
# Molten Salt Panel

DOE Solar Energy Technologies Office

Gen3 CSP Summit

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# Salt Chemistry Control and Regeneration

**Chloride salts cause intergranular corrosion.**

- Caused by impurities
- Corrosion depletes key alloying elements

**Corrosion is problematic and expensive.**

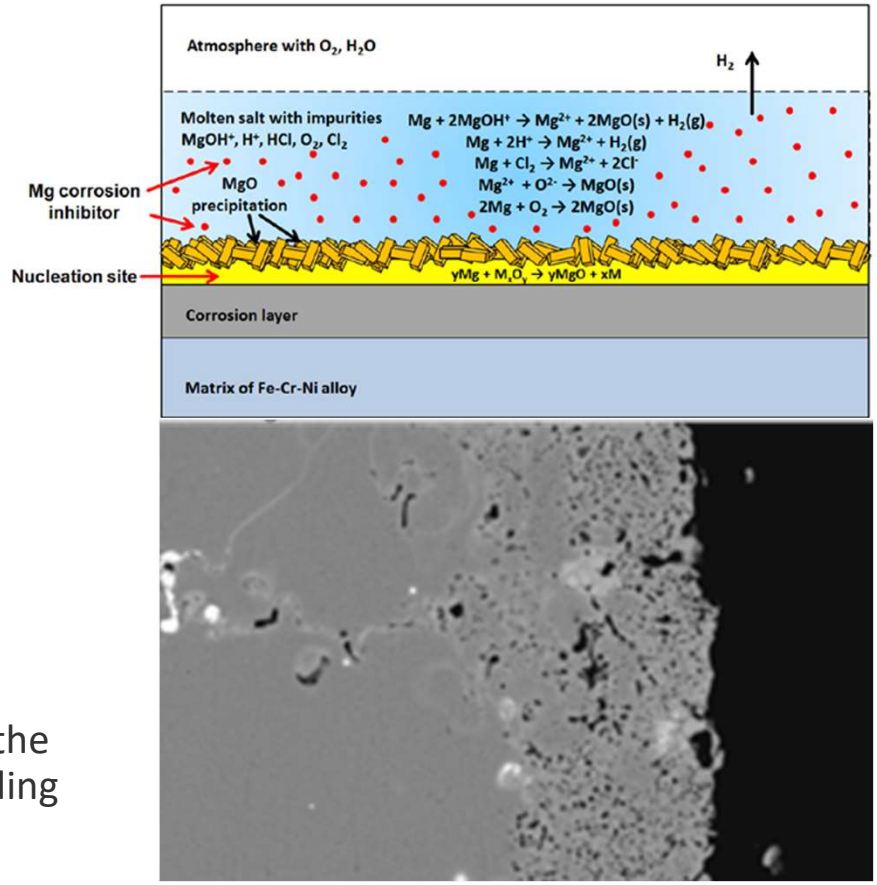
- Alloys corrode at unacceptable rates
- This requires expensive alloys and expensive maintenance

**Controlling salt chemistry can mitigate corrosion.**

- Salt-soluble *MgOHCl* in molten chlorides is one of the major species that reacts/corrodes metal *M* according to the reaction:

$$xMgOHCl + M \rightarrow xMgO + MCl_x + (^x/_2)H_2$$

- *Regenerating pure salts is important for plant operation*




***SEM of corroded H230 after molten chloride exposure***

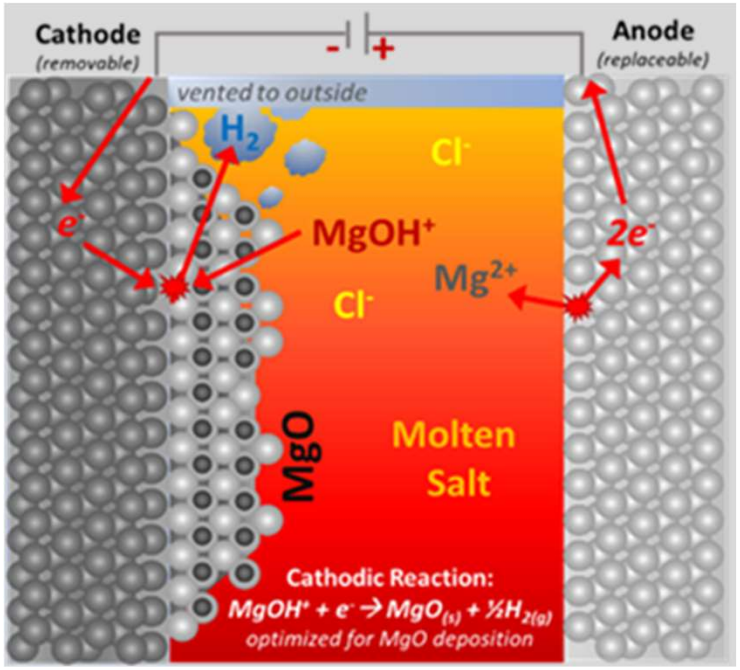
# Corrosion Control During Plant Operation

**A sealed and controlled environment mitigates formation of corrosive impurities**

- MgOHCl forms when salt is exposed to moisture

**Electrochemical purification can effectively remove corrosive impurities**

- Even in sealed systems, corrosive species will form due to small leaks and moisture in ullage gas
  - ➢ It can be controlled by *electrochemical purification*

