

# Natural Dyes: Sustainable way for Dyeing of Textiles

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**Abstract**—Nature is blessed with variety of plants having potential to be used as the source of colorants for textiles. The herbal colorants being non-toxic, non-hazardous and relatively more eco-friendly are arousing interest among consumers. Commonly parts of plants used for extraction of color are seeds, flowers, stems, leaves, barks and roots. It is interesting to check if antimicrobial property can also be imparted to the textile material using natural resources as large number of Indian plants also contain anti microbial and anti-fungal properties and it is possible that some of them have the substantivity towards the textile substrates. By doing so the naturally colored fibre substrate will emerged with anti microbial activity. These products will thus be able to enhance healthy and hygienic properties of textiles. The search for having the textile material decorated in colors has always been there but it is in general, the recent trend where the concept of eco-friendly textile products is emerging. Hence, there is a niche market for the textile material dyed with herbal colors and having other specialty finishes applied on it.

**Keywords:** Sustainable, natural, eco-friendly, dyeing, textile

## 1. INTRODUCTION

The textile dyeing industries use large amount of dyes, chemicals and auxiliaries and also consumes large quantities of water. Initially all dyes used in textiles were of natural origin until the discovery of first synthetic dye “mauviene”, (basic dye) in 1856 by Sir W. H. Perkin [1]. Since then the Synthetic dye industry has grown at a high rate and almost vanished the use of natural dyes. These days textile industry produces and uses approximately 1.3 million tons of dyes, pigments and other chemicals, almost all of which is manufactured synthetically using petroleum derivatives as raw material. Though the availability of natural dyes has been known for centuries, the reasons synthetic dyes have been so popular for simpler production, variety of colors, reproducible application processes, and the consumer’s demand for quality products having high color fastness at a reasonable price.

Synthetic dyes are not eco-friendly because they need toxic and hazardous chemicals for their production, generating non biodegradable waste. When unfixed dye, spent chemicals and auxiliaries and water not picked up by the fibre material they

are collectively discharged as effluent. Such effluents affect marine life [2], riverbeds, soil and crops [3]

Now a day consumers are becoming more aware about environmental and health issues [4]. Those dyes which were found to be carcinogens have been banned or replaced now. The textile industry is following and adapting the global ‘go-green’ movement. Sustainability is being promoted in all aspects of coloration [5, 6] Zero-discharge processing [7, 8] is becoming very popular and lot of researchers are working on this. For example, Levi Strauss is encouraging recycling of old and used denim and promoting efforts to cut down the amount of water required for washing during use [9]

The growing demand for sustainable products is playing a key role in prompting the reintroduction of natural dyes on a commercial scale. Natural dyes are believed to be biodegradable and non-polluting and eco friendly as they are derived from renewable sources [10] In some cases they also possess medicinal properties [11]. These features and a growing concern for the environment have created a niche market for the industrial scale use of natural dyes [12, 13]

## 2. NATURAL DYES

Natural dyes have been used since ancient times all across world [14]. Before synthetic dyes were discovered they were the only dyes available and used. The name natural dye includes coloring matter derived from natural sources, such as plants, animals and minerals. Across the world wide variety of plant sources are used for natural dyes and are reported by many authors time to time [15, 16, 17, 18] It has been [19] reported that more than 300 plant species have been identified in only India as traditional dye sources. Any plants ranging from undesirable weeds to cultivated can have potential to act as natural dye. If natural dyes can be produced efficiently and effectively they can reduce the use of toxics used during manufacturing of synthetic dyes which are continuously harming our environments. In natural dyes after the extraction of the dye, the biomass can be used for energy generation as a fuel so no waste is generated in manufacturing of natural dyes.

Some natural dyes can also impart additional property to fabric along with color.

### 2.1. Classification of natural dyes

Initially classification of dye was done simply on alphabetical order but now it is done according to the directions given in Color Index depending upon the parameters like structure, origin, method of application and color [20, 21]. Broad classification of Natural dyes is given in Figure 1. This Classification of is based on the inherent affinity of dyes for textiles.

