

Natural dyes and its applications: A brief review

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ABSTRACT

Dyes derived from natural materials such as plant leaves, roots, bark, insect secretions, and minerals were the only dyes available to mankind for the coloring of textiles until the discovery of the first synthetic dye in 1856. Rapid research strides in synthetic chemistry supported by the industrialization of textile production not only led to the development of synthetic alternatives to popular natural dyes but also to a number of synthetic dyes in various hues and colors that gradually pushed the natural dyes into oblivion. However, environmental issues in the production and application of synthetic dyes once again revived consumer interest in natural dyes during the last decades of the twentieth century. In the earlier days, dyes were derived only from natural sources. But natural dyes suffer from certain inherent disadvantages of standardized application and the standardization of the dye itself as dyes collected from similar plants or natural sources are influenced and subjected to the vagaries of climate, soil, cultivation methods etc. Hence, for the natural dyes to be truly commercialized and to take a competitive place with respect to the synthetic dyes, the standardization methods play a very significant and vital role. This study attempts to review the current status of natural dyes and its types and application and examines their future prospects.

Key Words: Dyes, Synthetic, Commercialized, Application

Introduction

Since prehistoric time natural dyes is used for coloring of food substrate, leather as well as fibers like wool, silk and cotton. The use of non-allergic, non-toxic and eco-friendly natural dyes on textiles have become a matter of significant importance due to the increased environmental awareness in order to avoid some hazardous synthetic dyes. [1]

Indians have been considered as initiator in the art of natural dyeing. At present synthetic compounds are used for dyeing textile materials and they cause water pollution as well as waste disposal problems because these are non-biodegradable and carcinogenic. These problems can be solved by the use of natural dye. There are huge applications of natural dye on textile so it is clamorous to promote technology for extraction. [2]

Natural dyes extract from a variety of the substance with are occur in nature such as plants (e.g., indigo and saffron); insects (e.g., cochineal beetles and lac scale insects); animals (e.g., some species of mollusks or shellfish); and minerals (e.g., ferrous sulfate, ochre, and clay) without any chemical treatment. [3]

For coloration of fabrics many chemicals are used in textile industry. However, environmental issues in the production and application of synthetic dyes once again revived consumer interest in natural dyes during the last decades of the

twentieth century But the total share of natural dyes in the textile sector is approximately only 1 % due to certain technical and sustainability issues involved in the production and application of these dyes such as non availability in ready-to-use standard form, unsuitability for machine use, and limited and non reproducible shades. Also, overexploitation of natural resources to obtain dyes may result in deforestation and threaten endangered species. For these reasons, the Global Organic Textiles Standard (GOTS) permits the use of safe synthetic dyes and prohibits the use of natural dyes from endangered species. Various research efforts have been undertaken all over the world to address the shortcomings of natural dyes in view of the tremendous environmental advantage they offer. [4]

Colorants obtained from natural sources such as plants, insects/animals and microbes have been scrutinized in recent past for their use in different kinds of applications. Research into new natural dyes sources along with eco-friendly, robust and cost-effective technologies for their processing and application have greatly aided in widening the scope of natural dyes in various traditional and advanced application disciplines. [5]

Natural dyes are good biodegradable. They are non-toxic non –allergic to skin non carcinogenic, easily available and renewable. Colour fastness is the resistance of a material to change any of its

colour characteristic are extent of transfer of its colorants to adjacent which materials in touch generally light fastness wash fastness and rub fastness are considered for textile fibers. [6]

Application of synthetic dyes release large amount of waste and unfixed colour. It cause health hazards pollution and disturb eco –balance. So now a days trend of using natural colours is drawing production. [7]

All over the world in the formation of different cultures of human being Color has played an important role. Our lives, the clothes we wear, the furnishings of our homes strongly influenced by colour. In the past, painters had used natural dyes extracted from plants, insects, molluscs and minerals for their paintings. The unique character of their works were the result of using different mixtures of dyes and mordents, as varnishes and lacquers responsible for cohesion of the pigments and protection of the layers destroyed by environmental effects.[8]

