

Natural Dyes: Application in Ecofriendly Textile Dyeing and Printing

Abstract

The textile dyeing and printing industry plays an important role in the economical growth as well as in the environmental sectors of any country. The use of non-toxic and eco-friendly natural dyes on textiles has become a matter of significant importance because of the increased environmental awareness in order to avoid some hazardous synthetic dyes. Apart from the introduction of natural dyes and their eco-friendly properties, this article reviews the studies carried out so far to understand the science of natural dyes and applications of natural dyes.

Keywords: Textiles, Natural Dyes, Dyeing, Printing, Synthetic Dyes, Mordants.

Introduction

A dye can generally be described as a coloured substance that has an affinity to the substrate to which it is being applied. The dye is usually used as an aqueous solution and may require a mordant to improve the fastness of the dye on the fibre. These dyes are mainly organic and inorganic chemical substances and when spread out in the environment, causes huge adverse impact on the environment. Natural dyes obtained from various parts of plants including roots, barks, leaves, flowers and fruits are known for their use in colouring of food, leather, wood and textiles. Since the advent of widely available cheaper synthetic dyes in 1856 having excellent colour fastness properties, the use of natural dyes has declined to a great extent. The reason behind it was economical, poor colour fastness properties of natural dyes and wide availability of synthetic dyes. But now in dyeing textiles, ecological standards are strictly applied throughout processing from raw material selection to the final product. The main challenge for the textile industry today is to modify production methods by using safer dyes and chemicals and by reducing cost of effluent treatment and disposal.

In order to avoid some hazardous synthetic dyes, the use of non-toxic and eco-friendly natural dyes on textiles has become a matter of significant importance because of the increased environmental awareness. However the use of natural dyes for dyeing textiles has mainly been confined to small scale industries, craftsman, exporters but recently a number of commercial dyers and export houses have started using natural dyes to overcome the environmental pollution caused by synthetic dyes. Although there are a small number of companies that are producing natural dyes commercially, for successful commercial use of natural dyes, the appropriate and standardised dyeing techniques need to be adopted without sacrificing the required quality of dyed textile materials. Therefore, to obtain newer shades with acceptable colour fastness behaviour and reproducible colour yield, appropriate scientific techniques need to be derived from scientific studies on dyeing methods, process variables, kinetics and compatibility of selective natural dyes. Also the need to reinvestigate and rebuilt the traditional process of natural dyeing to control each treatment and pre-dyeing process and dyeing process variables for producing uncommon shades with balanced colour fastness and eco-performing textiles has been felt.

The production of synthetic dyes is dependent on petrochemical source and some of synthetic dyes contain toxic or carcinogenic amines which are not eco-friendly. Moreover the global consumption of textiles is estimated around 30 million tonnes and is expected to grow at the rate of 3% per annum. The colouration of this huge quantity of textiles need around 7,00,000 tonnes of dyes which causes release of a vast amount of unused and unfixed synthetic colourants into the environment.

This article reviews the studies carried out so far to understand the science of natural dyeing and its application as well as the properties of natural dyes.

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Application of Natural Dyes

Antibacterial Properties of Natural Dyes

The natural fibres have protein cellulose etc. which provide basic requirements such as moisture, oxygen, nutrients and temperature for bacterial growth and their multiplication. This results in infection, allergies and other related diseases. Although the natural dyes are being used for a long time, the structures of protective properties of natural dyes have been recognised only in the pasts. Many of the plants used for dyes extraction are medicinal and possess remarkable anti-microbial activity. A number of studies have indicated that plants synthesize aromatic substances like alkaloids, terpenoids and phenolic compounds as their secondary metabolites which are anti-microbial and acts as defence mechanism for plants against micro-organisms. These compounds are of great importance as the substances have been successful in protecting plants from bacterial attack since time immemorial, without causing the bacteria to develop resistance to them. The use of natural products and natural dyes for antimicrobial finishing of textile materials has been widely reported. Curcumin for wool and kamala, pomegranate, gall nuts, lac for cotton found to be efficient biocides after dyeing.

