ELECTROCHEMISTRY IN CSP SYSTEMS

MOLTEN SALT ELECTROCHEMISTRY

- Electrochemical phenomena and approaches are enormously important in electrolytic systems such as molten salts
- Electrochemical phenomena govern the corrosivity of the salt and dictate the lifespan of equipment
- Electrochemical techniques can be leveraged to:
  - Monitor the health of the salt
  - Control the health of the salt
  - Understand and quantify the underlying thermodynamic and kinetic properties of the salt

FASTR Loop (ORNL)

Purification System Monitoring

Storage Tank Monitoring (not pictured)

Electrochemical Systems Instrumentation Rack
Electrochemical techniques can be used to extract crucial fundamental properties for the molten salt and its accompanying impurities and corrosion products:

- Thermodynamics of key corrosion reactions
- Mass transfer properties of dissolved species (diffusion coefficients)
- Thermogalvanic coefficients
- Reaction kinetics (e.g., decay rates of impurities such as MgOHCl)
Electrochemical approaches can provide monitoring and control of the salt purification processes that must be run before the salt can be used as a suitable heat transfer fluid. Tests at small scales enable development of the purification processes, while use at full scale ensures the system is run optimally.

**Gram- and Kilogram-scale Purifications**

Salt potential vs. time plot with the introduction of reactive metal basket for small-scale salt purification

**Full-scale Purification (hundreds of kg’s)**

Salt potential vs. time plot with the introduction of reactive metal basket for full-scale salt purification

1Full-scale purification performed in the FASTR loop at ORNL (Kevin Robb)
ELECTROCHEMISTRY IN CSP SYSTEMS
FLOW LOOP MONITORING

Electrochemical sensors are able to provide key in-line measurements of the salt chemistry and redox state. The measurements are acquired by analyzing the salt’s response to electrical signals that are applied to immersed electrodes.

Typical multielectrode array sensor for loop monitoring

Cr²⁺ concentration vs. time during typical TCL experiment

Salt potential vs. time during typical TCL experiment

¹MgCl₂-KCl-NaCl thermal convection loop run at ORNL (Bruce Pint)
Salt monitoring can be used in tandem with corrosion control capabilities to maintain the salt in a healthy state.

Electrochemical approaches such as electrolysis can be readily used to remove corrosive impurities.

The rate of actuation of the corrosion control systems can be automated to control the salt redox potential within the desired range:
- Salt potentials that are too high lead to oxidation of structural alloys
- Salt potentials that are too low lead to undesired alloying
ELECTROCHEMISTRY IN CSP SYSTEMS
MULTISCALE THERMAL CONVECTION LOOP SIMULATIONS

The combination of multiscale electrochemistry numerical solvers and the experimentally-derived fundamental physicochemical and thermochemical properties enables full-scale simulations of corrosion and chemistry in CSP-relevant flow loops.

**MASS TRANSFER PROPERTIES**

**REACTION KINETICS**

**THERMOCHEMICAL PROPERTIES**

- Temperature
- Velocity magnitude (midplane)
- Local Cr depletion/deposition rate
GOVERNMENT LICENSE NOTICE

The submitted manuscript has been created by UChicago Argonne, LLC, Operator of Argonne National Laboratory (“Argonne”). Argonne, a U.S. Department of Energy Office of Science laboratory, is operated under Contract No. DE-AC02-06CH11357. The U.S. Government retains for itself, and others acting on its behalf, a paid-up nonexclusive, irrevocable worldwide license in said article to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government.