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MOLTEN SALT ELECTROCHEMISTRY IN CSP SYSTEMS

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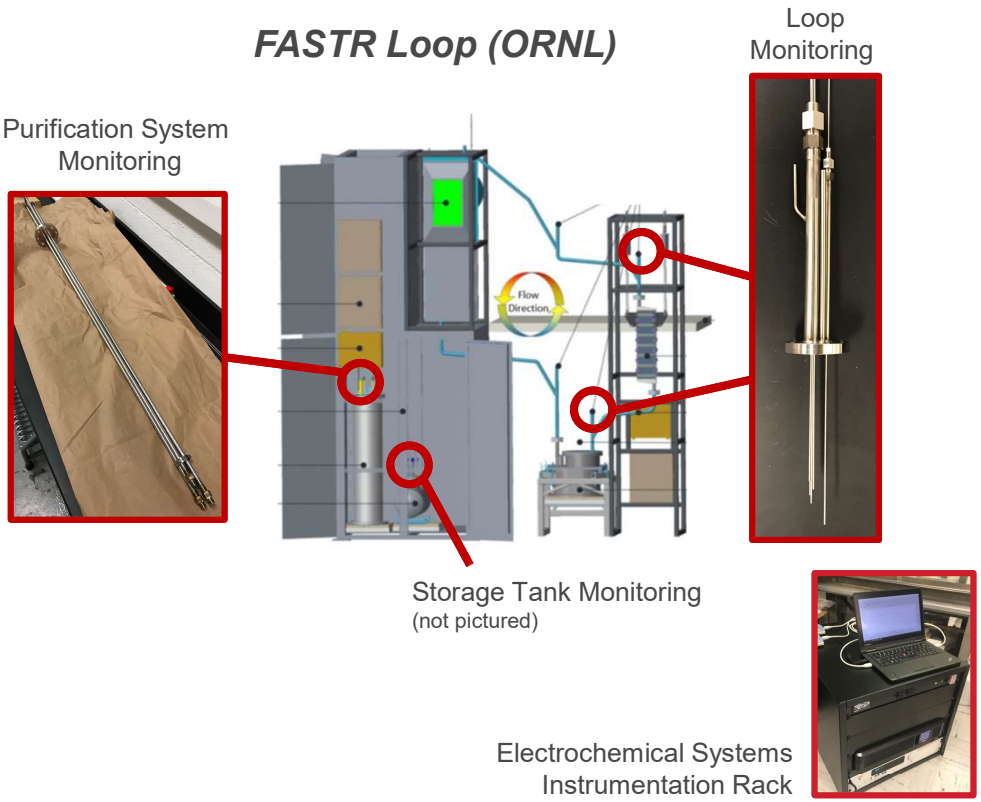
ELECTROCHEMISTRY IN CSP SYSTEMS

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



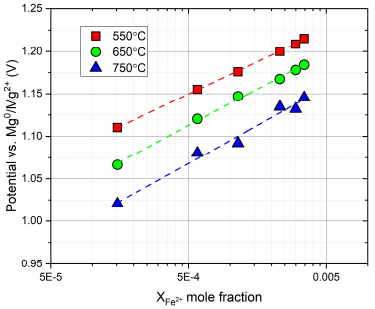
ELECTROCHEMISTRY IN CSP SYSTEMS

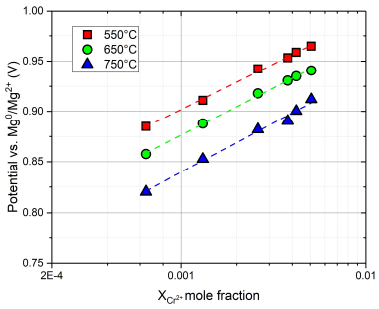
FUNDAMENTAL PROPERTIES

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

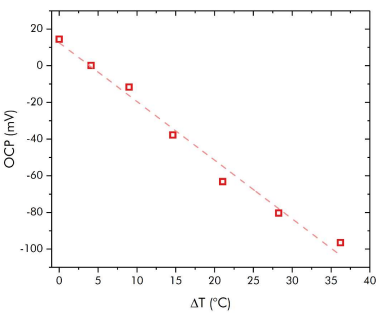
- Thermodynamics of key corrosion reactions
- Mass transfer properties of dissolved species (diffusion coefficients)
- Thermogalvanic coefficients
- Reaction kinetics (e.g., decay rates of impurities such as MgOHCl)

