Geophysical Research Abstracts
Vol. 19, EGU2017-6235, 2017
EGU General Assembly 2017

Strontium (Sr) separation from seawater using titanate adsorbents: Effects of seawater matrix ions on Sr sorption behavior

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Strontium (Sr) which has many industrial applications such as ferrite magnet, ceramic, and fire works exists in seawater with the concentration of approximately 7 mg/L. In previous report estimating economic potential on recovery of various elements from seawater in terms of their commercial values and concentrations in seawater, Sr locates upper than approximate break-even line, which implies Sr recovery from seawater can be potentially profitable. Recently, Sr separation from seawater has received great attention in the environmental aspect after Fukushima Nuclear Power Plant (NPP) accident which released much amount of radioactive Sr and Cs. Accordingly, the efficient separation of radioactive elements released to seawater has become critical as an important technological need as well as their removal from radioactive wastes.

So far, it has been introduced to separate Sr from aqueous media by various methods including solvent extraction, adsorption by solid materials, and ion exchange. Among them, the adsorption technique using solid adsorbents is of great interest for selectively separating Sr from seawater with respect to low concentration level of Sr.

In this study, we synthesized titanate nanotube (TiNT) by simple hydrothermal reaction, characterized its physicochemical properties, and systematically evaluated Sr sorption behavior under various reaction conditions corresponding to seawater environment. The synthesized TiNT exhibited the fibril-type nanotube structure with high specific surface area of 260 m^2/g. The adsorption of Sr on TiNT rapidly occurred following pseudo-second-order kinetic model, and was in good agreement with Langmuir isotherm model, indicating maximum adsorption capacity of 97 mg/g. Based on Sr uptake and Na release with stoichiometric balance, sorption mechanism of Sr on TiNT was found to be ion-exchange between Na in TiNT lattice and Sr in solution phase, which was also confirmed by XRD and Raman analysis. Among competitive ions, Ca significantly hindered Sr sorption on TiNT, whereas Na had little effect on Sr sorption despite the sorption mechanism of Na-exchange. The effect of Ca on Sr sorption was evaluated in detail by introducing distribution coefficient (K_d) that is critical factor to determine the selectivity, revealing slightly higher selectivity for Sr. The adsorption-desoption test of Sr in real seawater medium enabled to determine K_d and concentration factor (CF) for co-existing matrix ions in seawater, and these values were assessed in both aspects of removal and recovery of Sr from seawater. The TiNT could be easily regenerated by acid treatment and reused for repeated cycle, supporting its long term use for the practical application of removing and recovering Sr from seawater.