If we compared natural dye with synthetic dye then natural dyes are found eco-friendly and they have no carcinogenic or allergic effect for human being especially for dyers. They can get these natural dyes at low prices that are used mostly in our industry for dyeing of silk fabric. [9]

Natural dyes are widely used in many industries like producing confectionery, other food products, textiles, cosmetics, medicines, leather, paper, paint, ink, etc. [10]

NATURAL DYES

SOURCE OF NATURAL DYES

Natural dye can be obtained from different sources. Since ancient times natural dyes may have a wide range of shades and can be obtained from various part of plants including roots bark leaves to flowers and fruit[11] These dyes can be classified as 1) Natural dyes obtained from plants -Berry, flower, bark, leaf, seed etc (e.g. catechu, Indigofera, myrobalan, pomegranate). ii. Natural dyes obtained from insects – Cochineal and lac. iii. Natural dyes obtained from animal – Mollusk, murex snail, cuttlefish and shellfish. iv. Natural dyes obtained from mineral – Clay, ochre and malachite. [12]

Natural dyes comprise those colorants (dye and pigments) that are obtained from animal and vegetable matter without chemical processing. Natural dyes fall into three categories on the basis of their origin: plant, animal and mineral. [9].

1) PLANT DYES

The different parts of plants for example roots, nuts and flowers are sources of coloring pigments

and dyes. Henna (orange-red) -from leave of henna plants, Carechu (brown) -from resin (sticky substance from plant of acacia tree, Fustic (yellow)-from the wood of the fustic tree, Indigo (C₁₆H₁₀N₂O₂(blue)-from leaves and stems of the indigo plant, Logwood (black)-from the core (heart) of the log wood tree, Turmeric (violet) - from the roots the turmeric plant and Saffron (yellow) -from stigmas of the common crocus are the common ones [13].

Floral dye play an important role for dyeing of textile material because it provide color as well as fragrance.

Local plants are one source of natural colorant which is grouped under plant sources. They are easily available in the country and can be considered as zero cost dyes as they are planted for other purposes. Plants are the major sources of natural colorants and almost all their parts such as stem, leave, fruits, seeds and pills are used for extracting natural color and they have antimicrobial, antifungal, insect repellent, deodorant, disinfectant and other medicinal values. There were as many as 500 plant species identified as sources for dyes. These dyes are derived from various parts of the tree (flower, bark, seeds, leaves and roots). These vegetable sources are not only replaceable but also bio-degradable. They also have pharmaceutical and health benefit. [9]

2) ANIMAL DYES

Red mouthed rock shell was one of the main source of Tyrain purple and study blames its collapse on rising sea temperature. Phoenician purples and BIBLICAL BLUES are the most royal and sacred of all ancient dyeing were produced from Levantine sea snails of the family Muricidae. These mollusks may have been in use for the production of the royal purple pigment.[14]

3) MINERAL DYES

Malachite a material found in nature along with azurite was used for a greener pigment soot and manganese oxide were used as a black pigment [15]

Derive from colored clays and earth oxide; Chrom green-from a compound of chromium and oxygen, Chrom red-from from a compound of chromium and lead, Chrom yellow-from a compound of chromic acid and lead and Prussion blue-from a compound of iron and cyanide [16].