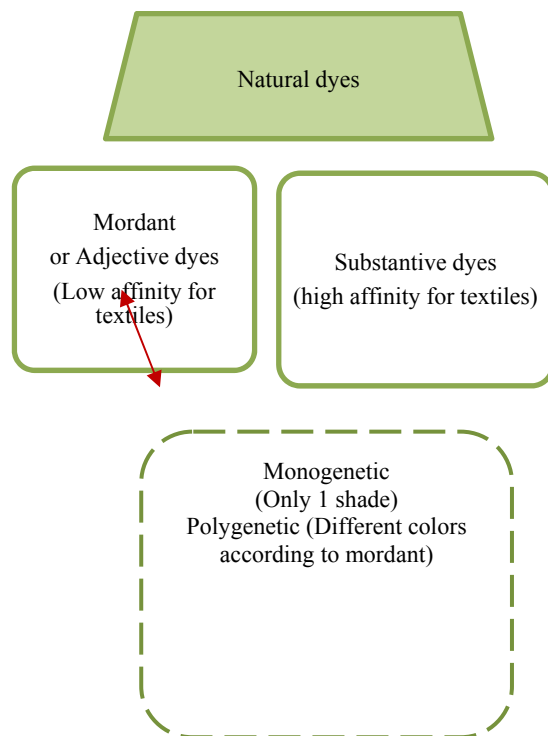


Fig. 1: Classification of natural dyes

Classification on the basis of chemical structure is given in Table 1[22]

Table 1: Classification of natural dyes on the basis of their color

Chemical Structure of Dye	Color
Indigoid	Indigo, purple and blue
Anthraquinone	Red
Alphanaphthoquinones	Shades of orange
Flavonoids	Yellow
Di-hydropyrans	Dark wooden shades
Anthocyanidins	Orange
Carotenoids	Reddish/ Orange pigments

### 2.2. Sources and extraction

The extraction process for natural dyes is very simple without having any technicality although it is time-consuming and

laborious process. Natural dyes are mostly derived from vegetations. Different plants contain different amounts of color in different parts such as leaves, flowers, bark, seed pods and roots [16]. Waste from industries can also act as raw material for natural dyes like grape and olive pomace from respective industries [23, 24]. Genetic engineering has also modified micro-organisms able to produce dyes [25-28].

Most common dye extraction techniques are steeping plant material and boiling off or fermentation in water. Extraction process is followed by purification process carried out either by simple filtration, or settling and evaporation for getting dye in paste, cake, granule or powder form. This process reduces transportation cost of raw materials and also helps to standardize the final product. Spray drying and super-critical carbon dioxide extraction are the new developments in this sector. Extraction using infrared waves, microwaves and ultrasonic is becoming popular because of more efficiency.

### 2.3. Characterization of Natural Dyes

Characterization of natural dyes is done by using UV-Vis Spectroscopy, FTIR, NMR, toxicity testing, chromatography etc. UV- Visible spectroscopy is used to determine the main hue present in dye extract. In natural extracts for mixed colorants spectra shows different peaks for different color [29]. To check the possibility of any harmful dermatological effect on human toxicity is tested providing evidence about its safer use [30]. FTIR is carried out on the samples to check the presence of bonds in the compound imparting it chemical functionality. Chromatography is used to determine color components in natural dyes [31] DSC or TGA is done of extracts to determine the thermal decomposition to understand its behavior during actual dyeing process.

### 2.4. Application techniques

In industries use of natural dyes was always denied till the only coloration techniques available to them were long exhaust methods. Those methods were laborious, time consuming [32]. Many researchers [1, 33- 35] have worked on the ways of dyeing recipes in a scientific manner. Many variations are done in the exhaust dyeing method to match the standard of natural dyes [36]. Uses of non-conventional methods such as ultrasound, microwave and infrared frequency dyeing have also been tried with natural dyes [37, 38] Padding using natural dyeing has been reported by only a few researchers [39, 40] and needs more detailed study.

Depending upon the type of dye mordanting is done. The process of applying mordants or mordanting is classified into three types [41, 42]: a) **Pre-mordanting** is where the textile material is first treated with the mordant and then dyed. b) **Meta mordanting** involves a dye bath containing both dye and mordant. The fabric is dyed in one step. c) In **Post mordanting** mordant is applied after the dye has been applied. This method yields deeper penetration of the dye and a level shade.

