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Removal of methylene blue dye from synthetic aqueous solutions using novel phosphonate cellulose acetate membranes: adsorption kinetic, equilibrium, and thermodynamic studies

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ABSTRACT

In this study, novel phosphonated cellulose acetate (PCA) membranes were used for adsorptive removal of cationic methylene blue (MB) dye under batch conditions and different preliminary concentrations of the pollutant and pH values at 25°C. The chemical structure of PCA membranes was established by Fourier transform infrared spectrophotometric analysis. Adsorption kinetics, isotherms, and thermodynamics were examined. The analysis of three kinetic models specifically pseudo-1st-order model, pseudo-2nd-order model, and Elovich model was performed. The rate of MB adsorption was found to accompany pseudo-2nd-order model. Adsorption data of MB have also been used to test various adsorption diffusion models. The diffusion rate modeling of Dumwald-Wagner and the intraparticle diffusion model have been used to determine the diffusion rate and the rate-controlling step. Boyd expression was also used to give the accurate indications. Sorption equilibrium of MB by PCA membranes was also quantitatively evaluated by isotherm models of Langmuir, Freundlich, Dubinin-Radushkevich, and Temkin. Adsorption behaviour followed the Langmuir adsorption isotherms (q_{max} = 10 mg/g). Finally, the negative $\Delta G°$ values designated that the MB adsorption onto sorbent membranes was viable and spontaneous, while the positive $\Delta H°$ value depicted that MB removal is endothermic.

Keywords: Cellulose acetate; Methylene blue; Kinetics; Isotherms; Thermodynamics

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