As minerals are used for fixing or improving the fastness of vegetable dye, the name natural dye is more appropriate which cover all the dyes derived from natural resources including

vegetable dyes as well as minerals. And some minerals are also used to give a coloring matter. For example seru, cow urine, cow dung, egg albumin. [9]

4) Insect dye

Secretion of insects and dried insect bodies are the major source of natural dyes. For example shell-fish provides the coloring matter. [9]

Lac and cochineal is an example of natural dye obtained from insect carmine and it gives similar colours. It is gathered by spreading cloth on the ground under infested trees, during the season of red rain.[17]

Application

1) Sensitization

Dye is used as a sensitizer in dye sensitized solar cells which converts visible light into electricity using sensitization of the cell. Performances of these cells depends on dye. Sensitization is an important application of natural dye. Natural dyes are cutting down high cost of metal complex sensitizers and also replacing expensive chemical synthesis process through simple extraction process. (18)

In photo electrochemical water splitting titanium dioxide-based semiconductors are used. For promote the efficiency of photo electrochemical reaction natural dye sensitizers are used due to their environmental friendliness and low cost. Fast electron injection and slow backward reactions are exhibited by dye sensitizers. A protective layer like conductive polymer layer is required for natural dye sensitizer because it is unstable in solution.[19]

Natural dye is used as photosensitizer in dye sensitized solar cells along with TiO₂ nano particles extracted from *Hemigraphis colorata* (Red flame) with minimal chemical procedure and is used without further purification. anthocyanin and beta-carotene is present in this dye and it is proved by UV-Visible absorption spectroscopy and micro-Raman spectroscopic studies. The photovoltaic property of *hemigraphis colorata* is due to the presence of high concentration of anthocyanin.[20]

Anthocyanin and Chlorophyll is natural sensitizers in dye sensitized solar cells (DSCs) which are extracted from Troll flower and Cypress leaf. UV-Vis absorption measurement showed that the mixture of two dyes enabled an enhanced and wider absorption in the wavelength range of 300 nm–700 nm compared to each single dye. FTIR results proved that anthocyanin is

chemically adsorbed onto the TiO₂ film, while it is physical adsorption for chlorophyll. The optimized ratio of the two dyes in the mixture was found to be ~2:5, inducing both sufficient charge transfer driving force and minimal energy loss. By incorporating this mixture into the solar cell as co-adsorbing sensitizer, the photovoltaic performance was prominently improved compared with the single dye sensitization system[21]

2) Coloration

Henna is known as lawsone. It is a red-orange pigment that has been used for the coloration of skin and hair as well as textile materials. In recent years Henna has received tremendous scientific interest for the dyeing of textile materials mainly due to it's fluent coordination with nature. Henna has low chemical reactivity and there is no side effect on environment.[22]

The natural dye annatto usually being recognized as *Bixa orellana*. It is a yellow–orange dye obtained from the seeds of this plant. It has high biodegradability, low toxicity, and compatibility with the environment. Carotenoids, apocarotenoids, terpenes, terpenoids, sterols, and aliphatic compounds are main compounds found in all parts of this plant and are reported to exhibit a wide range of pharmacological activities. Annatto is used in solar cells, leather, food, textile and other industries.[23]

Natural dye can be used for wool dyeing from a long time. Now a days some new sources also used for pure wool dyeing. *Celosia*, *Nerium*, *Hollyhock*, *Hibiscus mutabilis*, *Caryatia*, *Tegetus*, *Rambutan*, and *Curcuma* these plants are used for wool dyeing. Animal proteins, like wool dye best in acidic conditions and are weakened by alkalines. Sources of natural dyes which are used, primarily give color to wool generally in acid dye bath.[24]

Natural dye obtained from plants such as Black carrot, *Hibiscus*, *Delonix*, *Plumeria*, *Combretum*, *Ixora*, and *Bischofia* has been used for dyeing silk fabric.[25]

Conclusion

During the last few years many articles discussed about natural dye have been published. This review is attempt to highlight the undesirable effect of synthetic dye on the environment and humans health. However, up to the present moment there is no economical method to remove both the color and the toxic properties of the dyes released into the environment by synthetic dye. Natural dyes supposed to be cheap, non-toxic, renewable and sustainable resource with minimal

environmental impact, have attracted the attention of the scientific community to use them

in a variety of traditional and newly discovered application disciplines.

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