### 3. ADDITIONAL PROPERTIES IMPARTED BY NATURAL DYES

#### 3.1. Ultra-violet (UV) protection properties with natural dyes

Increasing demand for sun protection among consumers has brought attention of researchers towards imparting UV protection properties in textiles to protect skin damage from increased exposure to UV light. Studies show that cotton fabric dyed with green tea using chitosan mordanting effectively increases the UV protection property [43]. It has been reported that cotton and silk fabrics dyed by *Rheum* and *Lithospermum erythrorhizon*, [44] silk fabric dyed using vegetable dyes extracted from Flos Sophorae, and silk fabric dyed with eucalyptus leaf extract [45] show ultraviolet protective properties.

#### 3.2. Antibacterial and deodorizing properties of natural dyes

Textile substrates are susceptible to microbial attack resulting in degradation of product, bad odor, skin infection, allergies and related diseases [46]. Many plants have medicinal properties and hence show remarkable antimicrobial properties, some of them can also be used for dyeing textile [47]. Researchers have studied the antimicrobial activity of wool fabric when dyed with curcumin, pomegranate and gall nuts [11] and root of *Rhizoma coptidis* (berberine) and found satisfactory results [48]. When cotton fabric was dyed with onion skin and onion pulp extraction it shows antimicrobial activity [49].

#### 3.3. Deodorizing properties with natural dyes

Nature blesses some parts of plants with a unique fragrance. Researchers have tried best to use the fragrance to impart in textile substrates. They have studied the deodorizing and dyeing properties of cotton, silk, and wool fabrics dyed with reported deodorizing property of cotton, silk, and wool fabrics dyed with gardenia, coffee sludge, *Casia tora*. L., pomegranate extracts [50], *Amur Corktree*, *Dryopteris crassirhizoma*, *Chrysanthemum boreale*, and *Artemisia* extracts [51] and found satisfactory results

### 4. LIMITATIONS OF NATURAL DYES

Although natural dyes are sustainable, eco-friendly and have many advantages over synthetic dyes but they also have some limitations which are listed below:

- Less availability in amount and hues
- Low color yield [52]
- Difficulty in shade reproduction
- Unsuitability for coloring synthetic and synthetic-blended fabrics

- Poor performance towards desirable properties compared with most synthetic dyes [53]
- Poor fastness properties if not after treated properly
- Color variation, introduced by changes in growing conditions.

### 5. CONCLUSION

With increasing awareness about conserving our ecosystem choice of consumers is shifting towards more sustainable ways and products. Keeping this in mind researchers are working to find out more sustainable ways to replace the synthetic dyes normally used in coloration of textiles. For this they are looking towards Mother Nature for sustainable solutions. Natural Dyes extracted from vegetation and other natural sources have high potential but they can't fully replace the synthetic dyes because of some limitations. Researchers are continuously working on this because natural dyes are not only eco-friendly but along with color can also impart some additional properties. Although many companies are making naturally dyed clothes but cost factor plays a vital role. The only hurdle remaining in path of natural dyes is their commercialization on large scale.

### REFERENCES

- [1] Mussak, R., and Bechtold, T., Natural colorants in textile dyeing," in *Handbook of natural colorants*, Wiley, 2009.
- [2] Walsh, G., Bahner, L., and Horning, W., "Toxicity of textile mill effluents to freshwater and estuarine algae, crustaceans and fishes," *Environmental Pollution Series A, Ecological and Biological*, 21, 3, 1980, pp. 169–179.
- [3] Ajmal, M. and Khan, A., "Effects of a textile factory effluent on soil and crop plants," *Environmental Pollution Series A, Ecological and Biological*, 37, 2, 1985, pp. 131–148.
- [4] Dalby, G., "Greener mordants for natural coloration," *Journal of the Society of Dyers and Colourists*, 109, 1, 1993, pp. 8–9.
- [5] Bansal, P. and Roth, K., "Why companies go green: a model of ecological responsiveness," *Academy of Management Journal*, 2000, pp. 717–736.
- [6] Reid, R., "Go green—a sound business decision (part 1)," *Journal of the Society of Dyers and Colourists*, 112, 4, 1996, pp. 103–105.
- [7] Lee, H., Chen, G., and Yue, P., "Integration of chemical and biological treatments for textile industry wastewater: a possible zero-discharge system," *Water Science and Technology*, 2001, pp. 75–83.
- [8] Ranganathan, K., Karunakaran, K., and Sharma, D., "Recycling of wastewaters of textile dyeing industries using advanced treatment technology and cost analysis—Case studies," *Resources, Conservation and Recycling*, 50, 3, 2007, pp. 306–318.
- [9] C. Levi-Strauss. (2010, 18 December). *Recycling and consumer care*. available: <http://www.levistrauss.com/sustainability/product/re-use/>.
- [10] Memon, N., "Textile finishing: Increased demand for eco-friendly products," *Pakistan Textile Journal*, 59, 2010, pp. 46–47.
- [11] Gupta, D., Khare, S., and Laha, A., "Antimicrobial properties of natural dyes against Gram-negative bacteria," *Coloration Technology*, 120, 4, 2004, pp. 167–171.
- [12] Ratnapandian, S., Fergusson, S., and Wang, L., "Application of acacia natural dyes on cotton by pad dyeing," *Fibers and Polymers*, 13, 2, 2012, pp. 206–211
- [13] Ranganathan, K., and Lakshmi, G., "Growing preference for natural dyes," *Textile Magazine*, 47, 3, 2006, pp. 85–86.

