Insights on adsorption of carbamazepine onto iron oxide modified diatomaceous earth: Kinetics, isotherms, thermodynamics, and mechanisms

Abstract

To ameliorate adsorbent recovery by an external magnetic field, naturally occurring diatomaceous earth (DE) was modified with iron-oxide, characterized and applied for adsorption of carbamazepine (CBZ) from synthetic wastewater using batch equilibration method. The fabricated adsorbent was characterized using XRF, XRD, SEM-EDX, FT-IR, BET surface area analysis, VSM and pH of point of zero charge (pH_{pzc}) determination. The adsorption rate was described by the pseudo-first-order (PFO) model suggesting a physisorption controlled rate-determining step. Equilibrium adsorption data were fitted to linear and nonlinear isotherm models, *viz* Langmuir and Freundlich models, and were best described by Freundlich nonlinear equations implying heterogeneous multilayer adsorption. The best-fitting kinetic and isotherm model was determined using four mathematical error functions. The thermodynamic parameters, namely enthalpy ($\Delta H = -26.4$ kJ mol^{-1}), Gibbs free energy ($\Delta G = -2.22$ kJ mol^{-1} at 298 K), entropy ($\Delta S = -34.0$ kJ mol^{-1}), indicated that the adsorption was a spontaneous, exothermic, and physical process. The adsorption mechanism is postulated to involve cation-π interactions. Modified diatomaceous earth is a potentially excellent, low-cost, and novel sorbent for CBZ adsorption with 88% removal in 180 min and provides a possible alternative adsorbent for wastewater treatment.

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