization of dyeing methods, dyeing process variables, dyeing kinetics and test of compatibility of selective natural dyes have become very important, however the information on which is insufficient.

2. Natural Dyes

The word 'natural dye' covers all the dyes derived from the natural sources like plants, animal and minerals. Natural dyes are mostly non-substantive and must be applied on textiles by the help of mordants, usually a metallic salt, having an affinity for both the colouring matter and the fibre. Different modaratable groups are used for fixation of such dye. These metallic mordants after combining with dye in the fibre, it forms an insoluble precipitate or lake and thus both the dye and mordant get fixed to become wash fast to a reasonable level.

3. Classification of Natural Dyes

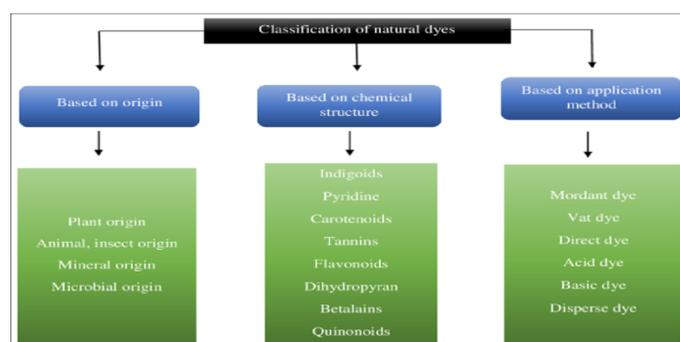


Figure 1: Classification of Natural Dyes

Natural dyes can be classified (Gulrajani & Gupta, 1992) in a number of ways. The earliest classification was according to alphabetical order or according to the botanical names. Later, it was classified in various ways, e.g. on the basis of hue, chemical constitution, application class etc.[1]

4. Dye Extraction Process

Extraction of colour component from source natural dye material is important step for dyeing any textile substrate to maximize the colour yield. Moreover, standardization of extraction process and optimizing the extraction variables both, for a particular source natural dye material have technical and commercial importance on colour yield and cost of extraction process as well as dyeing cost. The natural dyes can be taken from various vegetable sources like flowers, stem or wood, roots, bark, etc. Natural dyes of different origin can be extracted using aqueous method

i.e. by using water. The collected source material is generally shadow dried in air or sun dried within a temperature range of 37-40°C for the moisture content of the source natural dye material is reduced to 10-15% with proper drying since most of the material have moisture content of 40-80% and cannot be stored without drying. After drying, grinding is carried out to break down the material into very small units or preferably powder form. Extraction refers to separating the desired colour component by physical or chemical means with the aid of a solvent. Optimum conditions of extraction variables are determined through extracting the natural colour component from source material by varying extraction parameters of liquor and measuring the optical density of corresponding coloured liquor by using spectrophotometer.

5. Application of Dyes

Natural dyes are colorants obtained from plants, animals, or minerals. They are widely used because they are eco-friendly and biodegradable. Textile Industry: Dyeing of cotton, silk, wool, and linen. Food Industry: Used as natural food. Cosmetics and Personal Care: Used in herbal cosmetics, soaps, shampoos, and hair dyes. Medicines and Ayurveda: Some natural dyes have antibacterial and medicinal properties. Art and Craft: Used in painting, rangoli, printing, and handicrafts. Leather Industry: Used for coloring leather products in an eco-friendly way. Ink and Paper Industry: Used in eco-friendly inks and for coloring paper. Environmental Benefits: Safe, non-toxic, and reduce environmental pollution.

6. Characterization of Dyes

For characterization, purified dye powder is to be taken for preparation of 1% aqueous dye solution separately and is subjected to wavelength scan in a micro processor or computer attached UV-Vis absorbance spectrophotometer for 190-1100 nm range. Further, individual purified natural dye powder is washed once again in distilled water and in 100% acetone in sequence before final drying and may be subjected to FTIR Spectroscopy study in double beam FTIR spectrophotometer using KBr disc technique for characterization of its chemical nature and functional group present in the natural dyes.

