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Nanocrystalline hydroxyapatite from fish scale waste: Preparation, characterization and application for selenium adsorption in aqueous solution

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HIGHLIGHTS

- Nanocrystalline FHAp from fish scale waste by alkaline heat treatment is firstly prepared.
- The preparation method is simple, inexpensive and friendly environment.
- The adsorbent material showed excellent adsorption capacity of Se (IV).
- High adsorption capacity is explained in terms of Freundlich isotherm.
- The kinetic data were well fitted by a pseudo second-order model.

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ABSTRACT

Nanocrystalline hydroxyapatite prepared from fish scale waste (FHAp) using the alkaline heat treatment method was used as an adsorbent for the removal of selenite. The FHAp was characterized by BET surface analysis, TG/DTG/DTA, FTIR, XRD and TEM–EDX. Batch adsorption experiments were performed to investigate the effects of various parameters including pH of solution, contact time and initial selenium concentration on adsorption efficiency. The results revealed that FHAp nanocrystals (15–20 nm) possessed a good ability to adsorb selenite. First order kinetic, pseudo-second order and intraparticle diffusion model were used to evaluate the kinetic models and the mechanism of adsorption. A comparison of FHAp with other adsorbents was illustrated. Both kinetics and adsorption behavior using Freundlich and Langmuir isotherms were tested. It was found that the kinetics data were fitted well by a pseudo-second order model and the Freundlich isotherm suitably ascribed the adsorption. The adsorption capacities of the FHAp, CHAp (commercial hydroxyapatite), CS (chitosan) and FS (fish scale) itself towards Se (IV) ion were found to be 5.51, 1.42, 1.35 and 2.12 (mg g^{-1}) (L $mg^{-1})^{1/n}$, respectively. Therefore, it is evident that the FHAp nanopowders from the fish scale waste can be used as a natural adsorbent with high adsorption efficiency.

1. Introduction

Most trace elements can be both essential and toxic depending on their concentration. Selenium is considered one of the essential elements that have been paid much attention to owing to its complicated behavior. In general, it plays an important role at low concentrations in the metabolism of mammalian and human bodies, but it can lead to bioaccumulation and poison at high concentrations [1–3]. Selenium is transferred from plants to mammals in the food chain through the root system. In areas rich in selenium contamination, selenium is regularly present in sediment and soils and gathers through drainage. Once the plants have accumulated high levels of selenium which is uptaken by animals, alkali disease or blind staggers can take place [4,5]. Selenium is present in a number of both organic selenium and inorganic selenium compounds. Generally, the inorganic forms of Se (IV) and Se (VI) are more toxic than the organic forms. However, selenium in the form of Se (IV) is more toxic than Se (VI) [6–8]. Accordingly, the United States Environmental Protection Agency (EPA) defined the maximum contaminant level (MCL) for selenium in drinking water as 0.05 mg L^{-1} (or 50 ppb) to assure the safety of people [9].

The most popular treatment methods that have been developed for selenium removal include precipitation/coagulation, membrane filtration, activated alumina and reverse osmosis. The disadvantages of these methods are that they do not completely eliminate selenium from water (higher than 30 μg L^{-1} left in the solution), large volumes of mass sludge are generated, the high cost of reagents and the removal process is time consuming [10].

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