Removal of heavy metal ions from aqueous solutions with multi-walled carbon nanotubes: Kinetic and thermodynamic studies

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Abstract

Multi-walled carbon nanotubes were used successfully for the removal of Copper(II), Lead(II), Cadmium(II), and Zinc(II) from aqueous solution. The results showed that the % adsorption increased by raising the solution temperature due to the endothermic nature of the adsorption process. The kinetics of Cadmium(II), Lead(II), Copper(II), and Zinc(II) adsorption on Multi-walled carbon nanotubes were analyzed using the fraction power function model, Lagergren pseudo-first-order, pseudo-second-order, and Elovich models, and the results showed that the adsorption of heavy metal ions was a pseudo-second-order process, and the adsorption capacity increased with increasing solution temperature. The binding of the metal ions by the carbon nanotubes was evaluated from the adsorption capacities and was found to follow the following order: Copper(II) > Lead(II) > Zinc(II) > Cadmium(II). The thermodynamics parameters were calculated, and the results showed that the values of the free energies were negative for all metals ions, which indicated the spontaneity of the adsorption process, and this spontaneity increased by raising the solution temperature. The change in entropy values were positives, indicating the increase in randomness due to the physical adsorption of heavy metal ions from the aqueous solution to the carbon nanotubes' surface. Although the enthalpy values were positive for all metal ions, the free energies were negative, and the adsorption was spontaneous, which indicates that the heavy metal adsorption of Multi-walled carbon nanotubes was an entropy-driving process.

Keywords

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