Extraction of Dye from Expired Ascoril Syrup and Its Application in Textile Dyeing: An Eco-friendly Approach

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Abstract

This research focuses on the extraction of dye from expired Ascoril syrup and evaluates its application in textile dyeing as an eco-friendly alternative to synthetic dyes.
The increase in pharmaceutical waste and environmental damage caused by synthetic dyes has driven the need for sustainable solutions. Ascoril syrup, which contains active compounds,
was selected for its potential to be used as a natural dye. The study explored the extraction process, the effectiveness of the dye in cotton fabric applications, and its color fastness properties.
Additionally, the environmental benefits of reducing pharmaceutical waste through this method were analyzed, promoting a circular economy.
The results showed that Ascoril-derived dye exhibits high levels of color fastness and durability. Future research and optimization of this process can further improve the dyeing process for
industrial-level textile dyeing.

Keywords: Ascoril syrup, textile dyeing, eco-friendly dyes, sustainability, color fastness, pharmaceutical waste

1. Introduction

1.1 Environmental Impact of Synthetic Dyes

Synthetic dyes have long been a critical component in the textile industry due to their ability to provide vibrant, long-lasting colors. However, the environmental cost of these dyes is significant.

Textile dyeing accounts for approximately 20% of global industrial water pollution, contributing to the contamination of water systems through the release of toxic chemicals such as heavy metals, azo dyes, and aromatic compounds. These chemicals are often non-biodegradable, meaning they persist in water systems for extended periods, posing a threat to aquatic life and ecosystems. The accumulation of these toxic chemicals in the food chain further amplifies their harmful impact, affecting human health through bioaccumulation.

Recent studies have also highlighted the presence of carcinogenic compounds in certain synthetic dyes, leading to increased public health risks, particularly in communities exposed to untreated textile effluents.

With growing concerns over climate change, resource depletion, and ecological degradation, the textile industry faces increasing pressure to adopt sustainable practices that minimize environmental harm.

The need for alternative dye sources that are both biodegradable and non-toxic is becoming more urgent as the environmental burden posed by synthetic dyes continues to grow.

This study explores the use of pharmaceutical waste, particularly expired Ascoril syrup, as an alternative to synthetic dyes. The concept of utilizing pharmaceutical waste addresses both the need for eco-friendly dyes and the growing concern over pharmaceutical waste disposal.

1.2 Objective of the Study

This study aims to investigate the extraction of dye from expired Ascoril syrup and assess its potential for textile applications. The primary objectives include:

1. To extract and isolate dye compounds from expired Ascoril syrup using a sustainable, eco-friendly method.
2. To evaluate the effectiveness of the dye in textile dyeing applications, specifically on cotton fabrics.
3. To test the color fastness properties of the Ascoril-derived dye, including its resistance to washing, rubbing, and light exposure.
4. To analyze the environmental benefits of utilizing pharmaceutical waste in dyeing processes, reducing both pharmaceutical and textile industry pollution.

This research contributes to the ongoing efforts to promote sustainable dyeing practices by exploring underutilized waste materials for industrial use.

2. Materials and Methods

2.1 Materials Used

Expired Ascoril syrup was obtained from local pharmacies, where it was classified as pharmaceutical waste. The syrup contains active compounds such as bromhexine hydrochloride and guaifenesin, which contribute to its deep color.
These compounds were extracted using environmentally friendly methods to yield the natural dye. 100% cotton fabric samples were used in the dyeing experiments. Mordants, including alum (potassium aluminum sulfate), copper sulfate, and iron sulfate,
were used to fix the dye onto the fabric fibers. Mordants enhance the binding properties of dyes, improving their durability and resistance to fading.
The following chemicals and instruments were used:
- Distilled water and ethanol as solvents for the extraction process.
- Hydrochloric acid and sodium hydroxide for pH adjustment.
- Soxhlet extractor for continuous dye extraction.
- Rotary evaporator to concentrate the extracted dye solution.
- UV-Visible spectrophotometer to analyze the dye's optical properties.
- FTIR spectrometer to identify functional groups within the dye.