- [14] Ramakrishna, K., "Into the golden era of natural and vegetable dyes," *Colourage*, 46, 1999, pp. 29–30.
- [15] Cribb, A., and Cribb, J., *Useful wild plants in Australia*: Collins, 1981.
- [16] Dyer, A., *Dyes from natural sources*, Bell, 1976
- [17] Adrosko, R., and Furry, M., *Natural dyes and home dyeing (formerly titled: Natural dyes in the United States)*, 281, Dover, 1971
- [18] Dean, J., *Wild colour*, Octopus, 1999.
- [19] Mohanty, B., Chandramouli, K., and Naik, H., *Natural dyeing processes of India*, Calico Museum of Textiles, 1987.
- [20] Hummel, J., J., *The dyeing of textile fabrics*, Cassell, 1898.
- [21] Cardon, D., *Natural dyes*, Archetype London, 2007.
- [22] Dedhia, E., M., "Natural dyes," *Colourage*, 45, 3, 1998, pp. 45-49.
- [23] Bechtold, T., Mussak, R., Mahmud-Ali, A., Ganglberger, E., and Geissler, S., "Extraction of natural dyes for textile dyeing from coloured plant wastes released from the food and beverage industry," *Journal of the Science of Food and Agriculture*, 86, 2, 2006, pp. 233–242.
- [24] Meksi, N., Haddar, W., Hammami, S., and Mhenni, M., "Olive mill wastewater: A potential source of natural dyes for textile dyeing," *Industrial Crops and Products*, 40, 2012, pp. 103–109.
- [25] Nerurkar, M., Meena, C., and Khurana, N., "Microbial dyes: The undisputed natural dyes," *Journal of the Textile Association*, 71, 6, 2011, pp. 338–339.
- [26] Alihosseini, F., *Biosynthesis of colorants from microorganisms and their application on textile materials*, University of California, Davis, Doctoral Thesis, 2009.
- [27] Han, X., Wang, W., and Xiao, X., "Microbial biosynthesis and biotransformation of indigo and indigo-like pigments," *Chinese Journal of Biotechnology*, 24, 6, 2008, pp. 921–926.
- [28] Han, G., Shin, H., and Kim, S., "Optimization of bio-indigo production by recombinant *E. coli* harboring *fmo* gene," *Enzyme and Microbial Technology*, 42, 7, 2008, pp. 617–623.
- [29] Erics, J., Tiedemann and Yiqi Yang, "Fiber-safe extraction of red mordant dyes from hair fibers," *Journal of American Insitute for Conservation*, 34, 3, 1995, pp. 195-206.
- [30] Joshi, M., and purwar, R., "Developments in new processes for colour removal from effluent," *Review of Progress in coloration and related topics*, 34, 2004, pp. 58-71.
- [31] Kharbade, B., V., and Agarwal, O., P., "Identification of natural red dyes in old Indian textiles: Evaluation of thin-layer chromatographic systems," *J Chromatography*, 347, 1985, pp. 447- 454.
- [32] Broadbent, A. D., *Basic principles of textile coloration*, Society of Dyers and Colourists, 2001.
- [33] Chavan, R., "Revival of natural dyes—a word of caution to environmentalists," *Colourage*, 42, 1995, pp. 27.
- [34] Chavan, R., "Eco-fibres and eco-friendly textiles," *Textile Magazine*, 43, 1, 2001, pp. 61.
- [35] Gulrajani, M., "Natural dyes - Part I. Present status of natural dyes," *Colourage*, 46, 7, 1999, pp. 19.
- [36] Kumaresan, M., Palanisamy, P., and Kumar, P., "Application of eco-friendly natural dye on cotton using combination of mordants," *Indian Journal of Fibre and Textile Research*, 37, 2, 2012, pp. 194–198.
