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Kinetic, Equilibrium and Thermodynamic Studies of the Adsorption of Crystal Violet Dye Using Groundnut Hulls

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Abstract : Dyes are organic compounds with complex aromatic molecular structure that resulted in fast colour on a substance. Dye effluent found in wastewater generated from the dyeing industries is one of the greatest contributors to water pollution. Groundnut hull (GH) is an agricultural material that constitutes waste in the environment. Environmental contamination by hazardous organic chemicals is an urgent problem, which is partially solved through adsorption technologies. The choice of groundnut hull was promised on the understanding that some materials of agricultural origin have shown potentials to act as Adsorbate for hazardous organic chemicals. The aim of this research is to evaluate the potential of groundnut hull to adsorb Crystal violet dye through kinetic, isotherm and thermodynamic studies. The prepared groundnut hulls was characterized using Brunauer, Emmett and Teller (BET), Fourier transform infrared (FTIR) and scanning electron microscopy (SEM). Operational parameters such as contact time, initial dye concentration, pH, and effect of temperature were studied. Equilibrium time for the adsorption process was attained in 80 minutes. Adsorption isotherms used to test the adsorption data were Langmuir and Freundlich isotherms model. Thermodynamic parameters such as ΔG°, ΔH°, and ΔS° of the adsorption processes were determined. The results showed that the uptake of dye by groundnut hulls occurred at a faster rate, corresponding to an increase in adsorption capacity at equilibrium time of 80 min from 0.78 to 4.45 mg/g and 0.77 to 4.45mg/g with an increase in the initial dye concentration from 10 to 50 mg/L for pH 3.0 and 8.0 respectively. High regression values obtained for pseudo-second-order kinetic model, sum of square error (SSE%) values along with strong agreement between experimental and calculated values of qe proved that pseudo second-order kinetic model fitted more than pseudo first-order kinetic model. The result of Langmuir and Freundlich model showed that the adsorption data fit the Langmuir model more than the Freundlich model. Thermodynamic study demonstrated the feasibility, spontaneous and endothermic nature of the adsorption process due to negative values of free energy change (ΔG) at all temperatures and positive value of enthalpy change (ΔH) respectively. The positive values of ΔS showed that there was increased disorderliness and randomness at the solid/solution interface of crystal violet dye and groundnut hulls. The present investigation showed that, groundnut hulls (GH) is a good low-cost alternative adsorbent for the removal of Crystal Violet (CV) dye from aqueous solution.

Keywords : adsorption, crystal violet dye, groundnut halls, kinetics
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