Iran Polym J (2012) 21:609–619
DOI 10.1007/s13726-012-0066-6

ORIGINAL PAPER

Novel carrageenan-based hydrogel nanocomposites containing laponite RD and their application to remove cationic dye

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Received: 19 January 2012 / Accepted: 13 June 2012 / Published online: 26 July 2012

Abstract Novel hydrogel nanocomposites were synthesized by solution polymerization of acrylamide in the presence of carrageenan biopolymer and laponite RD clay. Laponite was used as an inorganic cross-linker. Ammonium persulfate was applied as an initiator. The structure and morphology of the nanocomposites were investigated using XRD, scanning electron microscopy, and transition electron microscopy techniques. The influence of both laponite nanoclay and the carrageenan content on the swelling degree of nanocomposites was studied and it was found that all nanocomposites containing carrageenan component have a high swelling degree compared to a nanocomposite without carrageenan. The obtained nanocomposites were examined to remove a cationic crystal violet (CV) dye from water. The effect of carrageenan and clay contents on the speed of dye adsorption revealed that while the rate of dye adsorption is enhanced by increasing the clay content, it was depressed as the carrageenan content increased in nanocomposite composition. The results showed that the pseudo-second-order adsorption kinetic was predominant in adsorption of CV onto nanocomposites. The experimental equilibrated adsorption capacity of nanocomposites was analyzed using Freundlich and Langmuir isotherm models. The results indicated that the experimental data fit the Langmuir isotherm best. Maximum adsorption capacity was obtained for carrageenan-free nanocomposite with 79.8 mg g^{-1} of adsorbed CV onto nanocomposite.

Keywords Carrageenan · Nanocomposite · Hydrogel · Laponite · Removal

Introduction

Hydrogels are hydrophilic polymer networks that can absorb a large amount of water from aqueous solutions without being dissolved. These networks can be synthesized through chemical or physical cross-linking. In chemical cross-linking, an appropriate organic cross-linker such as methylenebisacrylamide is usually used for polymer chains to connect each other by covalent bonds. In contrast, the physical cross-linking takes place by ionic or hydrogen bonds [1].

Recently, nanocomposite hydrogels have been synthesized using different nanoclays [2]. Among them, the hydrogels containing laponite nanoclay have attracted the attention of researchers. Haraguchi et al. [3, 4] have reported the synthesis of hydrogel nanocomposites without using organic cross-linkers. They have used laponite nanoclay as multifunctional cross-linker. The cross-linking mainly occurs in the presence of monomers containing the amide group, whereby the ionic and polar interactions at the clay–polymer interface would lead to physical cross-linking. In fact, by applying laponite nanoclay into a hydrogel composition, there would be physical cross-linking facilitated without any need of chemical cross-linkers to achieve sufficient improvements in physical and chemical properties of the hydrogels. When laponite is suspended in water, it forms disc-like particles with a thickness of 1 nm, a diameter of about 25 nm, and a

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