Protection from Ultraviolet Radiations

Exposure to ultra violet radiations coming down to earth from the sun can cause acute and chronic reactions and damage such as acceleration of skin ageing, various skin, eye and DNA damage, hence making consumers aware of the protection from sunlight. The ultraviolet radiation band consists of three regions- A-band (320-400 nm), B-band (290-320) and C-band (200-290). The C-band radiations are completely absorbed by the upper atmosphere while 6% of B-band and 94% of A-band radiations reaches to us. The A-band radiations hardly affect the human skin but the B-band radiations are responsible for causing cancer. Besides from avoiding direct sunlight, suitable clothes, hats and sunscreens are recommended. The protective properties of suitable clothes depend on fibre composition, fabric construction and fabric processing. Recently applications of natural dyes on ultraviolet protective textile materials have been observed. It is observed that dyeing of cotton fabric with natural dyes like madder, cochineal, indigo and green tea increases the ultraviolet protective abilities of the fabric and can be considered as an effective protection against ultraviolet radiations. This protection can be further enhanced with colourants of dark hues and high concentration of dyes in the fabric. It is found that fabrics dyed with natural dyes could absorb about 80% of ultraviolet radiations.

Natural Dyes Application in Textile Printing

Natural dyes from alkanet and rhubarb by using pigment printing technique was studied for printing of natural fabrics like cotton, wool, silk and flax resulting highest k/s value by using Mepro gum as a colour thickener. As the concentration of natural dye powder in the printing paste increases from 10gm/kg to 40gm/kg, the k/s value increases rapidly. Also it was found that colour fixing by steaming have higher strength than the colour fixing via thermodynamics. Also the best results were obtained by using metal mordants at a concentration of 20gm/kg printing

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paste. The colour fastness results were found to be ranging between very good to excellent. It is also studied that the pretreated cotton fabric by chitosan was printed with natural colouring matter, curcumin. The colour yield of the prints increased by increasing molecular weight of chitosan. The stiffness results of the printed cotton fabric pretreated with low molecular weight chitosan showed better performance and also the rubbing fastness of the printed fabric was good.

Role of Kinetics and Thermodynamics in Dyeing Process

To increase the rate of dyeing and to manipulate the process of natural dyeing efficiently in order to get maximum colour yield in economical way, it becomes necessary to get acquainted with the knowledge of different variables, rate of dyeing and chemical kinetics of dyeing process. The rate of dyeing and effect of variation in salt and pH of wool and silk with annatto dye was studied and it was found that at the same temperature of 90 degree, wool has lower rate of dyeing as compared to silk. When the fabric is dyed at high temperature, the lower affinity and less dye uptake are obtained however the higher temperature increases the initial rate of dyeing and diffusion coefficient. The diffusion coefficient of annatto dye was higher than on wool. The exhaustion of the dye increases with the increase in dye bath pH. The exhaustion of annatto to wool and silk is found to be maximum at dye bath pH around 4.5.

Mordants and Mordanting Methods

Mordanting process is the process of treatment of textile fabric with metallic salts to bind the dye onto the fabric. It can be achieved either by pre-mordanting, in-process mordanting or by post mordanting. Different types of mordants or their combinations can be used to obtain different colour or shade, to increase the dye uptake and to improve the colour fastness of any natural dye. Wool and silk when dyed with natural dye in the absence and presence of mordant (magnesium sulphate, aluminium sulphate and ferrous sulphate), it was found that mordanting improves colour strength, brightness and fastness properties in comparison to the dyeing without mordanting. Similarly dyeing of cotton using post mordanting method with ferrous sulphate and calcium hydroxide not only provided better shade but also better washing and light fastness in comparison to dyeing without mordanting.

Conclusion

Natural dyes are not the alternatives to the synthetic dyes but they have potential to reduce the consumption of some hazardous synthetic dyes. Since a large quantity of dyed textile material is required to consume, for successful commercial use of natural dyes the appropriate and standardized dyeing techniques need to be adopted. It is also concluded that the use of natural dyes can reduce the microbial activity of natural fibres and also help in the protection from ultraviolet radiations.

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