Spent Coffee Ground Biochar and Zinc Oxide Nanoparticles Composite as a Novel, Cost Effective Biosorbent and Photocatalyst for Synthetic Dye Removal

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Spent coffee ground (SCG) is a globally available powder form waste derived from coffee extraction with a production of 42,000 tons daily. 700,000 tons of synthetic dyes are produced annually. They are toxic, chemically stable and persistent. For example, methylene blue. Agriculture-waste-derived biochar can remove dye efficiently via adsorption but adsorption alone does not degrade dye molecules, leading to secondary pollution and reduced efficiency when saturated. The application of photocatalyst to degrade dye molecules is limited by photocorrosion, nanoparticle agglomeration and leaching. Our study developed a novel composite combining SCG biochar with zinc oxide nanoparticles (ZnONPs) for enhanced dye removal. Biochar was produced via high-temperature pyrolysis, and ZnONPs are synthesized via calcination. A500 (500 ? calcination) has achieved 73.89% of removal in 50mg/L methylene blue solution in an hour. Under visible light irradiation, A500 achieved 98.65% removal. Adsorption was dominated by chemisorption on heterogeneous surface as the experimental data correlates with Pseudo-second-order kinetic model and Freundlich isotherm. FTIR analysis confirmed hydroxyl group, carboxyl group, aromatic group, amine group and Zn^{2}? involved in adsorption. BET analysis showed high surface area (242.5 m^2/g). XRD confirmed ZnO nanoparticles presence (~ 40.2 nm). UV-DRS indicated a reduced band gap (from ~ 3.37 to ~ 2.98 eV) upon composite formation with biochar, enhancing visible light activity. AAS revealed low Zn^{2}? leaching (~ 2%), indicating great material stability. The composite also demonstrated effective removal against malachite green and methyl orange. Our study showed that B.R.E.W-Z is a novel, cost effective and feasible solution for dye wastewater treatment.

Awards Won:
Fourth Award of $600