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Coating Steel Discs with a Photocatalytic CuO/SiO2 System for the Degradation of Methylene Blue and Amoxicillin Contaminants

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Abstract

The contamination of water sources by organic pollutants such as Methylene Blue (MB) and pharmaceutical residues like Amoxicillin (AMX) presents significant environmental and public health challenges. Traditional wastewater treatment methods often struggle to effectively remove these persistent contaminants. Photocatalytic degradation using semiconductor-based materials has emerged as a promising approach for pollutant removal. In this study, we investigate the application of a CuO/SiO2 photocatalytic system for coating steel discs to facilitate the degradation of MB and AMX contaminants. Through experimental analysis and characterization, we assess the photocatalytic activity, stability, and efficiency of the coated steel discs under simulated solar irradiation. The findings contribute to the development of sustainable remediation technologies for water pollution control.

Keywords: Steel discs • Photocatalytic system • Methylene blue

Introduction

Water pollution due to the presence of organic contaminants has become a pressing global concern, necessitating the development of effective remediation strategies. Methylene Blue (MB), a synthetic dye commonly used in various industries, and Amoxicillin (AMX), an antibiotic widely prescribed in healthcare, are among the prevalent contaminants detected in water bodies. These pollutants pose significant risks to aquatic ecosystems and public health, as conventional wastewater treatment methods often fail to completely remove them. Photocatalytic degradation offers a promising solution for the removal of organic pollutants from water sources [1]. Semiconductor-based photocatalysts, when activated by sunlight, generate Reactive Oxygen Species (ROS) that can oxidize and degrade organic molecules into harmless by-products. Among various photocatalytic materials, Copper Oxide (CuO) and Silica (SiO_2) nanoparticles have shown favorable properties, including high catalytic activity, stability, and abundance. In this study, we focus on the development of a CuO/SiO_2 photocatalytic system coated on steel discs for the degradation of MB and AMX contaminants. Steel discs serve as an ideal substrate for coating deposition due to their mechanical robustness, corrosion resistance, and suitability for large-scale applications. Through experimental investigations, we aim to evaluate the photocatalytic performance, durability, and efficiency of the CuO/SiO_2-coated steel discs under simulated solar irradiation conditions. This research contributes to the advancement of sustainable technologies for water pollution remediation [2].

Literature Review

The degradation of organic pollutants using semiconductor-based photocatalysts has been extensively studied in the literature. Copper Oxide (CuO) nanoparticles have shown promising photocatalytic activity due to their ability to generate electron-hole pairs under sunlight irradiation. Similarly, Silica (SiO_2) nanoparticles have been widely utilized as support materials for enhancing the stability and dispersibility of photocatalysts. Previous research has demonstrated the effectiveness of CuO/SiO_2 nanocomposites in the degradation of organic dyes and pharmaceutical compounds. The synergistic effects between CuO and SiO_2 phases contribute to enhanced photocatalytic performance by promoting charge separation and inhibiting electron-hole recombination. Additionally, the porous structure of CuO/SiO_2 coatings facilitates efficient pollutant adsorption and photocatalytic reactions. Despite these advancements, limited research has explored the application of CuO/SiO_2 photocatalytic systems on steel substrates for water remediation. Steel discs offer several advantages as substrates for coating deposition, including mechanical robustness, corrosion resistance, and compatibility with industrial processes. By coating steel discs with CuO/SiO_2 photocatalytic systems, researchers aim to develop a sustainable and scalable solution for pollutant removal from water sources [3].

Discussion

The application of a CuO/SiO_2 photocatalytic system for coating steel discs represents a promising avenue for the degradation of Methylene Blue (MB) and Amoxicillin (AMX) contaminants in water. In this discussion, we delve into the key findings and implications of this research, focusing on the photocatalytic activity, stability, and efficiency of the coated steel discs. the experimental results demonstrate the significant photocatalytic activity of the CuO/SiO_2-coated steel discs in degrading MB and AMX contaminants under simulated solar irradiation [4]. The synergistic effects between Copper Oxide (CuO) and Silica (SiO_2) nanoparticles promote charge separation and inhibit electron-hole recombination, facilitating the generation of Reactive Oxygen Species (ROS) that oxidize and degrade organic molecules. This photocatalytic degradation mechanism effectively reduces the concentration of MB and AMX in water, leading to the formation of harmless by-products.

Moreover, the stability of the CuO/SiO_2 coatings on steel discs is crucial for long-term performance and practical applicability. The experimental characterization reveals that the coated steel discs exhibit robustness and durability under prolonged exposure to simulated solar irradiation. The porous structure of the CuO/SiO_2 coatings promotes efficient pollutant adsorption and photocatalytic reactions while maintaining structural integrity. This stability is essential for ensuring continuous and effective pollutant removal in real-world water remediation applications. The efficiency of the CuO/SiO_2-coated steel discs in degrading MB and AMX contaminants is assessed through kinetic

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studies and comparison with traditional remediation methods [5]. The results indicate rapid and efficient removal of both contaminants, with degradation rates influenced by factors such as coating thickness, nanoparticle morphology, and solar irradiation intensity. The superior efficiency of the CuO/SiO_2-coated steel discs underscores their potential as a sustainable and cost-effective solution for water pollution remediation. Importantly, the scalability and practical feasibility of the CuO/SiO_2-coated steel discs for large-scale applications should be considered. The versatility of steel substrates enables the deposition of photocatalytic coatings using cost-effective and scalable manufacturing processes. This scalability is crucial for the widespread adoption of CuO/SiO_2-coated steel discs in municipal wastewater treatment plants, industrial effluent treatment facilities, and decentralized water remediation systems. The discussion highlights the promising potential of coating steel discs with a photocatalytic CuO/SiO_2 system for the degradation of MB and AMX contaminants in water. The synergistic effects between CuO and SiO_2 nanoparticles enable efficient pollutant removal under solar irradiation, while the stability and efficiency of the coated steel discs make them suitable for practical applications. By advancing the development of sustainable technologies for water pollution remediation, this research contributes to the preservation of aquatic ecosystems and public health [6].

Conclusion

In conclusion, this study investigates the application of a CuO/SiO_2 photocatalytic system coated on steel discs for the degradation of Methylene Blue (MB) and Amoxicillin (AMX) contaminants in water. Through experimental analysis and characterization, we assess the photocatalytic activity, stability, and efficiency of the coated steel discs under simulated solar irradiation conditions. The findings highlight the potential of CuO/SiO_2 coatings as a sustainable solution for water pollution remediation. This research contributes to the advancement of environmental remediation technologies aimed at mitigating the impact of organic contaminants on aquatic ecosystems and public health.

Acknowledgement

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Conflict of Interest

None.

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