International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 12, December 2025)

Ultrasonic Green Dyeing of Cotton with Coconut Soft Husk and Biomordants

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***Abstract*— This review study looks into the cutting-edge field of environmentally friendly dyeing procedures, with a particular emphasis on the ground-breaking technique of ultrasonic dyeing, which makes use of coconut soft husk extracts and bio mordants. Because they require a lot of water, are very energy intensive, and pollute the environment with chemicals, traditional dyeing techniques have given rise to serious environmental issues. This is why the purpose of this article is to investigate the possibilities of ultrasonic dyeing, which is a technique that makes use of sound waves with a high frequency to increase the dye's penetration into textiles.**

The study shows the environmental benefits of employing coconut soft husk extracts as natural dyes, successfully utilizing a waste byproduct of the coconut industry. Specifically, the study looks at the environmental benefits of using natural colors made from coconut soft husk extracts. Bio mordants, which are produced from plant sources, are being developed as environmentally acceptable alternatives to chemical mordants. These bio mordants improve color fastness while simultaneously lowering pollution.

The research reveals that the approach is capable of producing a wide variety of colors by painstakingly analyzing the compatibility of various bio mordants and dyes derived from coconut soft husk. The method that has been suggested not only cuts down on the amount of water and energy that are used, but it also limits the number of chemical pollutants, making it compatible with sustainable principles.

In its conclusion, the review study emphasizes the significance of environmentally responsible dyeing processes for the textile industry in terms of its responsibility to the environment. It portrays the proposed method as a revolutionary approach that strikes a balance between the colouring requirements of the business and the needs of the environment to be preserved. The research considers the possibility of a future in which textiles are not only visually appealing but also in harmony with their natural environments.

***Keywords*—sustainable dyeing, ultrasonic dyeing, coconut soft husk, bio-mordants, environmental conservation, textile industry, eco-friendly coloration.**

I. INTRODUCTION

Although the textile business is extremely important to the functioning of the global economy, one cannot disregard the negative effects that it has on the natural world. The conventional dyeing procedures, which are characterized by the excessive use of water, energy, and chemicals, have aroused substantial environmental concerns in recent decades. As both consumers and businesses become more aware of the need for environmentally responsible activities, there is a growing need for environmentally friendly alternatives in a variety of industries, including the textile industry. Batch dyeing and exhaust dyeing are two examples of traditional dyeing processes that have been widely used in the textile industry for many years. However, the detrimental consequences that they have on the surrounding ecosystem are becoming more and more obvious. The process consumes enormous quantities of water, which frequently results in the contamination of nearby bodies of water with harmful chemicals and artificial dyes. In addition, the high energy requirements of these processes contribute to the generation of greenhouse gases and place an additional burden on the earth's natural resources.

To reduce the negative impact that the textile industry has on the environment and to respond to the environmental difficulties that we face, researchers are investigating new dyeing methods. Ultrasonic dyeing is a relatively new method that shows tremendous promise due to the possibility that it may cut both water and energy consumption while also increasing the amount of dye that is taken up by the material. When applied during the dying process, ultrasonic waves generate cavitation bubbles that stir the dye bath. This results in enhanced dye penetration and fixation onto the textile strands (Lara, Cabral, & Cunha, 2022). simply to download the template, and replace(copy-paste) the content with your own material.

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1.1 Research Problem and Objectives

The primary research problem addressed in this review paper is how to achieve sustainable dyeing of cotton textiles using coconut soft husk extracts as natural dyes and bio-mordants for dye fixation. The paper aims to explore the feasibility, effectiveness, and environmental benefits of this proposed dyeing method. The objectives of the research include:

1. Investigating the dyeing potential of coconut soft husk extracts as a source of natural dyes.
2. Exploring different bio-mordants compatible with coconut soft husk dyes for improved dye fixation.
3. Assessing the sustainability aspects of the ultrasonic dyeing process using coconut soft husk and bio-mordants.

Through an in-depth exploration of these objectives, this review paper intends to shed light on the viability of sustainable ultrasonic dyeing using coconut soft husk and bio-mordants as an eco-friendly alternative for the textile industry.

II. Sustainable Dyeing Techniques

The concepts of sustainable dying focus on reducing the harmful effects of the dyeing process on three key areas: the environment, human health, and the resources available. The overarching objective is to find a solution that allows for the production of colored textiles while also minimizing the impact on the ecological systems of the globe. The reduction of water use, energy consumption, and chemical discharge, as well as the improvement of dye fixation and color fastness, are fundamental principles. If the textile sector adheres to these principles, it will be able to make a major contribution to a more environmentally friendly and sustainable future (Elsahida et al., 2019).

