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Removal of Fluoride From Water Using Activated Carbon Fibres Modified With Zirconium by a Drop-Coating Method

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Abstract

Metal-modified carbon materials have been widely used for fluoride removal, but the traditional impregnation by soaking method suffers from low loading of metals and substantial use of chemicals. This study proposed a new approach to prepare zirconium modified activated carbon fibres (Zr-ACF) by a drop-coating method. Using the same amount of chemicals, the drop-coating method yielded a 5.5 times higher fluoride adsorption capacity than the soaking method due to more effective loading of Zr(IV) onto ACF. The effects of various preparation conditions, including the addition of a complexing agent (oxalic acid) and Zr/ACF mass ratio (0.2-1), were investigated. Zr-ACF prepared by drop-coating was characterised by SEM and BET, and the functional groups involved in the anchoring of Zr(IV) on ACF and the adsorption of fluoride onto Zr-ACF were identified by FTIR and XPS. Adsorption experiments at pH between 3 and 11 revealed that ion exchange and electrostatic attraction were the main adsorption mechanisms at different pH levels. Co-existing anions such as CO32-, HCO3- and Cl- had an insignificant negative impact (<5%) on fluoride adsorption capacity while SO42- decreased fluoride adsorption capacity by 11.5%. The adsorption kinetics followed the pseudo-second-order model. The adsorption isotherms followed the Langmuir isotherm model with a maximum fluoride adsorption capacity of 28.50 mg/L at 25 °C, which was higher than other carbon-based materials in the literature. The remarkable improvement of adsorption capacity and reduced chemical consumption demonstrate that Zr-ACF prepared by drop-coating is a promising adsorbent for fluoride removal.

Keywords: Activated carbon fibre; Adsorption; Drop-coating; Fluoride; Zirconium.