Formal Potentials of Key Corrosion Products (Cr, Fe)

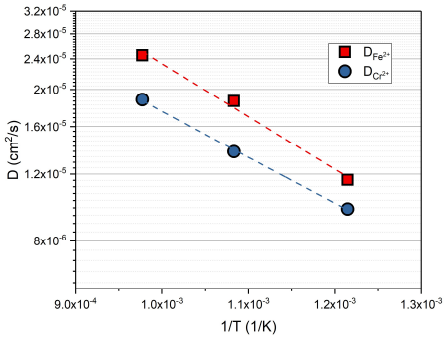




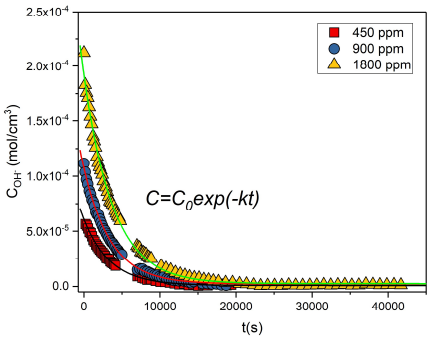
Thermogalvanic Behavior



Diffusion Coefficients



MgOHCl Decomposition Rates

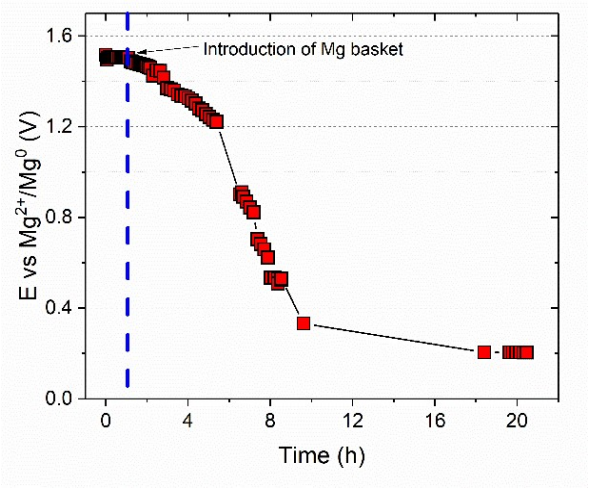


ELECTROCHEMISTRY IN CSP SYSTEMS

PURIFICATION SYSTEM MONITORING AND CONTROL

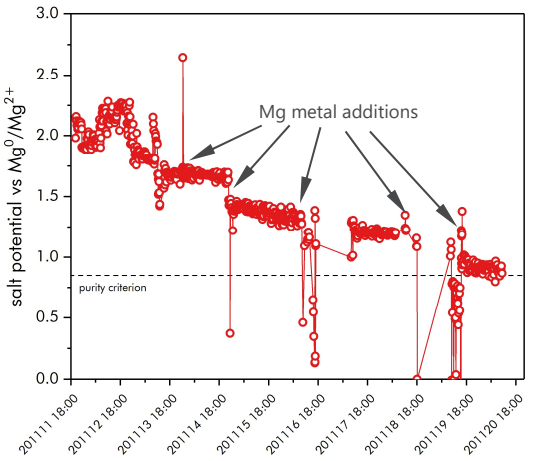
Electrochemical approaches can provide monitoring and control of the salt purification processes that must be run before the salt can be used as a suitable heat transfer fluid. Tests at small scales enable development of the purification processes, while use at full scale ensures the system is run optimally.