2.1 Overview of Eco-Friendly Dyeing Methods

The use of eco-friendly dyeing procedures as viable alternatives to conventional methods has gained traction in recent years. The utilization of plant-based sources as a means to extract pigments for coloring textiles is an example of one technique that falls under this category. Natural dyes are not only more environmentally friendly because they are biodegradable, but they also provide a wider range of color options. In addition to this, the application of bio-mordants, which are compounds that make it easier for the dye to adhere to fibers, further improves color fastness and removes the requirement for the use of harsh chemicals.

Fig:1 Eco-friendly Dyeing Process (Source: SlideShare.net)

In addition, whole new processes have evolved, such as ultrasonic dyeing, which is one example. The use of ultrasonic dyeing makes use of acoustic energy to improve the dye's ability to penetrate the fabric, which in turn results in lower dye and energy requirements. This technology also has the potential to be combined with environmentally friendly dye supplies, which would further increase the dyeing process's overall sustainability (Bureekhampun & Maneepun, 2021).

2.2 Comparison of Traditional and Sustainable Dyeing Techniques

Fig: 2 Traditional Dyeing Process (Source: Pallavi Sunil Gudulkar)

The examination of the differences between conventional dyeing processes and eco-friendly ones is an essential component of the ongoing effort to promote environmentally responsible business practices in the textile sector. Traditional methods, which are characterized by high water use, employment of chemicals, and energy expenditure, have severe consequences on both the well-being of humans and the ecosystems in which they are implemented. On the other hand, sustainable processes place a higher emphasis on the conservation of resources, the reduction of pollution, and the improvement of the interaction between fibers and dyes.

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The comparison takes into account a variety of factors, such as the amount of water used, the amount of energy consumed, the amount of trash generated, and the efficiency with which dye is fixed. When comparing the environmental impact and overall performance, sustainable methods such as natural dyeing and ultrasonic dyeing almost always come out on top when compared to more conventional procedures. In addition, methods of sustainable dyeing are in line with the desires of consumers for ethically made textiles, which contributes to an increase in marketability and the expansion of the sector (ACS Omega, 2020).

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2.3. Ultrasonic Dyeing Process

The groundbreaking process of ultrasonic dying colors fabrics in a way that is both environmentally friendly and efficient. This is accomplished by utilizing the power of sound waves. The operation is accomplished by sending high-frequency ultrasonic waves through the dye bath and the fabric. This is the core of the working principle. When these waves come into contact with the liquid medium, a phenomenon known as cavitation takes place. This phenomenon results in the formation of small bubbles (Al-Etaibi & El-Apasery, 2021).

Because of the production and subsequent collapse of these bubbles, localized energy is produced, which in turn leads to improved diffusion and penetration of dye molecules into the threads of the fabric. Because of its dynamic agitation mechanism, the dye is absorbed quickly and uniformly, which eliminates the need for longer dying times and more chemicals than are really necessary (Wang et al., 2018).

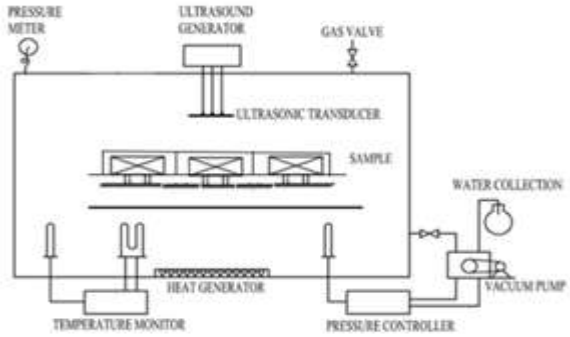

Fig: 3 Ultrasonic Dyeing Process (Source: Pallavi Sunil Gudulkar

2.4 Advantages of Ultrasonic Dyeing

When compared to conventional dyeing procedures, ultrasonic dyeing represents a paradigm change because it provides a number of benefits that contribute to its sustainability. First and foremost is the significant decrease in the amount of water used. Because cavitation enables increased dye penetration, the amount of water required for dye fixation can be reduced to a minimum. As a result, ultrasonic dyeing is intrinsically water-efficient. In addition, the procedure can be carried out at lower temperatures, which results in less energy consumption and a smaller carbon footprint associated with the dyeing activities. The regulated cavitation makes it easier to use less chemical additives, which results in less contamination of the wastewater and safer working conditions for the people who work in the dye house (Nazmul Islam et al., 2017).