6.1 UV-Visible Spectroscopic

UV-Visible spectroscopic studies are carried out by different scientists (Erica et al, 1995) to identify the UV-Vis spectral scan of a number of natural dyes viz, madder, cochineal, indigo, etc., using different solvents for extraction[2]. Neem bark (Mathur et al, 2003) colourant shows two absorption maxima at 275 and 374 nm while beet sugar shows three absorption bands at 220, 280 and 530 nm as per recent study (Mathur et al, 2001)[3,4]. The visible spectra of ratanjot (Gulrajani et al, 1999) at acidic pH showed maximum absorption around 520-525 nm, but under alkaline pH there is a shift to 570 nm and another peak at 610-615 nm and red sandal wood shows a strong absorption peak at 288 nm, the maximum absorption at 504 and 474 nm at pH 10 in methanol solution (Gulrajani et al, 2003). Gomphrena globosa (Sankar & Vankar, 2005) flower colourant shows one major peak at 533 nm[5,6,7]

6.2 Chromatographic analysis

Thin layer chromatography (TLC) is used by many workers to identify natural dyes in textiles (Kharbade et al, 1985)[8]. Dyes detected are insect dyes and vegetable dyes viz., yellow, red and blue colours. The natural scale insect, madder and indigoid dyes are also analysed by HPLC (Koren, 1994)[9]. The quantitative and qualitative analysis of red dyes such as alizarin, purpurin, carminic acid etc. by HPLC are also investigated/analysed (Balankina et al, 2006)[10]. Detection of annatto dyestuff, norbixin and bixin is reported by means of derivative spectroscopy and high performance liquid chromatography (HPLC) (Bhattacharya, 1999).[11]

6.3 Test of toxicity, biotechnological processing and environmental impact of natural dyes

Toxicity is the ability of a substance to cause damage to living tissue, impairment of nervous system or severe illness when ingested, inhaled or being absorbed by skin. The toxicity (Zippel, 2004; Joshi & Purwar, 2004) data provide evidence about the adverse effect of natural dyes to human body.[12-13]

7. Need of Mordant

Different types of mordants yield different colours even for the same natural dye. Therefore, final colour, their brilliance and colour fastness properties are not only dependant on the dye itself but are also determined by varying concentration and skillful manipulation of the mordants. A mordant is more important than the dye itself. Moreover, the ideal mordant for bulk use should produce appreciable colour yield in practicable dyeing conditions at low cost, without seriously affecting physical properties of fibre or fastness properties of the dyes. Also, It should not cause any noxious effect during processing and the dyed textile material should not have any carcinogenic effect during use. Mordants can be classified into the following categories: a) Metallic mordants : The metallic mordants are of two types: i) Brightening mordants (Alum, Chrome(potassium dichromate), Tin(stannous chloride), ii) Dulling mordants : Copper (cupric sulphate), Iron (ferrous sulphate) b) Tannins c) Oils type mordants

8. Mordanting Methods

Mordanting can be achieved by pre-mordanting (before dyeing), simultaneously mordanting and dyeing or it may be a post mordanting system (after dyeing). Different types of mordants can be applied on the textile to increase the dye uptake of natural dyes. Extensive work has been reported (Paliwal, 2001; Jahan P & S, 2000; Sengupta, 2001; Prabu & Premraj, 2001; Sunita & Mahale, 2002; Moses, 2002; Rani & Singh, 2002; Bain et al, 2002; Paul et al, 2002) for dyeing of textiles with natural dyes adopting specific mordanting system for a particular textile material[14-22]. There is study (Dayal et al, 2006) for effect of copper sulphate and potassium dichromate on silk, wool and cotton fibre and reported their effects on colour fastness properties. The wool treated with metal ions such as Al(III), Cr (VI), Cu (II), Fe (II), Sn (II) and rare earths such as La (III), Sm (III) are used for beet sugar colourant, it can withstand the requirement of BIS fastness standard.[23]

