Corrosion and Precipitation in Molten Salt Reactors

Consortium for Enabling Technologies & Innovation

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Objective

Improve the understanding of uranium chemistry in molten salt reactors by studying U(III) and U(IV) in molten salt systems spectroelectrochemically.

Introduction

Advantages of Molten Salt Reactors (MSR)

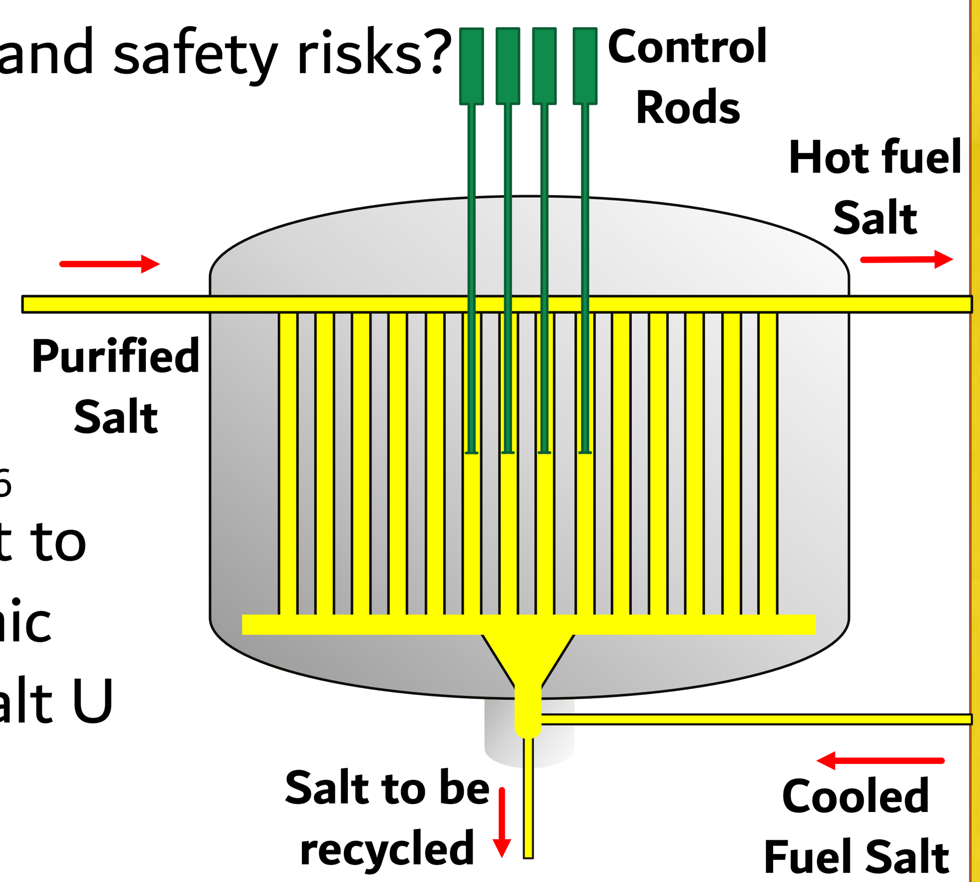
- Offer enhanced safety and efficiency through low pressure and high temperature operations
- Reduce the radiotoxicity of waste by 1/10,000th compared to conventional reactors
- Ease of enrichment and separation of fissile Pu

Questions

- What chemistry is taking place that can contribute to **corrosion and precipitation effects?**
- How does the chemistry affect **proliferation concerns** and safety risks?

Plan

- Measure the **diffusion coefficient** of U through molten salts
  - Test method: $K_4Fe(CN)_6$
- Use diffusion coefficient to inform molecular dynamic simulations of molten salt U mixtures



Methods

Electrochemistry Experiments

- Materials
  - Bob's cell as an electrochemical cell
  - Gamry 3000 Potentiostat to measure cyclic voltammograms (CV)
  - 5.007 mM $K_4Fe(CN)_6$ in 100.15 mM KNO_3
- Data Analysis
  - Calculate the diffusion coefficient from a CV
    - Control potential
    - Measure resulting current for varying scan rates (50-500 mV/s)

