Biosorption of methylene blue from aqueous solution by potato (Solanum tuberosum) peel: equilibrium modelling, kinetic, and thermodynamic studies

El-Khamssa Guechi*, Oualid Hamdaoui

Laboratory of Environmental Engineering, Faculty of Engineering, Department of Process Engineering, Badjji Mokhtar - University, P.O. Box 12, 23000 Annaba, Algeria, emails: guichi_wahida@yahoo.fr (E.-K. Guechi), ohamdaoui@yahoo.fr (O. Hamdaoui)

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ABSTRACT

In this study, an abundant agricultural waste, potato (Solanum tuberosum) peel, was used as a biosorbent material to test its suitability for removing a basic dye, methylene blue (basic blue 9), from aqueous solutions. The potato peel (PP) was characterized by infrared spectroscopy (FTIR), specific surface area, isoelectric potential (pH_ZPC), and scanning electron microscopy and the functional organic groups were determined by the Boehm titration method. The influence of operating conditions such as contact time, initial concentration of the dye, biosorbent dose, ionic strength, initial solution pH, temperature, and biosorbent particle size on dye removal was discussed. The results show that the increase of the initial concentration, dose of biosorbent material, and pH has a positive impact on the biosorption of dye. However, the ionic strength, the temperature, and particle size have a negative effect on the dye removal. Biosorption kinetic data obtained at different concentrations were modeled using the Lagergren’s pseudo-first-order and Blanchard’s pseudo-second-order kinetic models to determine the rate constants. It was found that the kinetics of the biosorption of dye closely followed the pseudo-second-order kinetic model. Equilibrium biosorption data were analyzed by four isotherms, namely the Langmuir isotherm, the Freundlich isotherm, the Elovich isotherm, and the Flory–Huggins isotherm. The equilibrium data were best represented by the Langmuir isotherm model, showing maximum monolayer biosorption capacity, $q_m$, of 105.26 mg g$^{-1}$. It can be concluded that the PP has homogeneous surface energy. Thermodynamic parameters such as standard enthalpy change ($\Delta H^\circ$), standard entropy change ($\Delta S^\circ$), and standard free energy change ($\Delta G^\circ$) were evaluated. The thermodynamic results suggest that the biosorption is a typical physical process, spontaneous, and exothermic in nature.

Keywords: Biosorption; Methylene blue; Potato peel; Characterization; Isotherm; Modeling

*Corresponding author.