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Removal of fluoride from aqueous solution using Amberlite-IRA-aluminum sorbent nanoexchanger

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ABSTRACT

In the present study, aluminum-modified anionic exchanger nanoparticles were synthesized by introducing Al(III) ions onto the functional sites of the polymeric anion exchanger Amberlite-402. The modified anionic exchanger gathered the favorable sorption properties of inorganic nanoparticles with the excellent hydraulic characteristics of polymeric beads. Hazardous persistent fluoride ions in water were removed by the new sorbent using both batch and fixed-bed column techniques. Different parameters that affect the adsorption process such as initial concentration, pH, and temperature have been investigated. It is found that the adsorption of fluoride ions is efficient in a wide range of pH. However, maximum removal is observed at pH = 3.0. In addition, the adsorption capacity is slightly affected by temperature and is increased by decreasing the temperature from 308 to 288 K to reach 80.33 mg g^{-1}. The coexisting ions chloride and nitrate were also studied. Their existence had a significant effect on reducing the efficiency of fluoride removal from 24.5 to 17.5 mg g^{-1} and 15.0 mg g^{-1}, respectively. The study showed that the adsorption process favored the Langmuir adsorption model. Thermodynamic parameters were also calculated and positive $\Delta G°$ values were related to a non-spontaneous nature of the adsorption. Fixed-bed column experiments were carried out for investigating the following parameters: influent fluoride concentrations, bed depths, and various flow rates. The breakthrough time increased either with increasing flow rate, decreasing bed depth, or decreasing influent fluoride concentration. The X-ray diffraction, energy dispersive X-ray spectroscopy, and scanning electron microscope studies were carried out for the characterization of the new sorbent. These studies confirmed that aluminum ions are successfully loaded onto the surface of Amberlite-402. This study proves that novel Amberlite-IRA-Al is more efficient than other defluoridation techniques.

Keywords: Ion-exchange; Fluoride; Aluminum sorbent; Adsorption; Regeneration

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