- [37] Vankar, P., "Chemistry of natural dyes," *Resonance*, 2009, pp. 7.
- [38] Vankar, P., and Shanker, R., "Ecofriendly ultrasonic natural dyeing of cotton fabric with enzyme pretreatments," *Desalination*, 230, 2008, pp. 62–69.
- [39] Patel, B., Agarwal, B., and Patel, H., "Novel padding technique for dyeing babool dye on cotton," *Colourage*, 50, 1, 2003, pp. 21–26.
- [40] Mongkholrattanasit, R., Kryštůfek, J., and Wiener, J., "Dyeing and fastness properties of natural dyes extracted from eucalyptus leaves using padding techniques," *Fibers and Polymers*, 11, 2010, 3, pp. 346–350.
- [41] Gulrajani, M. and Gupta, D., *Natural dyes and their application to textiles*: Department of Textile Technology, Indian Institute of Technology, 1992.
- [42] Bhattacharyya, N., *Natural dyes for textiles and their eco-friendly applications*: IAFL Publications, 2010
- [43] Kim, S., "Dyeing characteristic and UV protection property of green tea dyed cotton fabrics. Focusing on the effect of chitosan mordanting condition," *Fibers and Polymers*, 7, 3, 2006, pp. 255–261.
- [44] Feng, X. X., Zhang, L. L., Chen, J. Y., and Zhang, J. C., "New insights into solar UV-protectives of natural dye," *Journal of Cleaner Production*, 15, 4, 2007, pp. 366–372.
- [45] Mongkholrattanasit, R., Kryštůfek, J., Wiener, J., and Viková, M., "UV protection property of silk fabric dyed with eucalyptus leaf extract," *The Journal of The Textile Institute*, 102, 3, 2011, pp. 272-279.
- [46] Thiry, M. C., "Small game hunting; antimicrobials take the field," *AATCC Rev*, 2, 2001, pp.11-17.
- [47] Singh, R., Jain, A., Panwar, S., Gupta, D., and Khare, S. K., "Antimicrobial activity of some natural dyes," *Dyes and Pigments*, 66, 2, 2005, pp. 99-102.
- [48] Ke, G., Yu, W., and Xu, W., "Color evaluation of wool fabric dyed with *Rhizoma coptidis* extract," *Journal of Applied Polymers Science*, 101, 5, 2006, pp. 3376-3380.
- [49] Chen, C., and Chang, W., "Antimicrobial activity of cotton fabric pretreated microwave plasma and dyed with onion skin and onion pulp extractions," *Indian Journal of Fibre & Textile Research*, 32, 1, 2007, pp. 122-125.
- [50] Hwang, E. K., Lee, Y. H., and Kim, H. D., "Dyeing, fastness, and deodorizing properties of cotton, silk, and wool fabrics dyed with gardenia, coffee sludge, Cassia tora. L., and pomegranate extracts," *Fibers and Polymers*, 9, 3, 2008, pp. 334-340.
- [51] Lee, Y. H., Hwang, E. K., Jung, Y. J., Do, S. K., and Kim, H. D., "Dyeing, fastness, and deodorizing properties of cotton, silk, and wool fabrics dyed with Amur Corktree, *Dryopteris crassirhizoma*, *Chrysanthemum boreale*, *Artemisia* extracts," *Journal of Applied Polymers Science*, 115, 4, 2010, pp. 2246-2253.
- [52] Fereday, G., "Natural dyes," British Museum Press, 2, 2003, pp. 39.
- [53] Samanta, A. K., and Agarwal, P., "Application of natural dyes on textiles," *Indian Journal of Fibre & Textile Research*, 34, 4, 2009, pp. 384–99.