Selectivity and Kinetic Behavior of Heavy Metals and Radionuclides on Supported Ion-Exchange Adsorbents

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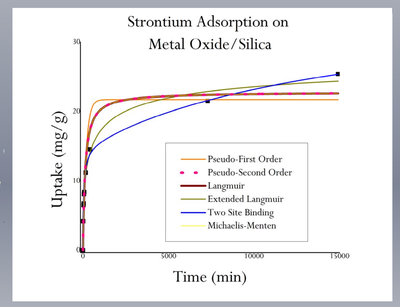
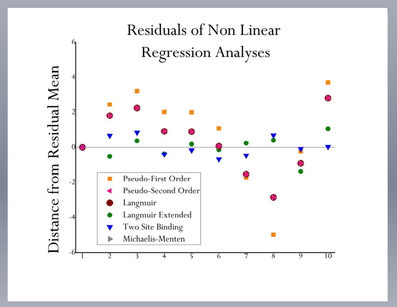
Abstract

The removal of radionuclides by selective concentration from seawater is an especially attractive goal since oceans contain valuable materials, although at low concentrations. Radionuclide sources include natural abundance and seepage plus that which is due to industrially generated wastewater streams and nuclear incidents. Challenges include the selectivity required for the low concentrations, high material volumes, and high ionic strengths. To address these problems, a recently available supported ion-exchange adsorbent was determined by kinetic assay to be selective for uranium from simulated seawater. These assay were also preformed for neodymium, lead, cobalt, strontium, cadmium, cesium, copper, thorium, barium, chromium, and nickel adsorbates, chosen due to either their presence in common wastewater streams or as surrogates for more exotic radionuclides. The adsorbent was also tested using groundwater and lake water, each doped with analyte ions. Analysis of the data revealed properties about the exchange mechanism regarding the Langmuirian growth of the analytes on the adorbent and leaching during subsurface migration by target ions. Under simulated conditions, the test material was able to concentrate heavy ions on the surface of the exchange interface with particular selectivity for uranium.

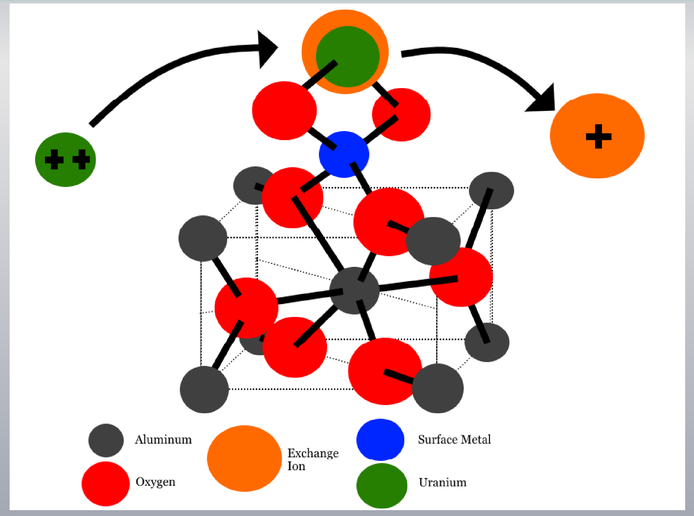
Sampling and Analysis

Non-Linear Modeling Approach

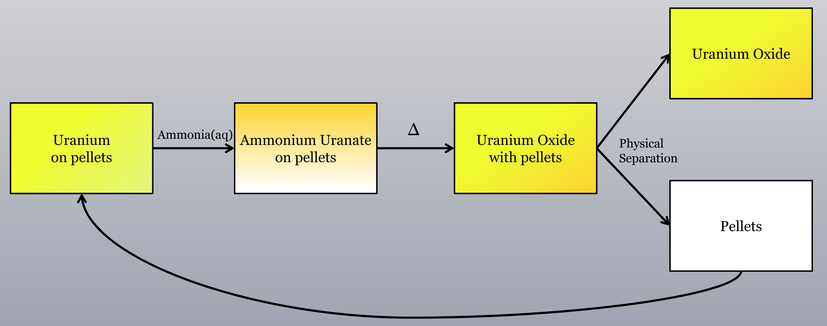




Adsorption Mechanism

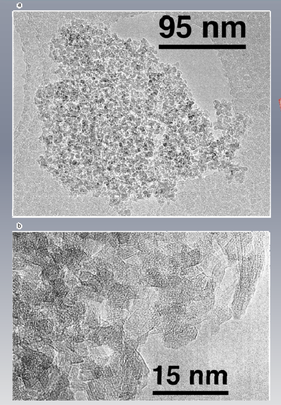


Processing



Cation Competition and Adsorption

Sorbent Pellets



Reduced Material Expense

Resin	Type	Theoretical uranyl Capacity (mmol/g)	Estimated cost per mole of Uranium
Bio-Rad Chelex 100	Weakly acidic cation-chelating resin	0.3	$12,966
Dowex™ 21K	Styrenic strong-base anion-exchange resin	0.6	$225
Purolite A-520E	Styrenic strong-base anion-exchange resin	1.4	$142
Dowex™ 1-X8	Styrenic strong-base anion-exchange resin	1.6	$356
Eichrom Diphonix	Cation-chelating resin	3.5	$1600
Xtractite	**inorganic metal oxide mineral exchanger**	**4.3***	**$55**

**Note that performance depends on numerous variables. In particular, ion exchange resins, unlike Xtractite, are often far from the theoretical capacity when saturated. For example Xtractite sorbent has a capacity of 3.5 mmol/g while that reported for DOWEX 21K by the Dept. of Energy is only 0.00013 mmol/g*

Sources and Funding

Mesoporous alumina microscope images from:
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Xtractite bottle and logo image property of Xplosafe.

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