The Dual Roles of Activated Carbon as an Adsorbent and Photocatalyst for Azo Dye Removal

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The rise of the fast fashion and textile industries has proliferated the release of toxic azo dye effluent into the environment, contributing to ~20% of global industrial pollution. Azo dye removal via the adsorptive and photocatalytic properties of activated carbon (AC) may provide an efficient, cost-effective treatment for industrial wastewater effluent. This study investigated AC's potential for the removal of structurally diverse azo dyes, Mordant Orange 1 (MO1) and Reactive Black 5 (RB5), through AC's dual mechanisms of adsorption and reactive radical generation via photocatalysis. MO1 (430 mg/L) was incubated with AC and UV irradiation inclusion or exclusion for 60 minutes and subjected to UV-visible spectroscopy to determine dye concentrations remaining in solution. AC (40 mg) under darkness removed 99% of MO1. Near complete MO1 removal without the generation of any residual organic byproduct was confirmed with a total organic carbon analysis. Under UV light, MO1 removal stayed the same, suggesting that MO1 removal by AC takes place through only adsorption. A reactive oxygen species assay revealed RB5 (77 mg/L) removal by AC under UV irradiation due to reactive radical generation which is photocatalyzed by AC. Post-experimental findings, a computational analysis with the Amsterdam Modeling Suite, conducted to determine the impact of chemical modifications on AC's photocatalytic properties, showed a decrease in AC's band gap energy with the addition of aldehyde groups. Following future in situ research, AC is anticipated to serve as a versatile material for the removal of various azo dyes through its mechanisms of adsorption and photocatalysis.

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