Synthesis and Application of Magnetized Charcoal for Wastewater Treatment

Farozan Umer[1,2]*, Maryam Mahmood[1]
[1]Department of Chemistry, Jinnah University for Women, Karachi, Pakistan.
[2]Department of Chemistry, University of Karachi, Karachi, Pakistan.
*E-mail: farozan.umer@juw.edu.pk

ABSTRACT

The presence of dye wastewater in the environment have significant threats to environmental ecosystem and sustainability. The low-cost and effective method to treat wastewater is required to remove the dye content from the wastewater. The current research focuses on the magnetization of activated charcoal for the removal of methylene blue dye. The commercially available activated charcoal is introduced during preparation of magnetic iron particles by co-precipitation method to generate magnetized composite surface for adsorption. The prepared surface is characterized by the scanning electron microscope and electron dispersion spectroscopy (SEM-EDS) for the surface structure and particles size. Two different types of dyes methylene blue (MB) and reactive orange (RO) form aqueous system are subjected for adsorption study on magnetized activated charcoal. The prepared composite surface effectively adsorb both type of dyes rapidly.

Keywords: Magnetic Nano-Particles, Adsorption, Methylene Blue, Reactive Orange.

INTRODUCTION

The extensive release of industrial dye waste water in the environment is a significant threat to the ecosystem and sustainability of the environment due to their toxic, non-biodegradable, and harmful effect on living organism. The removal of dyes from industrial wastewater before releasing in environment has become a major focus. Different chemical and physical methods such as ozonation, precipitation, solvent extraction, ion exchange, microbiological degradation, adsorption, and oxidative decomposition have been developed to treat dye-contaminated water (Al-Asadi *et al*., 2025). Adsorption on activated charcoal is the most prominent technique for the removal of organic dyes due to its low cost, large surface area, and high capability to adhere dye molecule. (Xu *et al*., 2025; Jiang & Ren 2025). Magnetic nano particles also used for adsorption and catalytic degradation of dyes. A composite of magnetic nano particles and activated charcoal can have broader application such as adsorption of metal ions and dyes, degradation of dye and effective removal of adsorption surface from aqueous medium after adsorption by means of magnetic field (El Meziani *et al.*, 2025; Li *et al.*, 2025). Recent studies have demonstrated that composite adsorbent surfaces composed of activated charcoal and magnetic nanoparticles exhibit high efficiency in removing various types of dyes, such as methylene blue, rhodamine B, and azo dyes from wastewater (Dhila, *et al*., 2025).

OBJECTIVE

The objective of current research to prepare a composite consist of magnetic nono-particle and activated charcoal to achieve maximum decolourization from aqueous medium and to determine physical parameters of the adsorption kinetics.

METHODOLOGY

The composite adsorbing surface was prepared by co-precipitation method using iron salt as core magnetic material and activated charcoal. The batch adsorption experiments were carried out using different conditions

for optimization of adsorption method for MB and RO dyes. Effect of different parameters for adsorption efficiency such as concentration of dye, adsorbent quantity, pH and adsorption time was studied. Kinetic and thermodynamic models were applied to the data to determine physical parameters and feasibility of adsorption.

KEY FINDINGS

The magnetization of activated charcoal enhanced the efficiency of adsorption of MB and RO dyes. The prepared surface is so effective that 90% of the dye adsorbed within 10 minutes on to the surface. The neutral pH is found to be most effective for the adsorption of dyes. High concentration of dye can be removed by enhanced dosage of adsorbent surface.

CONCLUSION

The magnetized activated charcoal have good adsorption capacity for the removal of MB dye. The magnetization on nano scale enhanced the surface area and increase interaction. It also produce ease in separating the surface from waste water after adsorption by means of magnetic field.

REFERENCES

1. Al-Asadi, Safaa Talib, *et al*. "A Comprehensive Review of Methylene Blue Dye Adsorption on Activated Carbon from Edible Fruit Seeds: A Case Study on Kinetics and Adsorption Models." Carbon Trends (2025): 100507. Print.
2. Dhila, Hozefa, Abhishek Bhapkar, and Shekhar Bhame. "Metal Oxide/Biochar Hybrid Nanocomposites for Adsorption and Photocatalytic Degradation of Textile Dye Effluents: A Review." Desalination and Water Treatment 321 (2025): 101004. Print.
3. El Meziani, Salma, *et al*. "Sustainable Adsorption Technologies for Textile Dye Removal: Advances in Biomass-Derived and Magnetically Modified Activated Carbons." Cleaner Chemical Engineering (2025): 100210. Print.
4. Jiang, Rurong, and Fang Ren. "Adsorption of Methylene Blue Dye by Modified Reed Activated Carbon: Adsorption Optimization and Adsorption Performance." Polish Journal of Environmental Studies 34.3 (2025): 2223-32. Print.
5. Li, Keran, *et al*. "Preparation of Novel Magnetic Hydrotalcite-Based Adsorbents and Their Synergistic Adsorption of Dye Molecules and Heavy Metal Ions: Response Surface Methodology Analysis and Adsorption Mechanisms Investigation." Colloids and Surfaces A: Physicochemical and Engineering Aspects (2025): 138519. Print.
6. Xu, Luhui, *et al*. "A Rotating Magnetic Field Propelled Photocatalytic Fe3o4/G-C3n4 Microrobot for Degrading Phenol and Methylene Blue: Kinetics, Mechanisms, and Effect of Water Matrices." Water Cycle (2025). Print.