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Synthesis of Novel Fabrics for Extraction of Uranium from Seawater

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Abstract
The world's oceans contain more than 4.5 billion tons of uranium; however access to this resource is limited by the ability to extract uranium from seawater efficiently. Lacing fabric substrates with chemical functionalities specific for uranium adsorption is one approach to meeting this challenge. Advanced adsorbent materials are being developed using polymeric substrates with high chemical stability, excellent degradation resistance and improved mechanical properties. Fabrics include polypropylene, nylon and advanced Winged Fibers from Allasso industries featuring extremely high surface areas for improved grafting density. Using Co-60 gamma source and 10-32 MeV electron beam linear accelerator, the various fabrics have been irradiated over a wide range of dose rates, total doses and temperatures.
Innovative vinyl phosphate and oxalate exhibiting high distribution coefficients and selectivity for uranium along with excellent potential for free radical polymerization have been utilized in the functionalization of the fabric substrates. Azo compounds with higher selectivity have also been utilized but have required the use of a grafted chemical precursor. Attachment of the chelating adsorbent or its precursor to the substrate polymer is maximized through the optimization of numerous variables including monomer concentration, dose rate, total dose, solvent and temperature.
Following irradiation, fabrics are washed, dried and weighed to determine the degree of grafting (DoG). The presence of monomer in the fabrics is verified using numerous experimental techniques including X-ray photoelectron spectroscopy (XPS), scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS), and Fourier-transform infrared spectroscopy-attenuated total reflectance (FTIR-ATR). Zeta potential measurements allow for surface charge measurements to confirm the negative charge required for uranium chelation. The fabric capacity for uranium extraction was tested by rotating samples for 7 days in a rotary agitator with actual seawater spiked with 0.2 or 1.0 mg·L-1 uranium. The fraction of uranium in the solution which was removed due to uptake on the fabrics was found to rise with increasing DoG at both uranium concentrations. SEM-EDS measurements are used to map the distribution of adsorbed uranium on the polymeric fibers.
Current work includes optimization of grafting density in addition to material characterization on the molecular level and analysis of the sample microstructure. Further testing in synthetic seawater will be conducted to compare the selectivity of each adsorbent fabric towards uranium compared to that of other species, in addition to determining the loading and adsorption rates under various conditions such as pH, temperature and salt concentration. Experiments in real seawater will consider effects of organics on the adsorbent materials, test for durability and reusability and determine kinetics and efficiency of the uranium extraction as a function of degradation.

Country/Organization invited to participate

United States of America

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