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Synthesis of co-polymer-grafted gum karaya and silica hybrid organic–inorganic hydrogel nanocomposite for the highly effective removal of methylene blue

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Abstract

The aim of this work was to study the adsorption behavior of the nanosilica-containing hydrogel nanocomposite of gum karaya grafted with poly(acrylic acid-acrylamide) (GK-cl-P(AA-co-AAM)) in the adsorption of methylene blue (MB) from aqueous solutions. The hydrogel nanocomposite was synthesized by the base-catalyzed hydrolysis and water condensation reactions of tetraethylorthosilicate in an aqueous medium containing a dispersion of GK-cl-P(AA-co-AAM). Structural and morphological characterizations using Fourier transform infrared spectroscopy, X-ray diffraction, and transmission and scanning electron microscopies supported the formation of the grafted hydrogel polymer of GK and the SiO(sub2)-containing nanocomposite. The Brunauer–Emmett–Teller adsorption studies showed that the surface area and porosity of the hydrogel polymer significantly increased after nanocomposite formation with SiO(sub2). The hydrogel nanocomposite was employed for the removal of MB from an aqueous solution: 96% of the MB was removed with a hydrogel nanocomposite dose of 0.2 g L(sup-1). The adsorption process was found to follow pseudo-second-order kinetics, and the adsorption isotherm was best fitted with the Langmuir monolayer isotherm model with a maximum adsorption capacity of 1408.67 mg g(sup-1), which was much higher than that of the hydrogel polymer. Different adsorption thermodynamic parameters supported the endothermic nature as well as the spontaneity of the adsorption process. The hydrogel nanocomposite showed excellent regeneration capacity in the acidic medium and was successfully used over three adsorption–desorption cycles. Therefore, the GK-cl-P(AA-co-AAM)/SiO(sub2) hydrogel nanocomposite has shown potential as an efficient adsorbent for the highly effective removal of cationic dyes from aqueous solution.