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)[1]



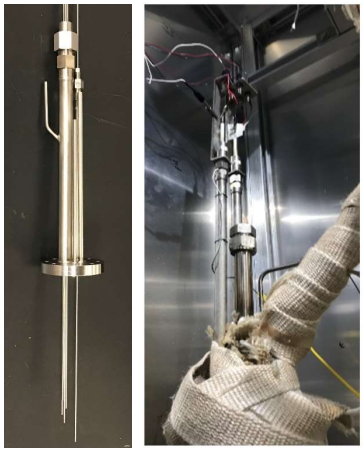
Salt potential vs. time plot with the introduction of reactive metal basket for full-scale salt purification

[1]Full-scale purification performed in the FASTR loop at ORNL (Kevin Robb)

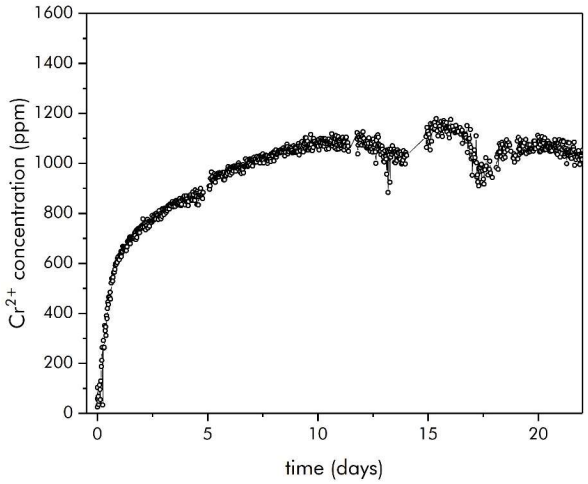
ELECTROCHEMISTRY IN CSP SYSTEMS

FLOW LOOP MONITORING

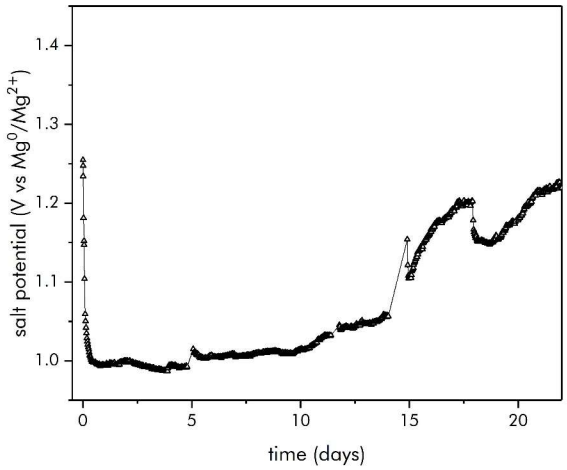
Electrochemical sensors are able to provide key in-line measurements of the salt chemistry and redox state. The measurements are acquired by analyzing the salt's response to electrical signals that are applied to immersed electrodes.



Typical multielectrode array sensor for loop monitoring



Cr^{2+} concentration vs. time during typical TCL experiment[1]



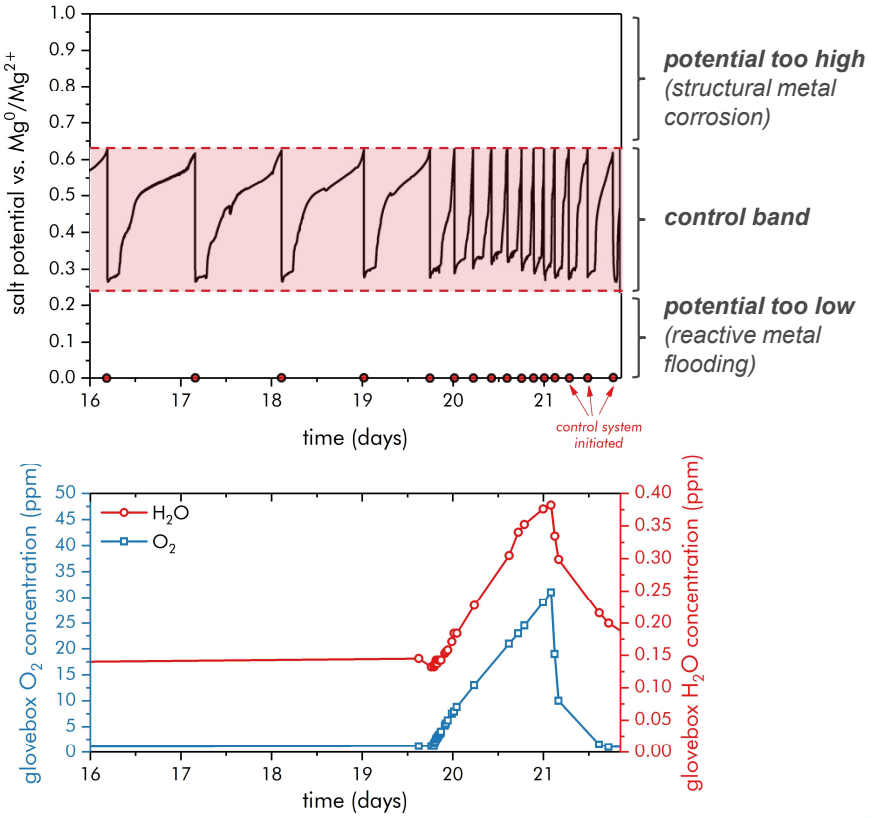
Salt potential vs. time during typical TCL experiment[1]