9. Methods of Natural Dyeing

i. Most of the natural dyes have no substantively on cellulose or other textile fibres without the use of a mordant. Conventional methods of natural dyeing: Dyeing can be carried out in an alkaline bath, acidic bath or in a neutral bath. There are various reports available on different methods of mordanting on different fibres such as cellulosic, protein and synthetic for dyeing with different natural dyes. Dyeing of

cotton and silk with babool, tesu, manjistha, heena, indigo, mariegold etc is reported (Gulrajani et al, 1992; Saxena et al, 2001; Vankar et al, 2001; Nanda et al 2001; Patel & Agarwal, 2001). Various kinds of shades like black to brown, green to yellow to orange, etc can be obtained by application of different mordants.[24-28]

ii. Non-conventional dyeing methods: Nanotechnology is increasingly attracting worldwide attention because it is widely perceived as offering huge potential in a wide range of end uses. The unique and new properties of nanomaterial's have attracted not only scientists and researchers but also businesses, due to their huge economical potential. One possible application is to directly employ pigment nanoparticles in textile coloration. The use of scCO₂ as a fluid medium for coloration of textile fibres, especially polyester, has been examined. This technology has become so promising that it has provided new opportunities to develop suitable dyes for this medium. The coloration is conducted in a stainless steel high pressure apparatus. Process and equipment are developed for textile dyeing in supercritical carbon dioxide (Kraan, 2007)[29]. A technical-scale, 100-L dyeing machine is designed and built for polyester beam dyeing in scCO₂ at 300 bar.

10. Properties of Dyes

10.1 Color Fastness

Colour fastness is the resistance of a material to change in any of its colour characteristics or extent of transfer of its colourants to adjacent white materials in touch or both for different environmental and use conditions or treatments like washing, dry cleaning etc or exposure to different agency heat, light etc. Fading means changes in the colour with or without loss of depth of shade for exposure to particular environment/agency/treatments either by lightening or darkening of the shades. . The colour fastness is usually rated either by loss of depth of colour/ colour change in original sample or it is often expressed by staining scale.

10.2 Washing Fastness

With a view to examine and improving wash fastness (Duff et al, 1977), tests are carried out under standard condition (50 °C) and also at 20°C with a washing formulation used in conservation work for restoration of old textiles. Some dyes undergo marked changes in hue on washing, shown to be attributed to even small

amounts of alkali in washing mixtures, high-lighting the necessity of knowing the pH of alkaline solutions used for cleaning of textiles dyed with natural dyes. As a general rule, natural dyes (on wool) have only moderate wash fastness as assessed by the ISO 2 test. In the ISO 2 test, the fastness of the indigo and logwood is superior to that of the native natural dyeing such as privet berries and water lily root respectively, but in the comparison of native and imported yellow, reds, red/purples, greens and browns, there is little difference between the two groups (Duff et al, 1977)[30]. It is found from a recent report that treatment with 2%CTAB or sandofix-HCF improve the wash fastness to nearly 1 unit and treatment with 1% benzotriazole improved the lightfastness of dyed jute textiles nearly half to one unit (Samanta et al, 2006; 2007; 2010 & 2011; Samanta & Agarwal, 2008)[35]

10.3 Rub Fastness

Rub fastness of most of the natural dyes have been found to be moderate to good and do not require any after treatment. Jackfruit wood, manjistha, red sandal wood, babool, mariegold etc have good rubfastness (Samanta et al, 2006; 2007; 2010 & 2011) [31-34].. Good rub fastness is seen for mariegold on cotton, silk and wool (Sarkar et al, 2005; Sarkar, 2006)[36,37]. Good rub fastness (dry and wet rubfastness) is reported for silk dyed with acalypha and other natural dyes (Mahale et al, 1999; 2002 & 2003)[38-40]. Cutch and ratanjot shows moderate to good dry rub fastness but the wet rub fastness is found to be average (Khan et al, 2003 & 2006).[41,42]

11. Conclusion

Most of the natural dyes/ colour are eco-safe, except a few. Some of the natural colours are not only eco-safe, but also has added value for its medicinal effects on skin and are more than skin friendly. Textile dyers must know the chemistry of these natural colours and its added advantages of medicinal; values. Use of suitable binary or ternary mixtures of similar or compatible natural dyes for colouring natural eco-friendly textiles in variety of soothing / uncommon shades with eco-friendly mordants and finishing agents are the most desirable product of the customers for future.

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