Functionalized Porous Organic Polymers as Uranium Nano-Traps for Efficient Recovery of Uranium from Seawater

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ABSTRACT:

BACKGROUND

The problem: The long-term use of nuclear power for energy applications relies on the secure and economical supply of nuclear fuel. Among various natural sources of uranium for use in nuclear reactors, sea water is highly appealing given that the oceans contain about 4.5 billion tons of dissolved uranium, almost 1000-fold that estimated for mineral reserves. Nonetheless, the concentration of uranium in seawater is extremely low (3–3.3 mg/L or 3–3.3 ppb); this, coupled with the presence of relatively high concentration of other metal ions, makes uranium recovery from seawater a challenge which requires the development of efficient and effective separation processes. Various adsorbent technologies based upon synthetic organic polymers, biopolymers, inorganic materials, mesoporous silica materials, porous carbon-based adsorbents, and ionic liquids have been widely developed for the extraction of uranium from seawater. However, these benchmark sorbent materials suffer from a number of drawbacks such as low adsorption capacity (typically 0.1~3.2 mg-U/g adsorbent), poor selectivity, and slow kinetics. This proposal focuses on the development of functional porous organic polymers (POPs) as a new type of adsorbents for uranium extraction with high efficiency and high effectiveness.

OBJECTIVES

The solution: Our approach to highly efficient and highly effective uranium extraction from seawater involves the custom-design of highly robust and water/chemical stable porous organic polymer (POP)-based uranium “nano-traps”, conducted by an interdisciplinary team of researchers. In general, POPs represent a new frontier in sorbent materials because they can exhibit high surface area and they can be custom-designed in terms of pore size and chemistry to fit a particular task. The POP-based uranium “nano-traps” will be created via “crystal engineering” guided design followed by stepwise post-synthetic modification. Three classes of POP-based uranium “nano-traps” will be developed, which feature high adsorption capacity, fast kinetics, and high selectivity of uranium thereby overcoming the weaknesses and handicaps associated with current adsorbent technologies.

There will be three specific objectives (tasks) to this 3-year project:

Task 1. Design, synthesis, and characterization of ~30 POP materials based upon 3 different families of “platforms”.

Task 2. Systematic investigation of the prepared POPs as uranium “nano-traps” for adsorption of UO_2^{2+} in the lab scale.

Task 3. The 5 lead compounds will be studied with respect to ambient seawater uranium adsorption experiments under practical conditions.