[1]$MgCl_2$-KCl-NaCl thermal convection loop run at ORNL (Bruce Pint)

ELECTROCHEMISTRY IN CSP SYSTEMS

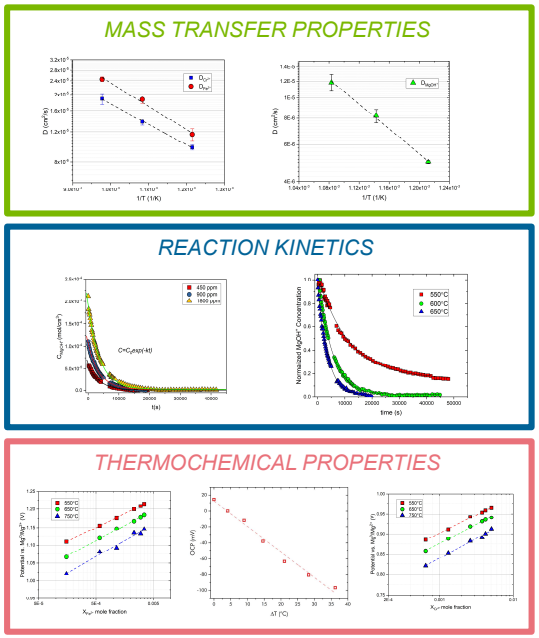
CORROSION CONTROL

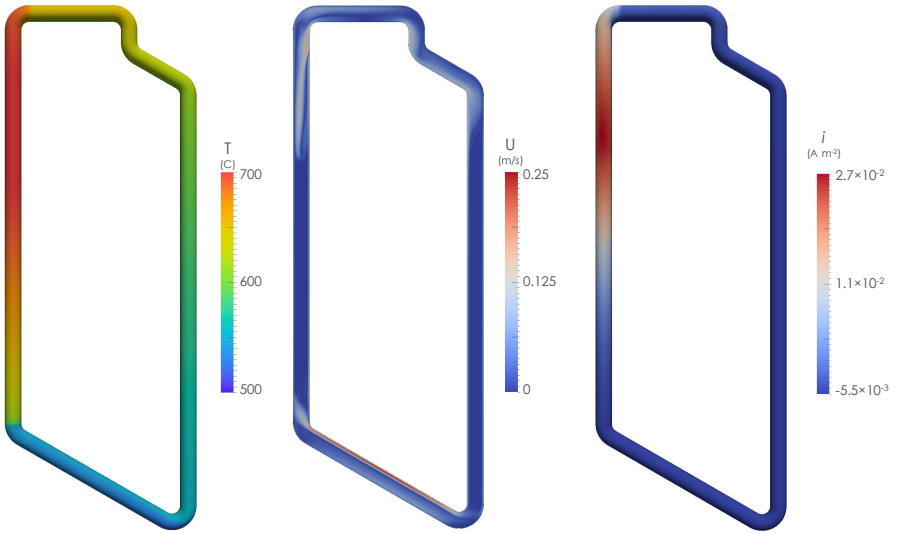
- Salt monitoring can be used in tandem with corrosion control capabilities to maintain the salt in a healthy state.
- Electrochemical approaches such as electrolysis can be readily used to remove corrosive impurities.
- The rate of actuation of the corrosion control systems can be automated to control 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



