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Adsorption of Direct red 81 dye onto friendly prepared iron oxide/multi-walled carbon nanotubes nanocomposite: kinetics and thermodynamic studies

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ABSTRACT

This paper describes the synthesis of an iron oxide/multi-walled carbon nanotubes (Fe_2O_3/MWCNT) nanocomposite for the removal of Direct red 81 dye as an organic pollutant. The nanocomposite was characterized using various techniques, including X-ray diffraction, Fourier-transform infrared spectroscopy, thermogravimetric analysis, UV-visible spectrophotometry, scanning electron microscopy, and transmission electron microscopy. The study demonstrates the feasibility of preparing a nanocomposite through a simple impregnation followed by a decomposition solid-state reaction, which reduces time and chemical costs. The characteristics of the nanocomposite and the kinetics of the adsorptive removal of the organic dye are described in detail, including the factors that govern adsorptive behavior such as pH, temperature, initial concentration of the dye, and adsorbent dosage. The results show that the efficiency of the adsorption process increases with increasing concentration of reactants and temperature. The study used Langmuir and Freundlich adsorption isothermal models, and the equilibrium data revealed that the Langmuir model fit linearly with the Direct red 81 adsorption, with the highest adsorption capacity being 73.05 mg/g. Additionally, the kinetics of the process fit linearly with the pseudo-second-order model. The thermodynamic studies showed that the adsorption process was endothermic and spontaneous, with a negative value of free energy change indicating favorable adsorption. Finally, a reusability study showed that the prepared composite had good decolorization performance over four consecutive cycles, indicating its potential as an effective and efficient adsorbent for the removal of organic pollutants.

Keywords: Multi-walled carbon nanotubes (MWCNTs) nanocomposite; Friendly preparation; Ammonium ferric citrate; Direct red 81 dye; Adsorption isotherms; Kinetics

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