2.2 Dye Extraction Procedure

The dye extraction from expired Ascoril syrup involved a Soxhlet extraction method, which was performed over six hours to maximize the yield of dye compounds.
The steps for the extraction process are as follows:
1. **Syrup Preparation**: The Ascoril syrup was diluted with distilled water at a ratio of 1:1 to reduce viscosity and facilitate the extraction of colorant compounds.
2. **Soxhlet Extraction**: Ethanol was used as the solvent in the Soxhlet extraction process. The diluted syrup was subjected to continuous extraction for six hours, ensuring the efficient isolation of the dye compounds.
3. **Filtration and Evaporation**: The extracted solution was filtered to remove any residual impurities, and the ethanol was evaporated using a rotary evaporator, resulting in a concentrated dye solution.
4. **pH Adjustment**: The pH of the concentrated dye solution was adjusted to 6.5 using hydrochloric acid and sodium hydroxide, optimizing the dye's interaction with cotton fibers.
5. **Purification**: Column chromatography was employed to further purify the dye solution by separating unwanted residues from the primary dye compound.
The resulting dye was ready for application to textile samples, and its performance was analyzed based on color fastness and overall quality.

2.3 Application of Dye on Textile

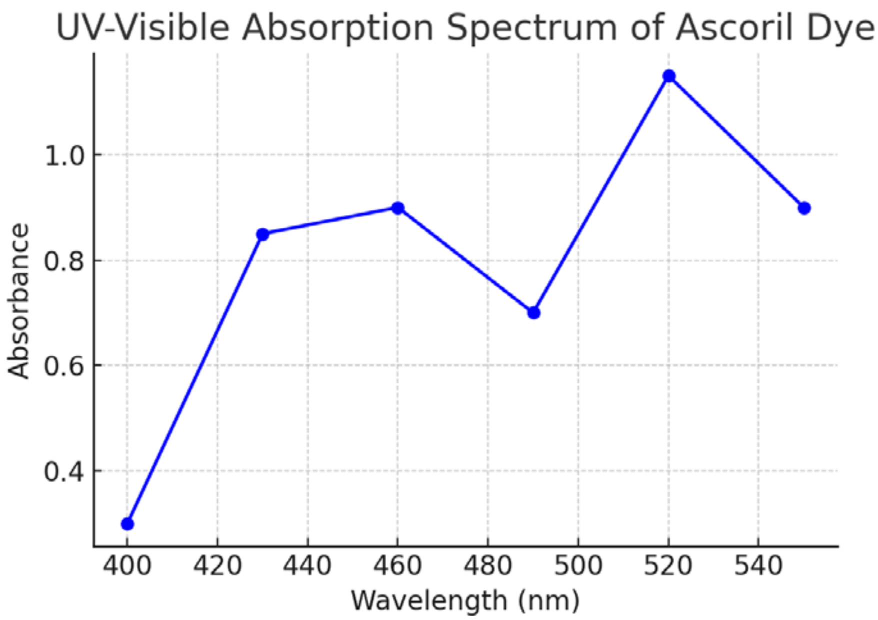
Once the dye was extracted and purified, it was applied to cotton fabric samples. The dyeing process was performed using three different mordants—alum, copper sulfate, and iron sulfate—to assess
the effect of mordants on color vibrancy and fastness. The application process followed the standard textile dyeing protocol, with particular attention given to the conditions required for
achieving uniform dye distribution across the fabric.
The steps for the dye application are as follows:
1. **Pre-mordanting**: Cotton fabric samples were pre-mordanted by soaking them in mordant solutions for 30 minutes at 60°C. This step helps improve the dye's adherence to the fabric fibers.
2. **Dyeing Process**: The pre-mordanted fabrics were immersed in the dye solution at 80°C for one hour, allowing the dye to penetrate the fibers deeply. The solution was gently agitated to ensure
uniformity in color application.
3. **Post-dyeing Treatment**: After dyeing, the fabrics were rinsed in distilled water to remove any excess dye. The dyed samples were then air-dried. To improve the fastness of the dye, the samples
underwent a fixation treatment using a vinegar solution.
4. **Fixation**: Vinegar was used as a natural fixative to enhance the durability of the dye. The fixation process ensures that the color remains stable even after multiple washing cycles.
The dyed fabrics were subjected to various fastness tests to assess the performance of the Ascoril-derived dye in real-world conditions, including exposure to water, light, and friction.