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





temperature

velocity magnitude
(midplane)

local Cr depletion/deposition rate

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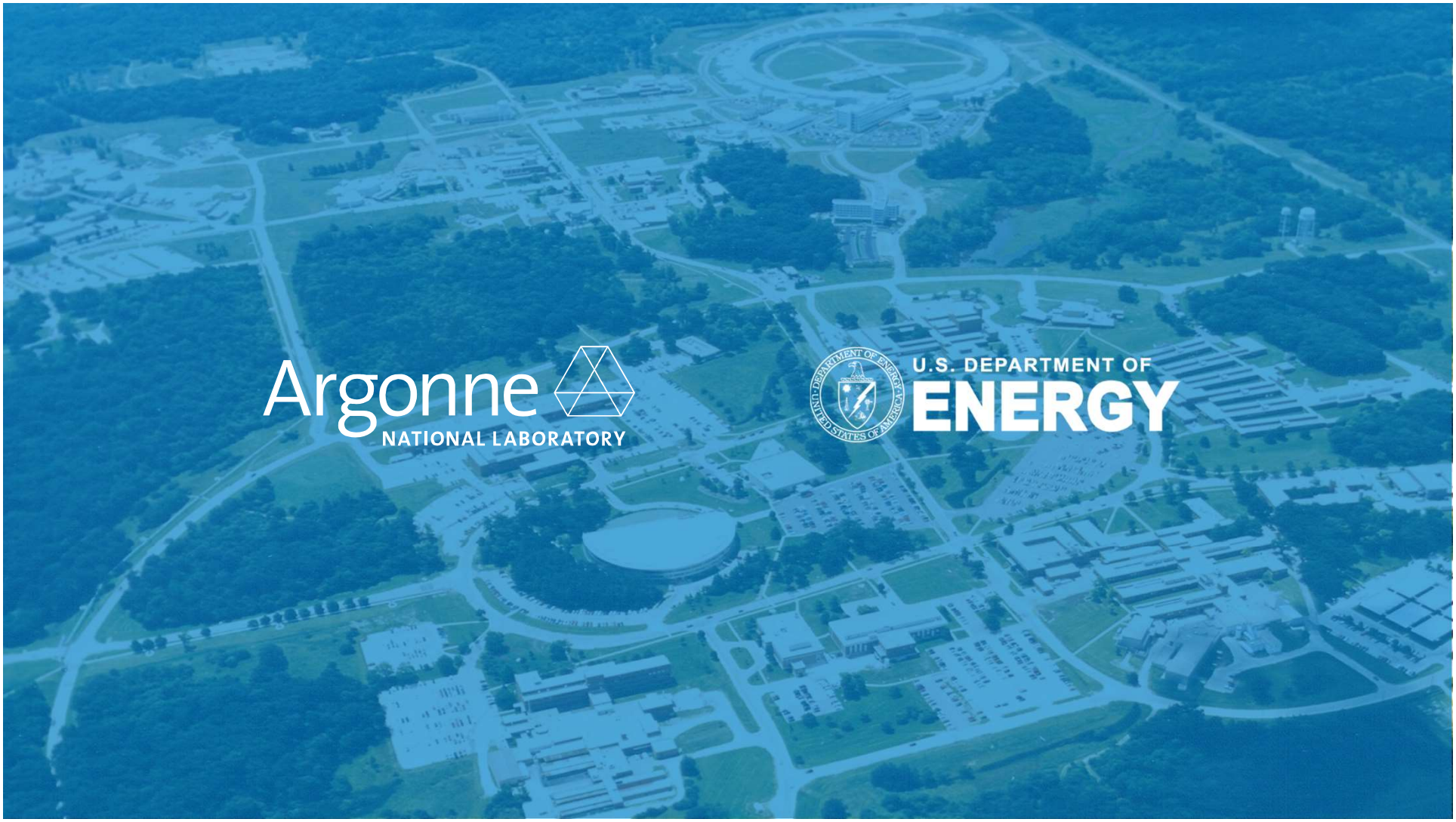
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