Because of its forward-thinking methodology and environmentally friendly results, the implementation of ultrasonic technology in the textile sector has gained traction in recent years. Previous research investigations have investigated the performance of ultrasonic dyeing on a wide range of textiles as well as classes of dye. Investigations have shown that it can increase dye uptake efficiency, decrease the amount of time required for dyeing, and improve color fastness qualities.

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Furthermore, ultrasonic dyeing has shown promise in dying difficult textiles like as mixes and synthetics, which addresses a constraint that has been present in traditional dyeing procedures for a very long time.

The use of ultrasonic dyeing in a variety of the textile industry's processes has gained widespread acceptance. The ability of the technology to offer brilliant and consistent coloration has attracted attention in a variety of contexts, including fashion textiles and technical textiles. Dyeing elaborate patterns and designs, where accurate distribution of the dye is essential, has also shown to be a useful application for ultrasonic dyeing. The connection of ultrasonic dyeing with environmentally friendly techniques helps to further increase its significance in the market as rising consumer demand for sustainable products continues to develop (Islam & Ke, 2020).

In conclusion, the purpose of this chapter was to offer a comprehensive investigation into the process of ultrasonic dyeing. It elucidates the complex working principle of cavitation-driven dye penetration and highlights the multiple benefits that it offers in comparison to more conventional dyeing procedures. In addition to this, the chapter highlights the contributions of earlier research as well as the various applications of ultrasonic dyeing in the textile industry. This paves the way for succeeding chapters that go more into specific applications of the technology.

2.5. Natural Dyes from Coconut Soft Husk

2.5.1. Composition and Properties of Coconut Soft Husk

Coconut soft husk, a byproduct of the coconut industry, presents an untapped resource for natural dyes in the textile sector. Rich in tannins, flavonoids, and polyphenols, coconut soft husk contains a diverse range of pigments that can yield various shades when applied to textiles. The husk's fibrous structure, combined with its dye-rich compounds, makes it an ideal candidate for sustainable coloration. Additionally, the availability of coconut soft husk waste offers a solution for waste reduction in the coconut processing chain, enhancing the overall sustainability of the dyeing process (Kusumawati, Samik, & Muslim, 2021).

2.5.2. Extraction Methods for Dye Compounds

Extracting dye compounds from coconut soft husk involves a series of steps to release and concentrate the pigments for dyeing. Common extraction methods include hot water extraction, ethanol extraction, and aqueous extraction with organic solvents.

Each method has its advantages in terms of efficiency and pigment yield. The extracted dye solution can be further processed to remove impurities and adjust concentration, ensuring consistent and reproducible dyeing outcomes.

2.5.3. Color Range Achievable from Coconut Soft Husk Dyes

The color palette achievable from coconut soft husk dyes is diverse and ranges from earthy tones to vibrant hues. The specific color obtained depends on factors such as the dye concentration, pH of the dye bath, mordant used, and fiber type. Natural compounds within the husk, such as tannins, can yield shades of brown and gray. However, through careful experimentation and optimization of dyeing conditions, a broader spectrum of colors—including yellows, greens, and even reds—can be achieved. The ability to produce a range of colors makes coconut soft husk dyes versatile for various textile applications.

III. Bio Mordants For Dye Fixation

3.1. Mordants and Their Role

Mordants are vital components in the process of dying, playing a pivotal role in the enhancement of color fastness and dye uptake into textile fibers. Mordants can be broken down into two categories: direct mordants and indirect mordants. They serve as bridges between the dye molecules and the fibers, which ensures good attachment and fading resistance. Traditional chemical mordants, despite their efficacy, frequently cause environmental damage due to the presence of heavy metals in their composition and the possibility that they will pollute water systems. In response, there has been a rise in interest in the investigation of bio-mordants, which are natural chemicals that possess mordanting qualities (Kumar Samanta, 2020). This is being done as a sustainable alternative.

3.2. Bio Mordants and Their Advantages

Bio-mordants are derived from plant sources and exhibit characteristics that align with eco-friendly dyeing practices. Unlike chemical mordants, bio-mordants are biodegradable, non-toxic, and renewable. This makes them environmentally benign throughout the dyeing process, from application to eventual disposal. Furthermore, bio-mordants often have additional benefits, such as imparting antibacterial or antioxidant properties to the dyed textiles, thereby enhancing their value and functionality.

