615/E2

Graphene oxide, carboxymethyl cellulose (CMC), and montmorillonite (MMT) based nanocomposite for the removal of hardness in water

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The contamination of water is a major problem in many parts of the world and will eventually lead to freshwater scarcity. The hardness of groundwater is the most common problem associated with water quality, mainly due to the high concentrations of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in groundwater. These elevated levels of hardness in water could cause adverse health effects such as chronic kidney disease of unknown etiology (CKDu) and difficulties such as scaling on pipes and fabrics, as well as lead to an odd taste. Therefore, this research was carried out to develop a novel, nontoxic, biodegradable, graphene oxide (GO), cross-linked carboxymethyl cellulose (CMC), and montmorillonite (MMT) clay-based nanocomposite as an effective adsorbent to remove the hardness of water. In this context GO was synthesized using the modified Hummers method and the cross-linked CMC was produced using CMC powder and acetic acid. Cross-linked CMC was used to facilitate improved sorption properties and antifungal activity of the composite. MMT clay was added in different ratios as a constituent material. Initially, several materials were fabricated using different compositions in the form of thin film membranes. To identify the performance of the composite material and constituent materials, the solubility and adsorption properties of the developed material towards Ca^{2+} and Mg^{2+} were investigated. The results reveal that the nanocomposite synthesized using GO, cross-linked CMC, and 2.50 g of MMT (GO-CMC-MMT-3) is the best material to remove water hardness. Characterization using SEM analysis, FT-IR, XRD, and UV-visible spectroscopy confirmed the successful synthesis of the material. Further studies were carried out for the GO-CMC-MMT-3 membrane to identify several parameters that have an impact on the adsorption (Ca^{2+} and Mg^{2+}) process from aqueous solutions. According to that, the optimum pH for the adsorption was found to be between pH 6-7 and the optimum contact time was found to be 45 minutes. In addition, the results of the adsorption isotherm data were fitted to both Langmuir and Freundlich models. The Langmuir isotherm model was identified as the best-fit with maximum adsorption capacities of 6.46 mg g^{-1} (Mg^{2+}) and 7.98 mg g^{-1} (Ca^{2+}) indicating the formation of a cation monolayer on the homogenous adsorption sites of the nanocomposite.

Keywords: Water hardness, graphene oxide, cross-linked carboxymethyl cellulose, montmorillonite, novel nanocomposite

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