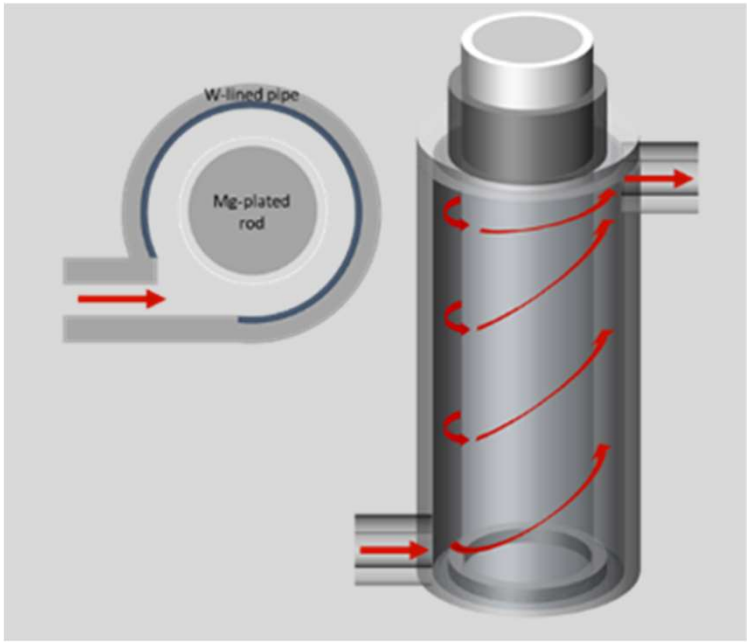



$$2MgOHCl \rightarrow 2MgOH^{+} + 2Cl^{-} \quad [molten\ salt]$$
$$Mg^{2+} + 2Cl^{-} \rightarrow MgCl_2 \quad [molten\ salt]$$
$$2MgOH^{+} + 2e^{-} \rightarrow 2MgO + H_2(g) \quad [cathode]$$
$$\underline{Mg(s) \rightarrow Mg^{2+} + 2e^{-}} \quad [anode]$$
$$2MgOHCl + Mg(s) \rightarrow MgCl_2 + 2MgO + H_2(g) \quad [overall\ reaction]$$

# Operations and Maintenance

## *Developing Work, beyond Gen3*

- NREL is designing, constructing, and validating a ***flow electrochemical purification cell*** for in-situ corrosion control during plant operation
- Corrosive ***MgOHCl will be removed as fast as it is formed***, so it will not build up and corrode alloys
- Byproducts of purification, which are less harmful, will be removed via filtration and ullage gas sweep

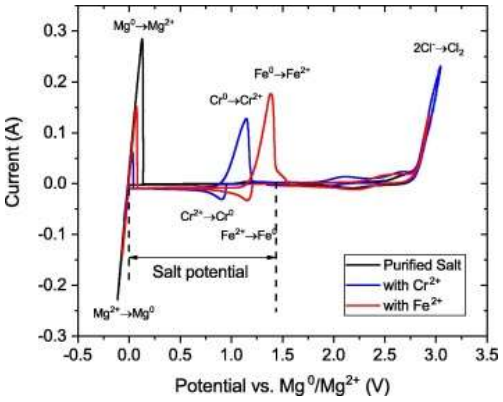



*In-line electrochemical purification cell*

# Sensors and Controls

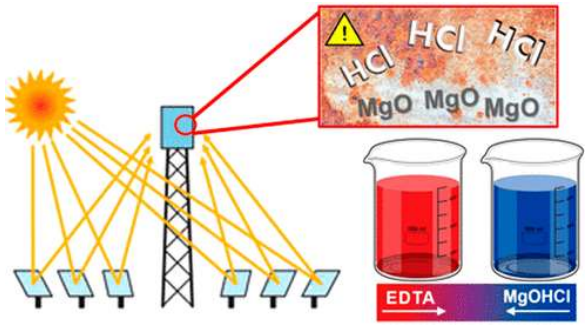
*To facilitate proper maintenance, **sensors and controls** are being developed for use during plant operation.*

## Salt Sensors



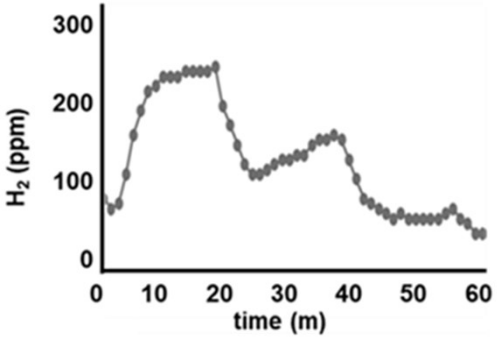

- Sensors use cyclic voltammetry to quantify impurities
- It detects corrosive $MgOH^+$ and byproducts from corrosion

## Titration




- Sensors are calibrated using accurate titration developed/optimized by NREL
- Easy procedure, no sophisticated instruments required

## Gas Analysis




- Byproducts of purification such as $H_2$ can be monitored with gas sensors


Klammer et al, *Analytical Chemistry*, 2020, 92, 3598-3604
Guo et al, *Journal of Electroanalytical Chemistry,* 2021, 115064

# System Resilience

Electrochemical purification cell will *substantially improve viability* of molten chloride salt-based systems.

- Decrease levelized cost of electricity
- Decrease operation and maintenance costs
- Enable use of less expensive containment alloys

*Top: discolored chloride salt containing impurities*
*Bottom: pure white chloride salts*