

Honeycomb-like porous-activated carbon derived from gasification waste for malachite green adsorption: Equilibrium, kinetic, thermodynamic and fixed-bed column analysis

Abstract

In this study, the preparation conditions for the gasification waste-based activated carbon (GWAC) were optimized with malachite green (MG) dye removal and GWAC yield as responses. The adsorption equilibrium, kinetic behavior, and thermodynamics properties were also analyzed. The optimum conditions for synthesizing GWAC were found at a radiation power, time, and impregnation ratios of 616 W, 1 min, and 1.06 g g⁻¹, respectively, which resulted in an 89.98% yield of GWAC and 99.01% MG removal. This sample shows the surface area and total pore volume of 351.92 m² g⁻¹ and 0.22 cm³, respectively. For the isotherm study, the Fritz–Schlunder model fitted the adsorption data very well with an R² value of 0.9919–0.9932. The results of the kinetic study showed that the MG adsorption followed a pseudo-first-order kinetic model (R² = 0.9625–0.9871). The film diffusion was found to be the rate-limiting step of MG adsorption. The adsorption of the MG dye onto GWAC was an endothermic and spontaneous process with ΔH of 9.183 kJ mol⁻¹. In continuous mode, Thomas and Yoon–Nelson models successfully predicted the MG adsorption on the GWAC. GWAC demonstrates its commercial feasibility based on a low production cost of 0.23 USD kg⁻¹.

Keywords

Activated carbon; Adsorption; Adsorption kinetic; Gasification waste; Malachite green