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PREPARATION OF UV-RESISTANT VEGETABLE DYES FOR TEXTILES

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Abstract

In recent years, there has been a growing interest in eco-friendly and sustainable textile coloration, with vegetable-based dyes gaining popularity due to their natural origin and environmental benefits. However, one of the major limitations of vegetable dyes is their susceptibility to degradation by ultraviolet (UV) radiation, which can lead to fading and reduced durability. This article explores methods for preparing UV-resistant vegetable dyes for textiles, focusing on natural sources, dyeing processes, and potential strategies for improving their UV stability. By combining traditional and modern techniques, this study aims to enhance the practical use of vegetable dyes in the textile industry, ensuring both sustainability and durability.

Introduction

Textile dyeing is an essential part of the fashion and textile industries. Traditionally, synthetic dyes were widely used due to their bright colors, stability, and ease of use. However, environmental and health concerns have led to a resurgence of interest in vegetable dyes, derived from plants, fruits, and other natural sources. While vegetable dyes are non-toxic and biodegradable, they are often prone to fading when exposed to UV radiation from sunlight.

Ultraviolet (UV) radiation can cause chemical bonds in the dye molecules to break, resulting in the fading of colors and reduced longevity of the dyed textiles. This limitation has sparked research into methods for enhancing the UV resistance of vegetable dyes. This article reviews the preparation of UV-resistant vegetable dyes for textiles, discussing natural sources of dyes, dyeing techniques, and strategies to improve UV stability.

Sources of Vegetable Dyes

Vegetable dyes are primarily derived from plant-based materials, including leaves, roots, bark, flowers, and fruits. Some commonly used sources for vegetable dyes include:

- Indigo (Indigofera tinctoria): A well-known natural dye used for blue hues.
- Madder (Rubia tinctorum): Provides red to pink shades.
- Turmeric (Curcuma longa): Known for its vibrant yellow color.
- Hibiscus (Hibiscus rosa-sinensis): Used for shades of red and purple.
- Walnut husk (Juglans regia): A source for brown tones.
- Annatto (Bixa orellana): Provides orange-yellow hues.

These natural dyes are typically selected based on the desired color outcome and their availability. However, while these dyes are sustainable and non-toxic, their tendency to fade under UV light limits their commercial viability in outdoor textiles, where UV exposure is high.

Dyeing Process for Vegetables Dyes

The process of dyeing textiles with vegetable dyes involves several steps:

Extraction of the Dye

The dye is extracted from plant materials by soaking or boiling the raw plant matter. The specific extraction method varies based on the plant source. For example, to extract indigo dye, the leaves of the indigo plant are fermented to release the pigment, while turmeric powder can be directly dissolved in water to yield its yellow color.

Mordanting

Mordants are substances that help fix the dye to the fabric, ensuring better color retention. Common mordants for vegetable dyes include alum, iron, tannins, and copper. The selection of a mordant is crucial, as it influences both the intensity of the color and the UV resistance of the dye.

Dyeing

Once the dye extract is prepared and the mordant has been applied to the fabric, the fabric is immersed in the dye bath. The temperature, time, and pH of the dye bath play an essential role in the final color and stability. After dyeing, the fabric is washed and dried.

Fixation

To improve the UV resistance of vegetable dyes, additional fixing agents or UV-protective coatings may be applied during or after the dyeing process.

These agents help form a stronger bond between the dye molecules and the fabric, thus improving their resistance to UV degradation.

Enhancing UV-Resistance of Vegetable Dyes

Several strategies can be employed to improve the UV resistance of vegetable dyes, making them more durable for use in textiles exposed to sunlight.

Use of UV-Resistant Mordants and Fixatives

Certain mordants and fixatives can enhance the UV stability of vegetable dyes. For instance:

- Aluminum-based mordants (such as potassium alum) help improve the color fastness and UV resistance of certain dyes, especially when combined with iron or tannin-based mordants.

- UV-absorbing agents, such as titanium dioxide or zinc oxide, can be applied as postdyeing treatments. These agents act as a physical barrier, preventing the dye molecules from direct exposure to UV radiation.

Incorporating Natural UV-Blocking Compounds

Some plant extracts are naturally rich in compounds that absorb UV radiation. For example:

- Tea extracts, green tea polyphenols, and pomegranate extracts contain natural antioxidants and UV-absorbing compounds, which can be used to treat the dyed fabric.

- Sunn hemp and mango leaves have been shown to exhibit UV-blocking properties, and their extracts can be combined with vegetable dyes to enhance their UV resistance.

Nano-coatings and Composite Treatments

Recent advancements in nanotechnology have enabled the development of UV-resistant coatings for textiles. Nano-sized particles, such as **silica** or **titanium dioxide**, can be applied to the fabric surface after dyeing. These particles form a protective layer that reflects UV light, reducing the amount of radiation that reaches the dye molecules.

In addition to their UV-blocking ability, these coatings can also improve the water resistance and mechanical strength of the textiles, making them more suitable for outdoor use.