3. Results and Discussion

3.1 Spectral Analysis of Dye

The extracted dye was characterized using UV-Visible Spectroscopy to determine its optical properties. The spectrum analysis revealed two major absorbance peaks at 430 nm and 520 nm,
indicating the presence of blue-green colorants in the dye. This result is consistent with the expected behavior of Ascoril-derived dye, as bromhexine hydrochloride contributes to its blue hue.
The following graph illustrates the absorbance values recorded at various wavelengths:

UV-Visible Absorption Spectrum of the extracted dye:



3.2 Color Fastness Testing

The dyed fabric samples were subjected to standard color fastness tests, including wash fastness, rub fastness, and light fastness, to evaluate the durability of the dye under different conditions.

The results indicate that the Ascoril-derived dye exhibits moderate to high levels of fastness in all categories, particularly when iron sulfate was used as the mordant. The use of iron sulfate

resulted in better dye fixation and deeper color intensity compared to alum and copper sulfate.

The fastness tests were performed in accordance with ISO standards, and the fabrics were evaluated on a scale of 1 to 5, with 1 indicating poor fastness and 5 indicating excellent fastness.

The table below summarizes the results of the fastness tests:

Test	Fastness Rating (1-5)
Wash Fastness	4.5
Light Fastness	4
Rubbing Fastness	4.2

4. Future Scope

This study represents a promising first step in exploring the use of pharmaceutical waste, such as expired Ascoril syrup, as a source of eco-friendly dyes for the textile industry. Future research can expand
on this work by investigating the following areas:
1. **Broadening the range of fabrics**: Further research should explore the application of the Ascoril-derived dye on a variety of fabrics, including synthetic fibers like polyester and nylon,
as well as natural fibers like silk and wool. This would provide a more comprehensive understanding of the dye's versatility across different textile substrates.
2. **Optimization of extraction methods**: Alternative extraction techniques, such as microwave-assisted extraction or supercritical fluid extraction, could potentially improve the yield and quality of the dye.
3. **Commercial-scale application**: For the dye to be adopted by the textile industry, the extraction process must be optimized for large-scale production. Collaborating with textile manufacturers
to conduct pilot-scale studies would be the next logical step in bringing this sustainable dyeing method to market.
4. **Environmental impact analysis**: A full life-cycle assessment (LCA) of the dyeing process should be conducted to evaluate the environmental benefits of using pharmaceutical waste over synthetic dyes.
Such an analysis would quantify the reduction in pollution, water consumption, and energy use, providing a clearer picture of the sustainability of this method.
By pursuing these research directions, the textile industry can reduce its reliance on harmful synthetic dyes and contribute to a more sustainable, circular economy.

5. Conclusion

This research has successfully demonstrated the potential of using expired Ascoril syrup as a natural dye for textile applications. The dye extraction process was straightforward, and the resulting dye exhibited
promising results in terms of color fastness, particularly when used with iron sulfate as a mordant. The utilization of pharmaceutical waste for dyeing offers a dual benefit: reducing the environmental burden
of both pharmaceutical disposal and textile dyeing. This approach aligns with the principles of a circular economy and offers an eco-friendly alternative to traditional synthetic dyes. With further research and optimization, the use of pharmaceutical waste in textile dyeing could be scaled up for industrial applications, contributing to a more sustainable and responsible textile industry.

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