$$i_p = 0.4463 nFAC \left(\frac{nvFD}{RT}\right)^{1/2}$$

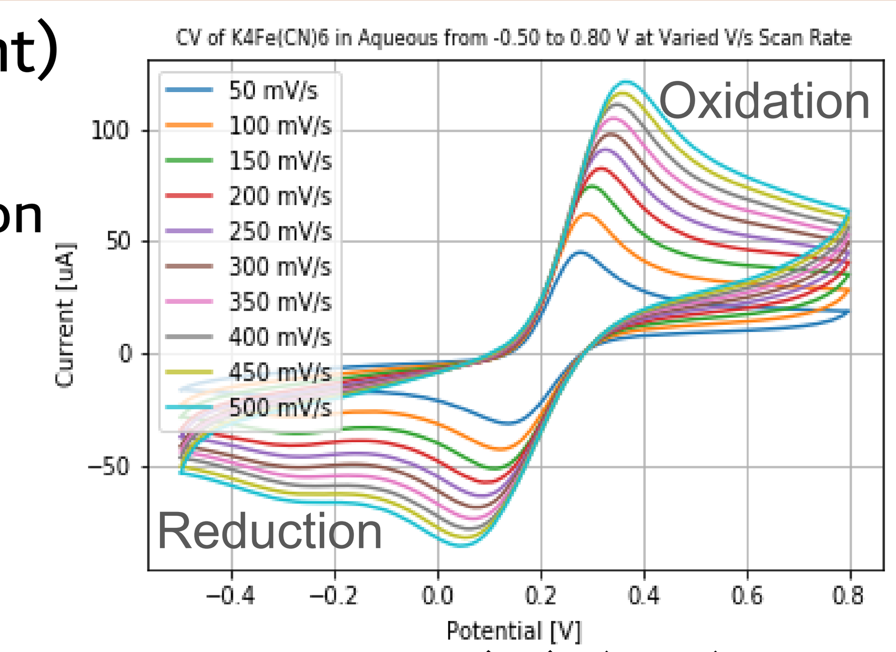
Randles-Sevcik Equation

Results

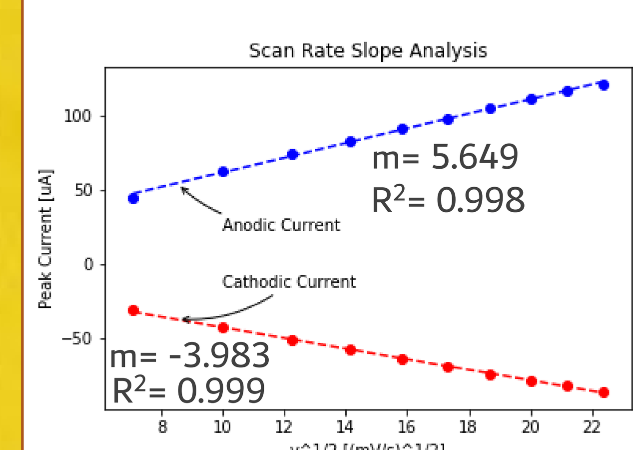
Cyclic Voltammogram (right)

Peak Drift

- A mild peak drift for oxidation and reduction with varying scan rate is seen in the CV
  - Oxidation peak drift was 0.0858 V
  - Reduction peak drift was 0.0929 V



Diffusion Coefficient (D) (left)



Data from CV

- Use the slope and the R-S equation to calculate the diffusion coefficient
  - $D = 1.758 \times 10^{-6}$ cm^2/s
  - Currently investigating the 4 factor difference from known system

Future Work

Diffusion Coefficient

- Determine the diffusion coefficient for Eu(III) in LiCl-RbCl and 3 LiCl-2 CsCl eutectic melts
- Compare to literature
- Determine the diffusion coefficient for U(III) and U(IV) in molten salt mixtures
- Use results to inform molecular dynamics

Extended X-ray Absorption Fine Structure (EXAFS)

- Determine the local coordination environment of U in a chloride eutectic molten salt
- Determine bond distance between bonded salt constituents relative to uranium

Raman Spectroscopy

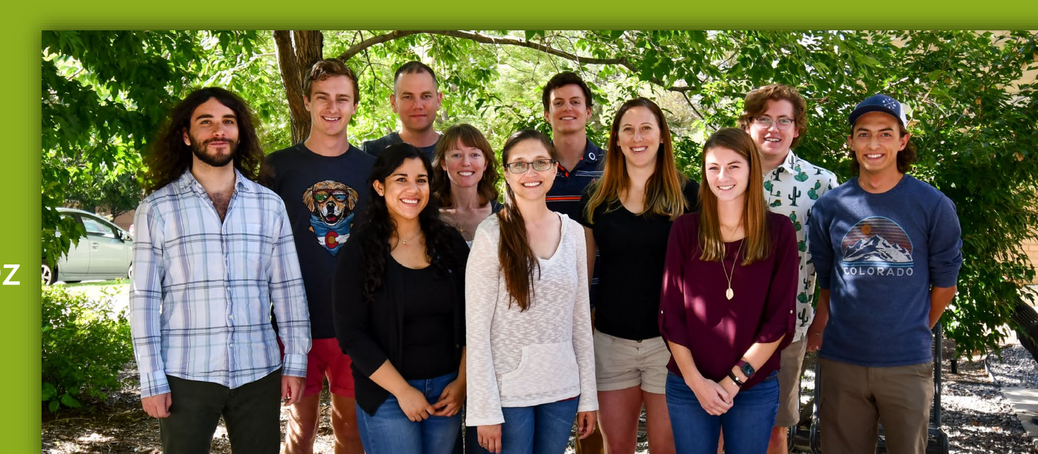
- Define the bonding characteristics of U with the salt constituents

Diffusion Coefficient

EXAFS

Raman

Shafer Group



Front: Andrew Fletcher, Vanessa Linero, Erin Bertelsen, Jennifer Shafer, Me, Jacob Tellez

Back: Eric Norfleet, Kevin Pastoor, Jessica Jackson, Brian Arko, Ian Wilkinson

References

Schroll, Cynthia A.; Chatterjee, Sayandev; Levitskaia, Tatiana; Heineman, William R.; Bryan, Samuel A. "Spectroelectrochemistry of $EuCl_3$ in Four Molten Salt Eutectics; 3 LiCl−NaCl, 3 LiCl−2 KCl, LiCl−RbCl, and 3 LiCl−2 CsCl; at 873 K." *Electroanalysis.* **2016,** 28, 2158 – 2165.

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