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Characterization and investigation of natural clay performance for Methylene Blue removal: results of the adsorption isotherm, kinetic and thermodynamic studies*

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Abstract

In this study, Van-Başkale (VB) clay was used for removal of Methylene Blue (MB) dye. The characterization of VB clay was carried out with the Fourier transform infrared spectra (FTIR), Brunauer-Emmett-Teller (BET), and scanning electron microscopy/energy-dispersive X-ray spectroscopy (SEM/EDX) analysis. The BET surface area was measured as 11.983 m²/g. The FTIR spectra indicated the functional groups which represented the Si-H bond, N-H bond, N-O bond and Si-C stretching vibrations. The SEM-EDX analysis of VB clay showed that its composition consisted of 61.45% O, 25.70% Si, 5.89% Al, 2.82% K, 2.28% Na, 0.97% Fe, and 0.89% Ca by weight. The effects of removal, i.e. parameters pH (2-7), temperature (298-318 K), initial concentration (10-50 mg L⁻¹) adsorbent dosage (0.2-3.0 g L⁻¹), and contact time on adsorption, were investigated. The data obtained were entered into the Langmuir, Freundlich and Dubinin-Radushkevich (D-R) isotherm models, and it was demonstrated that the correlation coefficient values for the Freundlich isotherm model were higher than for the other isotherm models. The pseudo second order (PSO) kinetic model was a better choice for the removal of MB than the pseudo first order (PFO) and intraparticle diffusion (IPD) kinetic models. Negative Gibbs free energy values obtained from thermodynamic calculations show that adsorption occurs spontaneously. The free energy of D-R adsorption calculated using the D-R isotherm was less than 8 kJ mol⁻¹, indicating that the process was physical adsorption. The activation energy (E_A) of this process was 29.21 kJ mol⁻¹ which confirmed the fact that the process was physical adsorption.

Keywords: adsorption, clay, methylene blue, isotherm, kinetic, thermodynamic

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