NANOCOMPOSITES FOR SUSTAINABLE COBALT (II) ION REMOVAL: SOL-GEL SYNTHESIS AND EXCEPTIONAL PERFORMANCE

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Abstract: The removal of Cobalt (II) ions from wastewater is of paramount importance due to its toxic effects on both the environment and human health. In this study, Fe_3O_4/MgO nanocomposites synthesized through the sol-gel method were employed as an efficient adsorbent for the removal of Cobalt (II) ions from aqueous solutions. The synthesized nanocomposites were thoroughly characterized, and their adsorption performance was evaluated. The nanocomposites' structural evolution during Cobalt (II) ion adsorption was examined using scanning electron microscopy (SEM), revealing a transition from a rod-like structure to an irregular shape, indicative of successful adsorption due to robust surface-ion interactions. X-ray diffraction (XRD) analysis identified cubic MgO and cubic Fe_3O_4 phases in the nanocomposites. Following Cobalt (II) ion adsorption, additional phases, such as hexagonal $Mg(OH)_2$, hexagonal $Co(OH)_2$, Rhombo H. axes $CoCo_3$, and cubic Co_3O_4, were detected, signifying changes in the nanocomposite's crystal structure. Vibrating sample magnetometry (VSM) analysis showed a magnetization of 30.19 emu g^{-1}, enabling convenient magnetic separation after treatment. Optimization parameters were established, including an adsorbent dosage of 0.03 g L^{-1}, an initial Cobalt (II) ion concentration of 40 mg L^{-1}, a contact time of 120 minutes, and a pH of 8. Under these conditions, the Fe_3O_4/MgO nanocomposites displayed a remarkable adsorption capacity of 1300.04 mg g^{-1} and an impressive removal efficiency of 97.5%. The kinetic data fitting closely followed the pseudo-second-order model (R^2=0.996), indicating chemisorption and intra-particle diffusion during the initial stage. Isotherm data analysis aligned well with the Langmuir isotherm model (R^2=0.995), validating monolayer adsorption with a maximum adsorption capacity of 1178.55 mg g^{-1}. This study underscores the potential of sol-gel-synthesized Fe_3O_4/MgO nanocomposites as a highly efficient adsorbent for Cobalt (II) ion removal from wastewater. The exceptional adsorption capacity and efficiency of these nanocomposites offer a promising solution for environmental remediation and water purification.

Keywords: Adsorption; Chemisorption; Magnetic separation; Wastewater treatment