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CONGO RED ADSORPTION ON MIXED-LAYER CLAY: INFLUENCE OF PHYSICO-CHEMICAL PARAMETERS AND MODELLING

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Abstract

This study examined the potential of a natural mixed-layer clay to remove an anionic dye, Congo Red (CR), from aqueous solutions. The effects of various physico-chemical parameters, including contact time, adsorbent mass, initial CR concentration, temperature, pH, and stirring speed, on the adsorption capacity were systematically studied. Kinetic analysis revealed that the pseudo-second-order model provided the best fit (R^2 = 0.999). Among the four isotherm models applied, the Langmuir model best described the adsorption process, yielding a maximum adsorption capacity of 156.25 mg/g (R^2 = 0.988). Thermodynamic parameters confirmed the endothermic ($\Delta H°$ = 53.13 kJ/mol), disordered ($\Delta S°$ = 188.15 J/mol·K), and spontaneous ($\Delta G° < 0$) nature of the CR adsorption process. Using Box-Behnken design modeling, CR concentration was identified as the most significant factor, followed by pH, temperature, and time. According to the BBD model's numerical optimization, the ideal parameters for CR adsorption were 30 minutes of contact time, 100 mg/L of dye, 45°C, and an acidic pH of 4, resulting in maximum adsorption efficiency of 117.255 mg/g. These findings highlight the clay's excellent adsorption capabilities for CR, making it a promising candidate for water decolourization applications.

Key words: adsorption isotherms, Box-Behnken design, Congo Red adsorption, mixed-layer clay, water decolourization

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