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Adsorption of a cationic dye from aqueous solution using low-cost Moroccan diatomite: adsorption equilibrium, kinetic and thermodynamic studies

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ABSTRACT

This article presents the adsorption of Methylene Blue (MB) onto diatomite, in order to develop a low-cost treatment technology as a process alternative for dye removal. Diatomite used in this work was taken from the Nador area in the northeast of Morocco. Diatomite is characterised by different physical–chemical methods (X-ray diffraction, nitrogen adsorption-desorption isotherm, scanning electron microscopy and Fourier transform infrared). Results showed that the adsorption of MB onto diatomite mineral is affected by various operating parameters like contact time, initial dye concentration, adsorbent dosage, pH and temperature. Adsorption equilibrium is reached after 1.5 h of contact time. Maximum MB removal is obtained at pH = 12. MB removal rate decreases as pH decreases. Adsorption equilibrium data are fitted to Langmuir, Freundlich, Redlich–Peterson and Toth models. Adsorption data are well described by Langmuir isotherm model indicating that a homogeneous adsorption occurs. A maximum adsorption capacity (or monolayer coverage) of 11 mg g^{-1} is obtained at 45°C. A value of the enthalpy of adsorption of 12.78 kJ mol^{-1} is found confirming the endothermic nature of adsorption process, while a Gibb's free energy change ($\Delta G°$) falling in the range −30.8 to −35.34 kJ mol^{-1} confirms the spontaneity of the process. Adsorption kinetics are fitted to a pseudo-second-order kinetic model. Experimental results indicate that the Moroccan diatomite could be used as a potential adsorbent for the removal of cationic dye molecules, at lower cost.

Keywords: Adsorption; Diatomite; Dye; Methylene Blue; Thermodynamic exploration

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