Using Ionic Liquids for the Development of Renewable Biopolymer-Based Adsorbents for the Extraction of Uranium from Seawater and Testing Under Marine Conditions

PI: Robin D. Rogers- University of Alabama

Collaborators: NA

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ABSTRACT:

We aim to understand the fundamental engineering parameters for a renewable high-performance adsorbent for the extraction of uranium from seawater based on our recently proven ionic liquid (IL)-chitin platform. Through blending chitin with other polymers we propose to enhance physical properties, control nano- and microscale fiber architecture, develop a versatile surface-modification for the adsorbent, and characterize the performance and degradation of the materials under marine conditions. The oceans are estimated to contain approximately 4.6 billion tons of uranium, more than a thousand times the amount found on land. If this uranium could be harvested economically, it could provide a sustainable long-term source of nuclear fuel while circumventing hazards associated with terrestrial uranium mining (such as the generation of radioactive mill tailings). Bulk extraction of uranium from the ocean in bulk by adsorption onto water-insoluble polymers which have been functionalized with uranium selective extractants has been demonstrated, but the process remains prohibitively costly. The cost could be lowered, however, if the adsorbent was made from a renewable material or even waste biomass.

Our group has researched the application of chitin, renewable and widely available biopolymer, as an adsorbent material for extracting uranium from seawater. The ionic liquid 1-ethyl-3-methylimidazolium acetate can dissolve shrimp shells, and the chitin can be reconstituted in the form of fibers, films, or even nanofibers. Regenerated chitin fibers can also be surface functionalized with uranium selective functional groups and used to extract uranium from dilute aqueous solutions.

Our goal here is to gain fundamental understanding over the process of improved adsorbent preparation through accomplishing the following objectives:

I. Understand how to *control bulk material properties* such as strength, capacity, stability to biodegradation, and anti-fouling through the homogeneous blending of chitin with other biopolymers and through control of the microscale architecture of the material.

II. Understand how to *control metal selectivity and capacity* by developing a versatile platform for surface modification of biopolymer adsorbent materials.

III. Understand how composition, architecture, and surface treatment affect the critical performance properties for extracting uranium from seawater by *measuring the performance of adsorbents* under simulated and actual marine conditions.

Our group will develop and study the physicochemical properties of adsorbents which vary by composition (type and ratio of polymers added to chitin), architecture, and functional groups appended to the surface (both type and degree of functionalization). We will test the extraction of uranium from simulated and actual seawater and conduct a study of how different adsorbents respond to microbes, chitinases, and other forms of biodegradation. Outcomes of this work will include the development of an environmentally and economically sustainable strategy for extracting uranium from seawater, enhanced understanding of the use of chitin as a material, and fundamental understanding on the interactions of polymers.