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Sustainable Hydrogel Nanocomposites Based on Grafted Chitosan and Clay for Effective Adsorption of Cationic Dye

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Abstract : Contamination of water, due to the discharge of untreated industrial wastewaters into the ecosystem, has become a serious problem for many countries. In this study, bioadsorbents based on chitosan-g-poly(acrylamide) and montmorillonite (MMt) clay (CTS-g-PAAm/MMt) hydrogel nanocomposites were prepared via free-radical grafting copolymerization and crosslinking of acrylamide monomer (AAm) onto natural polysaccharide chitosan (CTS) as backbone, in presence of various contents of MMt clay as nanofiller. Then, they were hydrolyzed to obtain highly functionalized pH-sensitive nanomaterials with uppermost swelling properties. Their structure characterization was conducted by X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) analyses. The adsorption performances of the developed nanohybrids were examined for removal of methylene blue (MB) cationic dye from aqueous solutions. The factors affecting the removal of MB, such as clay content, pH medium, adsorbent dose, initial dye concentration and temperature were explored. The adsorption process was found to be highly pH dependent. From adsorption kinetic results, the prepared adsorbents showed remarkable adsorption capacity and fast adsorption rate, mainly more than 88% of MB removal efficiency was reached after 50 min in 200 mg L⁻¹ of dye solution. In addition, the incorporating of various content of clay has enhanced adsorption capacity of CTS-g-PAAm matrix from 1685 to a highest value of 1749 mg g⁻¹for the optimized nanocomposite containing 2 wt.% of MMt. The experimental kinetic data were well described by the pseudo-second-order model, while the equilibrium data were represented perfectly by Langmuir isotherm model. The maximum Langmuir equilibrium adsorption capacity (q_m) was found to increase from 2173 mg g^{−1} until 2221 mg g^{−1} by adding 2 wt.% of clay nanofiller. Thermodynamic parameters revealed the spontaneous and endothermic nature of the process. In addition, the reusability study revealed that these bioadsorbents could be well regenerated with desorption efficiency overhead 87% and without any obvious decrease of removal efficiency as compared to starting ones even after four consecutive adsorption/desorption cycles, which exceeded 64%. These results suggest that the optimized nanocomposites are promising as low cost bioadsorbents.

Keywords : chitosan, clay, dye adsorption, hydrogels nanocomposites
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