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Abstract

Enhancing Photodegradation of Congo Red Dye under Visible Light Irradiation via ZnO Photocatalyst: Process Optimization using Response Surface Methodology †

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The Red Congo (RC) dye, widely employed across various industrial sectors such as textiles, food, and pharmaceuticals, owes its popularity to its deep red hue. However, despite its widespread usage, the presence of Red Congo raises significant environmental and health concerns. Due to its stable structure, CR dye is non-biodegradable, leading to severe health disorders in humans. Its extensive application in dyeing textiles, food products, medications, and other items often contributes to environmental issues, particularly wastewater pollution. The intricate chemical composition and resistance to the degradation of Red Congo present considerable challenges for wastewater treatment and pollution control. Consequently, researchers specializing in water treatment are increasingly driven to develop effective methods for removing Red Congo from industrial effluents.

This study focuses on the degradation of RC through a photocatalytic process utilizing zinc oxide (ZnO). The efficiency of ZnO as a photocatalyst is optimized using response surface methodology (RSM) combined with a Behnken design (BBD) under visible light conditions. Parameters, including the RC concentration (ranging from 20 to 60 mg/L), photocatalyst dosage (from 100 to 500 mg/L), and irradiation duration (from 20 to 100 min), are examined to evaluate their impact on the RC degradation rate (%). This study achieves an optimal photodegradation efficiency of up to 100% at an RC concentration of 20.24 mg/L, a ZnO dosage of 495.06 mg/L, and an irradiation duration of 97.71 min.

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