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Optimization, kinetics, equilibrium isotherms, and thermodynamics studies for Congo red dye adsorption using calcium alginate beads immobilized with dual adsorbent (*Neurospora crassa* dead fungal biomass and wheat bran)

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ABSTRACT

The present study is concerned with the batch adsorption of Congo red (CR) from aqueous solutions using calcium alginate beads (CAB) immobilized with dead biomass of *Neurospora crassa* along with wheat bran (DB–WB) as a dual adsorbent. The optimum conditions for CR adsorption were determined by studying various operational parameters such as initial pH, dye concentration, dual adsorbent loading in CAB, adsorbent dosage, agitation speed, and temperature. The process parameters were optimized using factorial experimental design to attain the maximum percentage adsorption. The CAB immobilized with DB–WB was characterized by attenuated transmission reflector and field emission scanning electron microscopy/energy dispersive X-ray spectroscopy (FESEM/EDS) analysis. The experimental equilibrium data were analyzed with various isotherm models. The results show that the best fit was achieved with the Langmuir isotherm model. Kinetic rate constants were found using different kinetic models. The adsorption kinetics for CR dye removal by CAB immobilized with DB–WB dual adsorbent follows pseudo-second-order kinetic model. Thermodynamic studies were performed to determine the change in Gibbs free energy (ΔG), change in enthalpy (ΔH), and change in entropy (ΔS) of the adsorption process. Thermodynamic parameters were evaluated by maximum adsorption capacities (q_{max}) at different temperatures. From the results, the adsorption was found to be spontaneous, endothermic in nature of the adsorption process and favored at high temperature. Desorption experiments were carried out using various desorbing agents to explore the possibility of regenerating the CAB immobilized with dual adsorbent. The maximum percentage of CR dye was desorbed using the solvent methanol. The reusability studies of CAB immobilized with dual adsorbent for the adsorption of CR was carried out in three runs.

Keywords: Congo red dye; Calcium alginate entrapped dual adsorbent beads; *Neurospora crassa* dead fungal biomass; Wheat bran; Equilibrium; Kinetics; Isotherms; Thermodynamics

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