Carbonization of corn (Zea mays) cob agricultural residue by one-step activation with sulfuric acid for methylene blue adsorption

Ali H. Jawad a, *, Shaymaa Adil Mohammed b, Mohd Sufri Mastuli a, Mohd Fauzi Abdullah c

a Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia, Tel. +603 55211721; emails: ahjm72@gmail.com, ali288@salam.uitm.edu.my (A.H. Jawad), Tel. +603 55436594; email: mohdsufrimastuli@yahoo.com (M.S. Mastuli)
b Department of Chemistry, College of Science, Al-Muthanna University, Iraq, Tel. +9647809400813; email: Samohammed15@gmail.com
c Faculty of Applied Sciences, Universiti Teknologi MARA, 02600 Arau, Perlis, Malaysia, Tel. +60 49882737; email: mohdfauziabd@perlis.uitm.edu.my

Received 9 August 2017; Accepted 27 June 2018

ABSTRACT

Corn (Zea mays) cob, an agricultural biomass residue, was carbonized by chemical activation with H2SO4 and examined for its suitability as a low-cost adsorbent for methylene blue (MB) adsorption from aqueous solution. Carbonized corn cob (CCC) was characterized by a CHNS-O analysis, Fourier transform infrared spectroscopy, scanning electron microscopy, X-ray diffraction (XRD), Brunauer–Emmett–Teller, and point-of-zero charge (pHpzc) analysis. Batch mode adsorption studies were conducted by varying operational parameters such as adsorbent dosage (0.02–0.20 g), solution pH (3–10), initial MB concentrations (50–300 mg/L), and contact time (0–360 min). The equilibrium data were well correlated by the Freundlich isotherm compared with Langmuir and Temkin models. The maximum adsorption capacity (qmax) of CCC for MB adsorption at equilibrium was 216.6 mg/g at 303 K. The kinetic uptake profiles were well-described by the nonlinear pseudo-first-order model. The thermodynamic adsorption parameters such as standard enthalpy (ΔH°), standard entropy (ΔS°), and standard free energy (ΔG°) showed that the adsorption of MB onto CCC surface is endothermic in nature and spontaneous under the experimental conditions. The above-mentioned results indicate that the CCC can be feasibly employed for the removal of MB from aqueous solution.

Keywords: Carbonization; Corn cob; Low-cost adsorbent; Sulfuric acid; Adsorption; Methylene blue