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3.3. Bio Mordants Compatible with Coconut Soft Husk Dyes

When trying to achieve successful and environmentally responsible dye fixation, one of the most important factors to take into account is the compatibility of biomordants with coconut soft husk dyes. In combination with coconut soft husk dyes, several mordants have been demonstrated to have promising results. One example of this is alum that has been generated from plants, which can efficiently mordant coconut soft husk colors and improve the color fastness capabilities of those dyes. Tannin-rich materials, such as extracts from plant barks or leaves, have also shown compatibility, which facilitates robust dye adhesion onto fibers. These materials are compatible (Pinheiro et al., 2019).

Additionally, investigating the possibilities of bio-mordants such as pomegranate peel, myrobalan, and quebracho in combination with coconut soft husk dyes gives an intriguing avenue for the fixation of sustainable colors. These mordants have the advantage of naturally occurring severe characteristics, which not only contribute to the color fastness of the dyeing process but also to the ecological integrity of the process as a whole.

In conclusion, the focus of this chapter is on the use of biomordants as an alternative to conventional dye-fixing methods. It begins with an explanation of mordants and their function in the dyeing process, then moves on to an examination of the benefits that bio mordants have to offer in comparison to their chemical analogues. The final section of this chapter provides information on a variety of bio mordants that are compatible with coconut soft husk dyes. These bio mordants are discussed in terms of their potential to improve the color fastness and sustainability of the dyeing process.

3.4. Environmental Benefits of Coconut Soft Husk and Bio Mordants

The proposed method of sustainable ultrasonic dyeing using coconut soft husk and bio mordants brings forth a plethora of environmental benefits. Coconut soft husk, as a natural dye source, utilizes a waste byproduct that would otherwise contribute to landfill or disposal issues. This approach transforms waste into a valuable resource, minimizing the environmental burden associated with waste management. Additionally, bio mordants further amplify the eco-friendliness of the process by replacing chemical mordants, reducing the release of harmful substances into the environment.

3.5. Reduction in Water Consumption, Energy Usage, and Chemical Pollution

The method that has been developed has the ability to significantly cut down on the amount of water that is used. This is one of the most notable features of the method. The ultrasonic dyeing process, when combined with coconut soft husk and bio mordants, enables efficient dye penetration, which results in shorter dying times and little water waste. This is made possible by the ultrasonic dyeing method. In addition, the decreased requirement for harsh chemical additives, which are typically used in traditional dyeing, helps to reduce the amount of chemical contamination found in wastewater (Mumal Singh et al., 2021).

The lower operating temperatures of ultrasonic dyeing, in conjunction with the natural qualities of coconut soft husk and bio mordants, translate to decreased energy demands. This is because lower operating temperatures require less energy to maintain. This decrease in energy usage not only helps to save resources but also reduces carbon emissions, which means that the solution that has been offered is a step in the right direction toward combatting climate change.

3.6. Comparison of Sustainability with Other Dyeing Techniques

It is vital to compare the viability of the suggested approach with the viability of existing dyeing procedures in order to evaluate its effectiveness. The conventional dyeing processes, which need a significant amount of water and energy, cannot compare to the suggested method because of its high levels of water efficiency, energy savings, and low chemical content. The increased marketability of the dyed textiles is a direct result of the use of natural dye sources and bio mordants. Natural dye sources and bio mordants are in line with the desires of consumers for environmentally conscious products.

In addition, when compared to other techniques of dyeing that are sustainable, the method that was offered stands out owing to its holistic approach, which incorporates several aspects of sustainability into a single concept. The combination of coconut soft husk, bio mordants, and ultrasonic dyeing demonstrates a thorough commitment to reducing the environmental effect of the dyeing process across its many different elements.

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IV. Challenges And Future Directions

4.1. Identification of Challenges and Limitations

The sustainable ultrasonic dyeing method that makes use of coconut soft husk and bio mordants has been developed, and while it shows promise, it is not without its limitations. Obtaining results in color that are both consistent and reproducible is one of the key challenges. The color constancy of products made from natural dyes can be affected by fluctuations in the dye's source, which can be caused by factors such as seasonal shifts and geographical origin. In addition, the compatibility between various bio mordants and dyes made from coconut soft husk might vary, which requires careful selection and optimization to achieve the best results.

In order to meet the requirements of industry, there is also the issue of scaling up the process. It is necessary to give serious thought to the equipment, resources, and logistical issues in order to determine whether or not it is feasible to implement the proposed method on a bigger scale while still keeping its sustainability features.

