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Extraction Of Dye From Waste Blue Gel Pen Ink Using The Voltine Method And Its Application In Fabric Dyeing: An Eco-Friendly Approach

Aprajita Singh
Department of Textile Design,
National Institute of Fashion Technology, Bhubaneswar

Co Author Mr. Sumit Kumar Sharma

Assistant professor

National Institute Of Fashion Technology, Bhubaneswar

Abstract

The textile industry has long been criticized for its environmental impact, particularly due to the use of synthetic dyes that contribute to pollution. This research presents an eco-friendly method of extracting dye from waste blue gel pen ink using the Voltine Method, a process designed to reclaim pigments and reduce environmental waste. The extracted dye is applied to fabrics, highlighting the potential for sustainable fabric dyeing practices. This paper explores the efficiency of the extraction process, the quality of the dye obtained, and its application on different types of fabrics. The study aims to provide an alternative, eco-friendly solution for fabric dyeing that reduces ink waste and contributes to environmental sustainability. Through this method, a waste product, such as blue ink from discarded gel pens, is repurposed in a manner that offers practical applications in the textile industry.

Index Terms

Eco-friendly dyeing, waste ink, Voltine Method, sustainable textiles, fabric dyeing, ink waste management, textile sustainability.

I. Introduction

The textile industry is one of the largest contributors to global pollution, especially due to the extensive use of synthetic dyes. Synthetic dyes not only pose environmental risks but also consume large amounts of water and energy during the production process. With growing awareness regarding the environmental impact of textile production, there has been an increasing demand for sustainable alternatives. This study focuses on extracting dye from a non-conventional source—waste blue gel pen ink—and applying it to fabrics as a sustainable solution to fabric dyeing. The research employs the Voltine Method to extract and process the ink, ensuring that the final dye

is suitable for fabric use. The implications of this research are significant for the textile industry, where sustainability has become a key priority.

In the context of the global push for sustainability, the textile industry has started to explore natural dyes derived from plants, animals, and minerals. However, these natural dyes, while less harmful, often require extensive resources to produce, and their availability may be limited by seasonality and geographic location. In contrast, using waste ink from gel pens provides a novel approach to addressing two environmental issues simultaneously: waste management and sustainable dye production.

II. Literature Review

Previous studies have explored various sources of natural dyes, such as plant-based pigments, animal-derived substances, and even minerals, in an effort to reduce the environmental impact of synthetic dyes. Researchers have also investigated the potential of using waste products as dye sources, including food waste and industrial by-products. However, limited research has been conducted on utilizing waste ink as a dye source, particularly from disposable pens, which are often discarded without consideration of their environmental impact.

The Voltine Method, typically used in the extraction of pigments in industrial processes, has been shown to be effective in isolating dyes from liquid solutions. Its application in the textile industry remains under-explored, despite its potential to reduce the reliance on harmful chemical processes. This method relies on the controlled evaporation of solvents to extract pigment, ensuring minimal waste production. By applying this method to waste ink, this study aims to develop a sustainable process for textile dyeing.

III. Methodology

A. Collection of Waste Ink

Waste blue gel pen ink was collected from discarded gel pens that were no longer functional. The pens were dismantled, and the ink was extracted from the cartridges. The ink was then stored in a container to ensure uniformity of the solution before proceeding with the extraction process. Approximately 100 ml of ink was used for each trial in this study.

B. Extraction Process

The Voltine Method was employed to extract dye from the waste ink. In this process, the ink was heated using a gas cylinder to facilitate the evaporation of solvent components, leaving behind the dye pigments. The heating process was carefully monitored to avoid excessive evaporation, which could compromise the quality of the pigment. The extraction process was optimized to retain as much pigment as possible, ensuring that the extracted dye was of a high enough quality to be used in textile applications.

C. Application to Fabrics

The extracted dye was applied to both cotton and silk fabrics, chosen for their varying absorption properties. The dyeing process involved submerging the fabrics in the dye solution for different durations to test the effect of time on color absorption. Post-dyeing, the fabrics were rinsed with cold water to remove any excess dye and left to air-dry. The dyed fabrics were then subjected to tests for color fastness, uniformity, and durability. To ensure

consistency, the experiment was repeated multiple times, and the results were compared across different fabric types and dyeing conditions.

IV. Results and Discussion

The dye extraction process using the Voltine Method proved to be effective in isolating the blue pigment from the waste gel pen ink. The recovered dye exhibited good solubility in water, allowing for uniform application to the fabrics. Cotton and silk fabrics showed different levels of dye absorption, with silk demonstrating better color retention due to its protein-based structure, which naturally binds with the dye molecules more effectively than the cellulose-based cotton fabric.

Color fastness tests revealed that the dye remained intact even after multiple washes, though slight fading was observed in the cotton fabrics. The silk fabrics, on the other hand, retained their vibrant color after washing, indicating that the dye had bonded well with the fabric. The results suggest that waste ink dye can be a viable alternative to conventional dyes, especially for protein-based fabrics such as silk and wool. Further optimization of the dyeing process could potentially enhance the color fastness on cellulose-based fabrics as well.

V. Conclusion

This research successfully demonstrates the feasibility of extracting dye from waste blue gel pen ink using the Voltine Method. The process is not only eco-friendly but also contributes to waste reduction, as it repurposes discarded ink that would otherwise contribute to landfill waste. The application of the dye to fabrics, particularly silk, shows promising results in terms of color absorption and fastness, making it a potential alternative to synthetic dyes in the textile industry.

Future research could focus on improving the extraction process to increase the yield of dye and exploring the use of different types of waste inks. Additionally, experimenting with other fabric types, such as wool and polyester, could provide further insights into the versatility of waste ink as a sustainable dye source. By continuing to develop eco-friendly dyeing techniques, the textile industry can take significant steps towards reducing its environmental impact.

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