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Green Processing of Dyes: Influence on Physico-Mechanical Properties, Color Stability and Environment

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Abstract

The present article describes the role of dyes in enhancing the various properties of fibers along with their brief history and the recent methodologies used to minimize their negative impact on environmental safety. Since primitive age, natural dyes were used as coloring agents in textile industry. Later, in nineteenth century, synthetic dyes due to their high dyeability, varying shades ability, and comparatively low cost have replaced natural dyes. However, environmental concerns like water and marine pollutions forced the textile industry to develop new methodologies for the utilization of natural dyes with improved properties. Literature reveals that the use of new and advanced techniques have enhanced the dyeability, strength, softness, antimicrobial and other properties of textiles. These are mainly classified in to; a) the chemical modifications of natural dyes, and b) the surface modification of fabrics. In addition to these, the negative and positive impacts of these methods along with the future scope of research have also been discussed.

Keywords: Dyes; Textile industry; Fiber; Natural and synthetic; Antimicrobial

Introduction

Dyes are acting as colored ingredients, possessing specific affinity via ionic or covalent chemical bonds, absorption, and mechanical retention towards the substrates (cotton, leather, hair and paper). They are soluble in the medium of application, which temporarily distort their crystal structure in solution; but, they regain their structure after the evaporation of solvent and retain their color on the substrates surface. Based on their origin and source, dyes are classified as (i) natural and (ii) synthetic, involving conjugation and un saturation in their structure. These unsaturated groups are called chromophore (N=N, C≡N, NO2, C=O, C=C, C≡C, etc.). Majority of these groups are capable of absorbing the electromagnetic radiations in UV-visible (400-800nm) region that results in the excitation of electrons from a lower energy level to a higher energy level. However, any compound that is able to absorb radiation in this (400-800nm) region can impart color to the substrate [1].

Since the ancient days, dyes have been involved in the coloring and designing of the textile, which induces extra ordinary activity of dyes in the textile industry. However, the significant environmental and health hazards are the main concerns that limits the use of synthetic dyes in the textile industry. For instance, the metal ion-containing (Chromium, Cobalt, Nickel, and Copper) dyes and synthetic dyeing auxiliaries cause serious health threats to human and the marine organisms [2]. Thus, the textile industry is forced to substitute these synthetic and toxic dye-materials with biocompatible, non-toxic, biodegradable, natural and sustainable compounds.

The application of environmentally safe, sustainable and biodegradable dyes like Terminalia chebula, extracts of grape pomace, turmeric, etc., proved to be an effective substitute to these dyes, the potential application of which reduce the negative effect of metal-based dyes in coloring the textiles. These environmentally benign materials show least impact on environmental pollution and human health. However, the industry mainly uses cotton and jute as the natural fibers in addition to polyester fiber, which are difficult to dye by natural dyeing agents due to the presence of anionic moieties such as hydroxyl and carboxyl groups in their structures that form electrostatic repulsive forces with similar moieties of natural dyes [3]. Thus, resulting in lower uptake of color that leads to their poor fastness properties and color strength. As a result, researchers have developed various techniques, which are mainly categorized in two classes, (a) the chemical modifications of natural dyes and (b) the surface modification of fabrics. Further, the surface modification of fabrics occurs through numerous methods such as cationization, enzyme treatment, grafting, plasma treatment, bio-polishing, ultrasonic treatments, mercerization, and radiation (microwave and UV) [4]. Among these methods, gamma radiation treatment proved to be the most effective technique as it increases the water repellency and resistance to the shrinkage of treated fabrics. However, the exposure of textile to gamma radiation above 15kGy considerably reduces the tensile strength of fabrics.

Therefore, alternative methods are being developed to improve the dyeability of natural fibers (cotton) via creasing and utilization of natural mordant (myrobalan) and biodegradable agents (enzymes) or biopolymers (chitosan and sericin) [5].

The formation of crease in cotton fiber is a complex process due to the presence of large number of primary and secondary intermolecular H-bonding in the polymer chains. The weak H-bonds present in the amorphous regions are easy to break via folding, which can reform at different positions that stabilize the crease. This crease on the fiber is prone to recover; therefore, the chemical treatments using formaldehyde-based cross linking agents have been utilized. However, the free formaldehyde groups present in the resin decrease the strength of fabrics by increasing the stiffness that reduces their abrasive properties. Thus, scientists introduced biomaterials to develop alternative methods through the utilization of biopolymers (chitosan and sericin) to increase the dye uptake by fabrics [6].