4.2. Discussion on Potential Solutions and Areas for Improvement

A number of different approaches can be taken in order to overcome the obstacles that stand in the way. Through strict quality control and the standardization of the dye extraction procedures, it is possible to reduce the amount of variation in the colors that are produced. A regular supply of high-quality coconut soft husk may be secured by collaboration with the local communities and farmers, which would reduce variations in the procurement of the material.

Increasing the capacity of the process could be accomplished by the creation of customized machinery that is sized appropriately for larger batches, all while maintaining the ultrasonic dyeing method's high level of productivity and long-term viability. It may be possible to improve dye absorption consistency by investigating novel extraction procedures for biomordants and determining the extent to which they are compatible with a wider variety of dye sources.

4.3. Exploration of Future Research Directions

It is recommended that future study be directed toward improving the effectiveness, adaptability, and longevity of the procedure that has been proposed. It is possible that additional research into the optimization of ultrasonic dyeing parameters, such as frequency, amplitude, and treatment time, could produce even better outcomes, hence boosting color uptake and fixation.

Exploring the use of other natural dye sources in addition to soft husk from coconuts has the potential to broaden the color range as well as make the method more flexible. Exploration should also focus on conducting research on the potential synergies that can exist between various biomordants and the effects that these synergies have when combined on color fastness and fiber characteristics.

In addition, the performance of life cycle evaluations to quantify the environmental impact of the proposed process in comparison to other dyeing techniques would give strong proof that it is sustainable. The integration of the proposed technology into regular dyeing methods might be facilitated by collaborative efforts between researchers, industry stakeholders, and legislators. This would support sustainable transformation within the textile industry.

In conclusion, this chapter focuses on the difficulties and restrictions posed by the method that has been proposed, while also giving potential answers and possible directions for advancement. This highlights how important it is to address these problems in order to successfully adopt and apply sustainable ultrasonic dyeing utilizing coconut soft husk and bio mordants. The final section of the chapter provides an overview of the fruitful future research directions that have the potential to propel forward developments in environmentally friendly dyeing techniques.

V. Conclusion

In this study, we embarked on a journey to explore the realm of sustainable dyeing methods through the innovative approach of ultrasonic dyeing using coconut soft husk and bio mordants. The key findings and insights gained from our investigation shed light on the potential of this method to revolutionize the textile industry's approach to coloration while minimizing its environmental footprint.

5.1. Key Findings and Insights

Our exploration into the sustainable dyeing landscape revealed the pressing need for eco-friendly alternatives to traditional dyeing methods. The significance of sustainability principles in dyeing practices was underscored, as conventional methods posed substantial challenges in terms of water consumption, energy usage, and chemical pollution. The introduction of ultrasonic dyeing using coconut soft husk and bio mordants emerged as a holistic solution that addresses these challenges while enhancing dyeing efficiency.

5.2. Significance of Sustainable Dyeing

It is impossible to stress the importance of using environmentally friendly dyeing techniques. The textile industry is well-known for its practices that use a significant amount of resources. Currently, the industry is at a crossroads where the adoption of environmentally friendly processes is not just an option, but a need. Our research reveals that the method that was suggested is compatible with this need, as it results in lower levels of water and energy consumption as well as lowered levels of chemical contamination. Not only do these characteristics establish

industry. The textile industry has the potential to redefine its impact on the environment by adopting this strategy, all while simultaneously producing goods that resonate with environmentally concerned the textile sector as a responsible steward of the environment, but they also satisfy the aspirations of consumers for textiles that are produced in an ethical manner.

As we come to the end of our investigation, it is important to take some time to consider how the proposed method can influence the protection of the natural environment. Incorporating ultrasonic dyeing, coconut soft husk, and biomordants into a single process represents a synergistic approach that is not only beneficial to the textile industry but also to the environment. We are able to pave the path for a more sustainable future if we make use of waste materials, reduce our consumption of resources, and embrace alternatives that are favourable to the environment.

The method that has been suggested has the potential to make a sizeable contribution to the problem of the water shortage, the consumption of energy, and the chemical pollution that are all related with dyeing. Our research presents a workable approach that can be implemented across the textile supply chain, which comes at a time when companies all over the world are working to embrace greener practices.

In conclusion, the outcomes of this work highlight the revolutionary potential of sustainable ultrasonic dyeing utilizing coconut soft husk and bio mordants. coconut soft husk is a byproduct of the coconut customers. As we move forward into the future, the method that has been suggested shines as a ray of light, offering the possibility of a world that is both more sustainable and more lively.

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