Western Michigan University
Technology and Innovation Advancement

Office of the
Vice President
for Research

Selective Anion Extraction

Product: Anion Extracting Nano-structures

Development Stage: Proof of Concept Complete

Primary Inventor: Gellert Mezel PhD, Assistant Professor, Dept. of Chemistry

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Selective extraction of specific, charge-dense anions from a solution is beneficial, but has been limited in practice by the inability of anion extraction to overcome the Hofmeister bias. In liquid-liquid anion extraction, the Hofmeister bias favors the extraction of charge-diffuse, weakly-hydrated anions from aqueous to organic medium, over charge-dense anions. Here is a listing of some anions ordered from charge dense to charge diffuse;
$F^- \approx SO_4^{2-} > HPO_4^{2-} > \text{acetate} > Cl^- > NO_3^- > Br^- > ClO_3^- > I^- > ClO_4^- > SCN^-$.

Nuclear waste is one example of a highly alkaline, anion-containing solution, where low concentrations of sulfate, chromate and phosphate must be removed to efficiently dispose of the waste. However, high concentrations of nitrate and carbonate in the waste prevent the extraction of the three, charge-dense anions.

Removal of chromate from plating waste, sulfate from scale built up in oil drilling pipes and valves, and a variety of charge dense anions from mining effluent are other examples, where selective extraction of the charge-dense anions would be valuable. Additional charge-dense anions that may require preferential extraction include; chloride, carbonate, fluoride, arsenate, and selenate.

Technology Description

To overcome the limitations of extracting charge-dense anions from an aqueous solution in the presence of more charge-diffuse anions, Dr. Mezei at Western Michigan University has developed a method to specifically extract the charge-dense anions into almost any organic medium. This process creates structures that are termed “nano-jars” because they encapsulate the target anion completely within a three-dimensional, toroid structure, resulting in sequestration of the charge-dense target anion for solvent extraction (see Figure on next page) shows the structure of one nano-jar.

A wide variety of organic solvents can be used for extracting the anion containing nano-jars from an aqueous solution including; CCl_4, CS_2, aromatic hydrocarbons, ethers, ketones, esters, nitriles, amines, halogenated and nitro compounds, DMF, DMSO and aliphatic hydrocarbons.

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Potential Benefits

- Complete, specific removal of charge-dense, target anion
- Removal of low concentrations of charge-dense anions from aqueous solutions containing high concentrations of interfering, charge-diffuse anions
- Separation of nano-jars from aqueous solutions with common organic solvents
- Nano-jar materials are easily recycled for repeated extractions
- Multiple charge-dense, target anions can be removed simultaneously

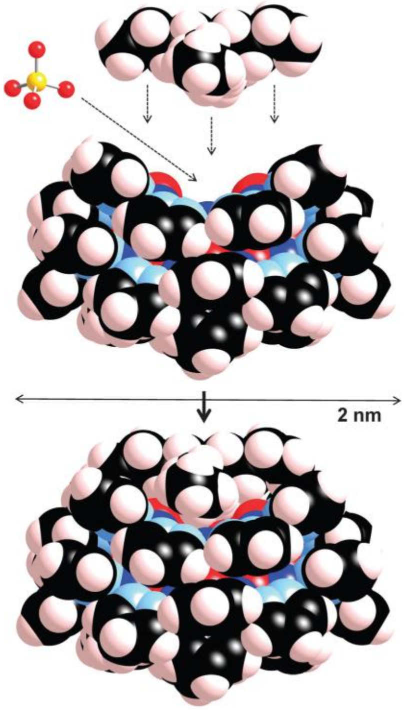

Figure: Formation of the sulfate-encapsulating ‘‘nano-jar’’ by sealing the nano-toroid with a Bu4N+ ‘‘lid’’ (side-view). Color-code: S-yellow, O-red, Cu-blue, N-light blue, C-black, H-pink.