Recently, sericin (a gummy substance around the silk fibroin) possessing large number of polar moieties such as carboxyl, hydroxyl and amino groups, having cross linking ability to combine and copolymerize with fibers, has attracted the interest of textile industry. Since they reduce high color absorption ability and mechanical strength to fabrics, these substances not only increase the dye uptake of the fiber, but also improves their biochemical and biological peculiarities such as antibacterial activity, biocompatibility, and antioxidant properties of treated fibers [7]. On the other hand, the chitosan treatment of fiber could exhibit similar effect, enhancing the dye absorption of cotton due to the amine groups present on its chemical structure. However, the week van der-Waals interactions and hydrogen bonds break on repeated washing, which subsequently results the fading of the textile color [8]. Therefore, a cross linking agent like polycarboxylic acids is used to bind the amine moieties of chitosan and hydroxyl moieties of cellulose, which strengthen the interactions between chitosan and fiber, resulting in the improved durability of the dye. These methods could further improve the resistant of the fabric to shrinkage and swelling, while increasing the smoothness [8].

In current scenario, the utilization of natural dyes (extracted from herbs, plants, minerals and invertebrates) in the textile industry is not limited for the coloring of fabrics [9]. Various natural dyes possess unique characteristics such as insect repellency, UV absorption, and antimicrobial activity, which make them more beneficial for industries [10]. Although large number of sources for the extraction of natural dyes have been identified during the past few years, but the extraction and optimization of coloring process in order to improve their dye fastness and strength properties of fabrics are the challenging processes and require further research. In addition, the utilization of such compounds as fillers and additives have a potential scope of application in other industries like coatings, packaging, paints, etc., that can open new areas of research and applications for these natural dye materials.

References

1. Gürses A, Açıkyıldız M, Güneş K, Gürses MS (2016) Dyes and pigments: Their structure and properties. Dyes and Pigments pp. 13-29.
2. Bukhari MN, Shahid-ul-Islam, Shabbir M, Rather LJ, Shahid M, et al. (2017) Effect of binary and ternary combination of metal salt mordants on dyeing and fastness properties of natural protein fibre with juglans regia L. dye. Journal of Natural Fibers 14(4): 519-529.
3. Yuanyong T, Wei W, Chunhong Y, Long Z, Jinyang L, et al. (2017) Nutritional and digestive properties of protein isolates extracted from the muscle of the common carp using ph-shift processing. Journal of Food Processing and Preservation 41(1): e12847.
4. Shabbir M, Islam SU, Bukhari MN, Rather LJ, Khan MA, et al. (2017) Application of terminalia chebula natural dye on wool fiber evaluation of color and fastness properties. Textiles and Clothing Sustainability 2: 1.
5. Machnowski W, Gutarowska B, Perkowski J, Wrzosek H (2013) Effects of gamma radiation on the mechanical properties of and susceptibility to biodegradation of natural fibers. Textile Research Journal 83(1): 44-55.
6. Sadeghi-Kiakhani M, Tehrani-Bagha AR, Safapour S (2018) Enhanced anti-microbial, anti-creasing and dye absorption properties of cotton fabric treated with chitosan-cyanuric chloride hybrid. Cellulose 25(1): 883-893.
7. Sadeghi-Kiakhani M, Gharanjig K, Arami M (2015) Grafting of prepared chitosan-poly(propylene) imines dendrimer hybrid as a biopolymer onto cotton and its antimicrobial property. Journal of Industrial and Engineering Chemistry 28: 78-85.
8. Tania IS (2018) Effects of resin treatments on the quality of cotton fabric dyed with reactive dye. 1: 102-107.
9. Pisitsak P, Tungsombatvisit N, Singhanu K (2018) Utilization of waste protein from antarctic krill oil production and natural dye to impart durable UV-properties to cotton textiles. Journal of Cleaner Production 174: 1215-1223.
10. Baaka N, Ben Ticha M, Haddar W, Amorim MTP, Mhenni MF (2018) Upgrading of UV protection properties of several textile fabrics by their dyeing with grape pomace colorants. Fibers and Polymers 19(2): 307-312.