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Hydrous CeO_2-Fe_3O_4 decorated polyaniline fibers nanocomposite for effective defluoridation of drinking water

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Abstract

Hydrous CeO_2-Fe_3O_4 (HCeFe) decorated polyaniline nanofibers (HCeFe NFs) were obtained through a simple co-precipitation deposition approach on pre-synthesized polyaniline nano-fibers (PANI NFs), and evaluated as adsorbents for fluoride removal from synthetic and real water samples. Field emission scanning electron microscopy/energy dispersive X-ray spectroscopy (FE-SEM/EDS), high resolution-transmission electron microscopy (HR-TEM), Braunauer-Emmett-Teller (BET), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), thermogravimetric-differential thermal analysis (TGA-DTA), X-ray photoelectron spectroscopy (XPS) and dynamic mechanical analysis (DMA) techniques were used to characterize the hybrid nanomaterials. The optimised HCeFe NFs adsorbent with specific surface area 66 m^2/g, exhibited excellent adsorption efficiency towards fluoride ions (F^-) via both electrostatic interactions and ion exchange mechanisms. F^- adsorption followed the pseudo-second-order rate model and best fitted the Langmuir isotherm, with the maximum capacities within 93.46-117.64 mg/g over a broad pH range 3-10, respectively. The determined thermodynamic parameters, including enthalpy ($\Delta H°$ - 15.1 kJ/mol) and Gibbs free energies change ($\Delta G° < 0$) indicated to the exothermic and a spontaneous nature of the sorption process. The regeneration of HCeFe NFs showed a considerable adsorption-desorption efficiency over three consecutive cycles. Ultimately, the adsorbent was tested on spiked F^- containing groundwater and the obtained results demonstrated its potential utility for defluoridation of natural water.

Keywords: Adsorption; Cerium-iron oxides; Co-precipitation deposition; Groundwater defluoridation; Isotherm; Kinetics; Polyaniline nanofibers.