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Cellulose nanocrystals-based hydrogel for adsorptive removal of methyl red from aqueous solution

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ABSTRACT

The development of new economical and recyclable adsorbents for the removal of pollutants from contaminated water is receiving increasing attention. The production of nanocellulose from waste is of great interest. In this study, cellulose nanocrystals (CNCs) were synthesised from industrial cotton waste and subsequently immobilised in sodium alginate (NaAlg) gels, resulting in the formation of porous hydrogel beads (CNCs-PHB). The resulting CNCs-PHB porous hybrid adsorbents were then characterised by FTIR spectroscopy and XRD analysis. The functional group analysis of FTIR spectra confirmed that the CNCs-PHB adsorbent is characterised by appropriate functional groups which are favourable for sorption of methyl red (MR) dye. The XRD diffraction pattern shows that the CNCs have the crystalline configuration of cellulose with a crystallinity index of 73%. The obtained CNCs-PHB adsorbents were used in the removal of MR in aqueous solutions. Batch adsorption studies were conducted by examining the effects of adsorbent dose (0.1–0.5 g), contact time (5–480 min), pH (2–10), and initial concentration of MR (10–50 mg/L). The results of the kinetic study show that the pseudo-equilibrium state is reached after 250 min. It has been shown that the adsorption capacity decreases with increasing amount of adsorbent. Strong MR elimination of 83% was achieved in very acidic environments (pH = 2) with CNCs-PHB adsorbents at initial concentrations of 10 mg/L. These results clearly show that the adsorption process is better correlated with pseudo-second-order (PSO) kinetics. The mathematical modelling by isothermal models of Freundlich, Langmuir, Sips, Dubinin–Radushkevich, and Temkin showed that only the Langmuir and Sips models are best adapted to experimental data, since the values of the correlation coefficient R^2 are at 0.98. The maximum adsorption capacity obtained is of the order of 32 mg/g.

Keywords: Cotton waste; Cellulose nanocrystals; Porous hydrogel beads; Adsorption; Acid hydrolysis; Methyl red

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