Synthesis of Nanocomposites Coupled with Activated Carbon and their Application for the Removal of Dyes by ultra-Sonicated Adsorption Process using Response Surface Methodology

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ABSTRACT

In the present study, NiO-MgO nanocomposite was synthesized by Sol-gel process. Activated carbon was incorporated with the nanocomposite to yield activated carbon coupled Bimetallic Nanocomposites NiO-MgO-AC. The nanocomposite was utilized in an ultrasonic adsorption process to remove Methylene blue (MB) dye from the simulated Dye effluent. FTIR, EDS, and SEM were used to determine the chemical composition and structural morphology. The surface neutrality was calculated using P^{H}_{PZC}, which was found to be 5.5. The experiments were carried out using a four-factorial central composite design with variables such as sonication time, MB dye concentration, pH, and adsorbent dose.

To find optimal operating parameters (OOP), the Response Surface Methodology (RSM) was employed. At a pH of 5.0, sonication time of 6.23 minutes, 0.02 g of nanocomposite, and 10mg.L^{-1} concentration of MB dye. The removal efficacy was found to be 93.983%. Various isotherm models, including Freundlich, Langmuir, Temkin, and Dubinin Radushkevichat 303-313K temperatures, were used to study the adsorption equilibrium. The RL values were less than one, suggesting that the adsorption technique was suitable. Furthermore, the values of n were found to be larger than one, indicating that the Freundlich adsorption model was appropriate.

The D-R isotherm provides values of E that were seen to be below 8.0kJ/mole at all temperatures indicating a physisorption process.

The thermodynamics of dye removal were also studied in order to obtain the system's ΔH^{o}, ΔS^{o}, and ΔG^{o} values. The pseudo-first and pseudo-second-order, intraparticle diffusion, Elovich, and Boyd kinetic models were used to determine the kinetics of adsorption.

The current study's findings indicated that nanocomposites can be efficiently utilized in waste treatment operations. The simulated dye wastewater treatment system was designed locally and can be efficiently employed on a commercial scale for the treatment of effluent before discharge into main streams to minimize its toxicity to the ecosystem.

Keywords: Adsorption, Central Composite Design, Simulated Dye Effluent Treatment process, Response Surface Methodology, Statistical Optimization, Ultrasonication, waste water treatment.