Recovery of Radionuclides from Aqueous Feed

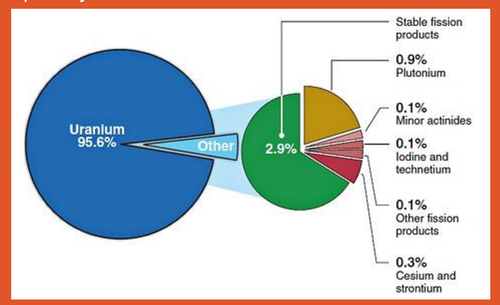
Objective: Develop and test an energy efficient method for extracting uranium from an aqueous solution.

Motivation

Fuel Reprocessing

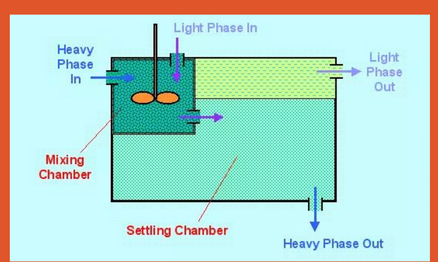
Fuel reprocessing is the practice of recycling "spent" nuclear fuel. In 1977, fuel reprocessing was banned in the US on the grounds of violating the non proliferation treaty originally established in 1970. However, other members of this treaty, such as France, still practice fuel reprocessing to this day.

"Spent" nuclear fuel still contains a significant quantity of useful material



PUREX

A well-established chemical process used for recycling the leftover useful material remaining in "spent" fuel. Heavily dependent on separating oil-and-water type mixtures. Traditionally uses a mixer-settler tank pictured below.

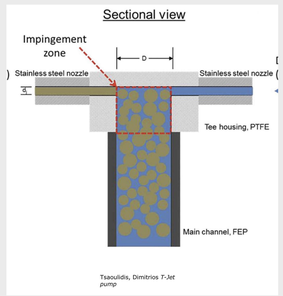


Oregon State University

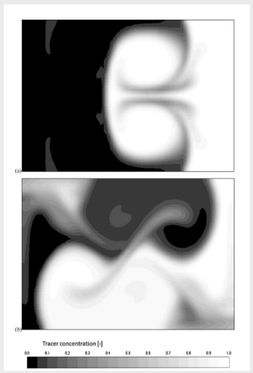
Research & Experimental Data

Mixing

Pumping/ mixing utilizes a T-Jet system and syringe pump. Reynolds numbers below 500 are needed to optimize mixing and obtain a S-shaped engulfment pattern in the mixing chamber. C-Shaped engulfment leads to a less desirable plug flow.



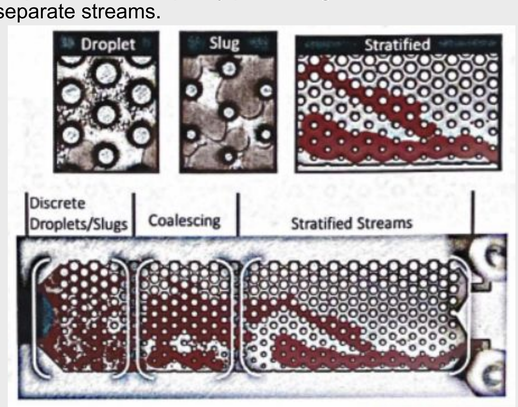
T-Jet system



C vs S Engulfment

Microfluidics

The separation device utilizes differences in chemical properties and a capillary pressure gradient to create two separate streams.



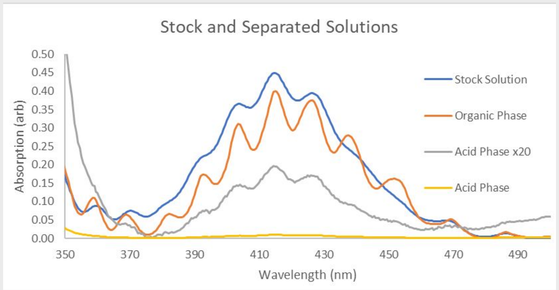
A "pin board" style microfluidic device

Chemicals

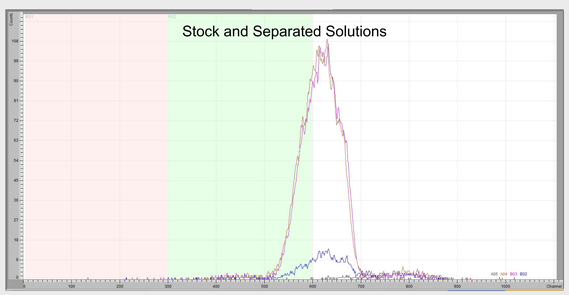
Chemical extraction was based around a simplified version of the established PUREX process, using tri-n-butyl phosphate (TBP) as a complexing agent in an organic solvent, to extract uranium from an aqueous phase of nitric acid. The typical organic solvent of kerosene was replaced by toluene, for its superior performance in the microfluidic device.

Analysis

Results were analyzed using a variety of verification and validation methods including visual inspection, volumetric analysis, UV-vis spectroscopy, and liquid scintillation counting.



Analysis of results using UV-Vis spectroscopy

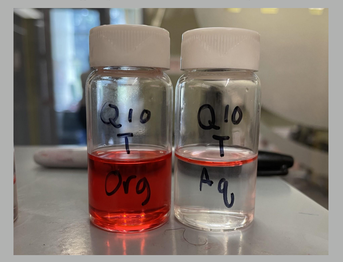


Analysis of results using liquid scintillation counting

Conclusion

Results

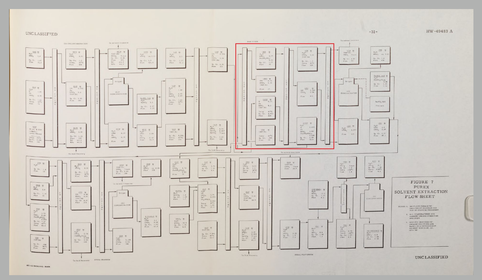
The data collected yielded a roughly 98% success rate for extracting uranium from the aqueous phase. Additionally, the two liquids were separated from each other using the microfluidic device with roughly 85% efficiency.



"Dry run" separation results

Future Work

- Determine decontamination efficiency: ability to separate uranium from the following:
  - Zirconium (present in large quantities)
  - Ruthenium (tends to follow uranium)
  - Americium, curium (have their own uses)
- Extend to work with thorium-based fuels
  - Requires different chemistry
  - Basic process exists (THOREX)



An overall flowchart of the PUREX process, with the part currently being tested outlined.

Meet the Group

Pictured left to right: Chris Kulah, Quinton Williams, Taighlor Story, Zane Tucker

Mentors (not pictured): Dr. Sasha Chemey, Dr. Natasha Mallette, Dr. Goran Jovanovic