Innovative Elution Processes for Recovering Uranium and Transition Metals from Amidoxime-Based Sorbents

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ABSTRACT:

Seawater contains about 3 ppb of uranium. With a total ocean volume of approximately $1.3x10^9$ km^3, there is at least 4.5 billion tons of uranium in seawater which is about 1000 times the amount of uranium known to exist in terrestrial ores.[1] Developing efficient, economic, and environmentally sustainable techniques for sequestering uranium from seawater is an active research area currently supported by DOE. Screening studies conducted in 1980s with more than 200 functionalized adsorbents show that the sorbent materials with the amidoxime group $RC(NH_2)(NOH)$ were most effective for uranium adsorption from seawater.[2] Recent research efforts in Japan and in the USA are focused on using amidoxime-based adsorbents for sequestering uranium from seawater.[3] The amidoxime-based fiber can be prepared by a radiation-induced graft polymerization method which involves acrylonitrile (CH_2=CH-CN) grafting onto polyethylene fabrics and chemical conversion of the -CN groups with hydroxylamine to the amidoxime groups. This type of sorbents show good mechanical strength and high capacity for uranium sorption from seawater. If this uranium sequestering technology could be made economically favorable and environmentally sustainable, our ocean would provide virtually an inexhaustible source of uranium for nuclear power production.

Uranium collected by the amidoxime-based sorbents is recovered typically by elution with an acid such as 1 M hydrochloric acid (HCl). A serious drawback of the acid elution process is deterioration of the sorbent material caused by acid hydrolysis making its reusability rather limited. This sorbent deterioration problem limits the economic competitiveness of the current amidoxime-based sorbent collection system for sequestering uranium from seawater. This project intends to develop a new two-step elution process to achieve the dual objectives of total recovery of uranium and effective recycle of the sorbent. The first step involves a sodium carbonate-hydrogen peroxide elution to selectively remove uranium from the sorbent with little or no damage to the sorbent. The second step uses supercritical fluid carbon dioxide as a solvent to extract transition metals and to regenerate the sorbent for repeated use. The change in uranium recovery efficiency and the durability of the sorbent for repeated use will be evaluated. The concept of combining carbonate-H_2O_2 elution and supercritical fluid extraction for total recovery of uranium from the amidoxime-based sorbents and for effective reuse of the sorbent material has not been attempted by any research group previously. This project may lead to a new elution technology to support DOE's mission of developing economically favorable and environmentally sustainable technologies for sequestering uranium from seawater.