U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

SETO CSP Program Summit 2019

Molten Chloride Thermophysical Properties, Chemical Optimization, and Purification

Purification Protocol, Impurity Determination, Salt Compositions, and Energy Density

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NREL NATIONAL RENEWABLE ENERGY LABORATORY

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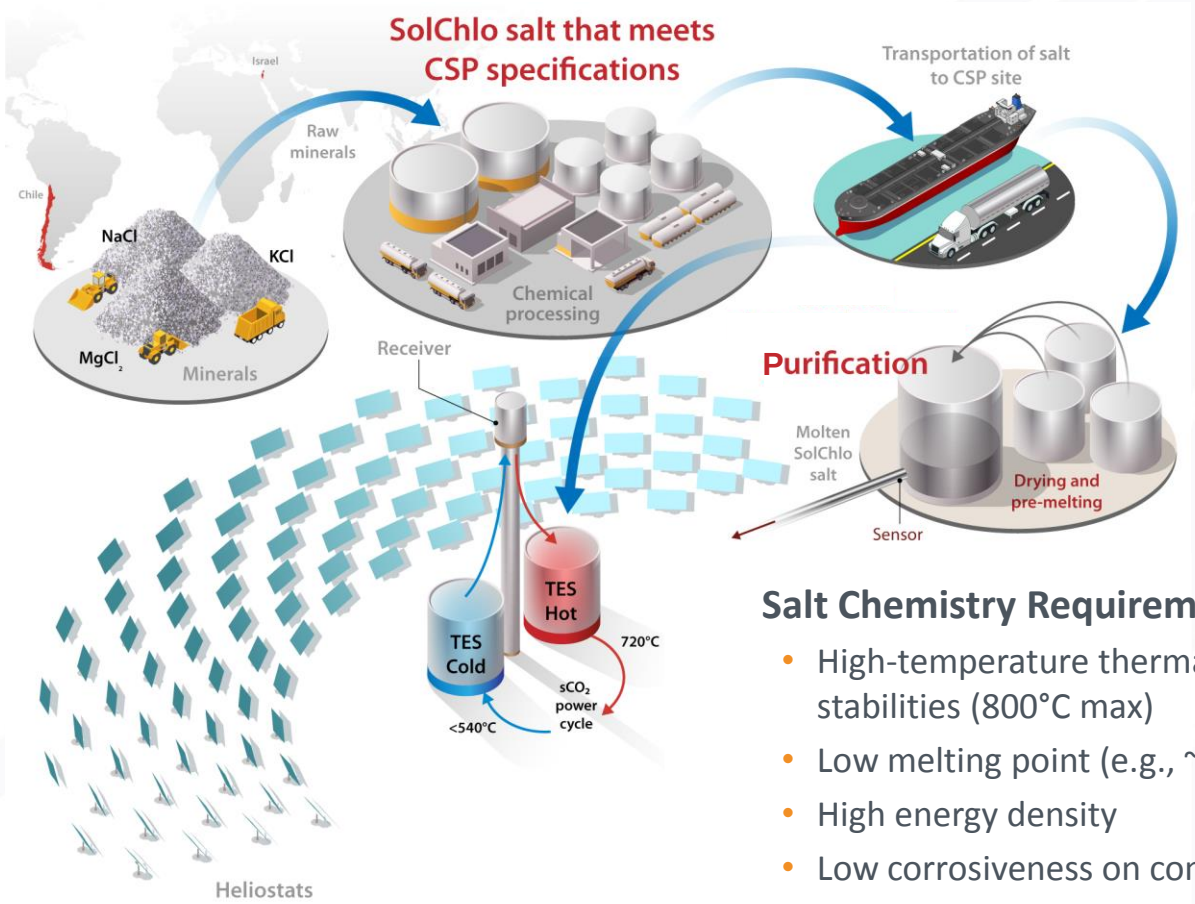
Gen3 CSP with Molten Chloride Salts



Salt Chemistry Requirements

- High-temperature thermal and chemical stabilities (800°C max)
- Low melting point (e.g., ~400°C)
- High energy density
- Low corrosiveness on commercial alloys

Gen3 CSP with Molten Chloride Salts

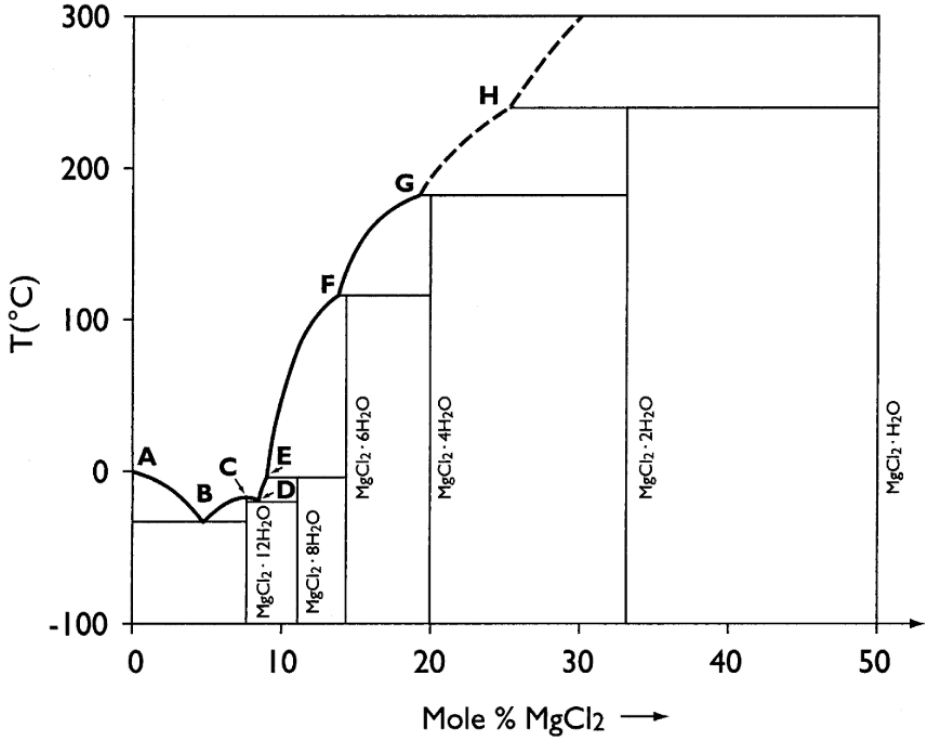
Challenges

- Thermophysical properties and corrosion mechanism are less known
- ***Affordable*** route needs to be carefully engineered toward the optimal salt composition(s) from ***commercially available*** and ***low-cost*** raw materials

NREL's Strategies

- Benchmark corrosion behavior of the commercial salt and mitigated by engineering thermal, and chemical purification processes.
- Tracking of salt composition shift and change of corrosive impurities during drying, purification, and melting and plant operation.
- Accurately and reliably measure relevant thermophysical properties to select the optimal salt composition(s) with the highest per-cost energy density.

Purification Protocol



G. Kipouros and D. Sadoway (2001)

Thermal purification

- Step-wise dehydration of $MgCl_2 \cdot 6H_2O$ (or $KMgCl_3 \cdot 6H_2O$) at 117°C, 180°C, 240°C, and 400°C
- However, hydrolysis of $MgCl_2$ with released H_2O to form MgOHCl and HCl(g)

Chemical purification

- Reduction of MgOHCl and impurity cations by elemental Mg

Reactions during Purification

- Dehydration and hydrolysis at 117°–400°C

$$MgCl_2 \cdot xH_2O \rightarrow MgOHCl + HCl(g)$$

- Thermal decomposition of MgOHCl above ~550°C

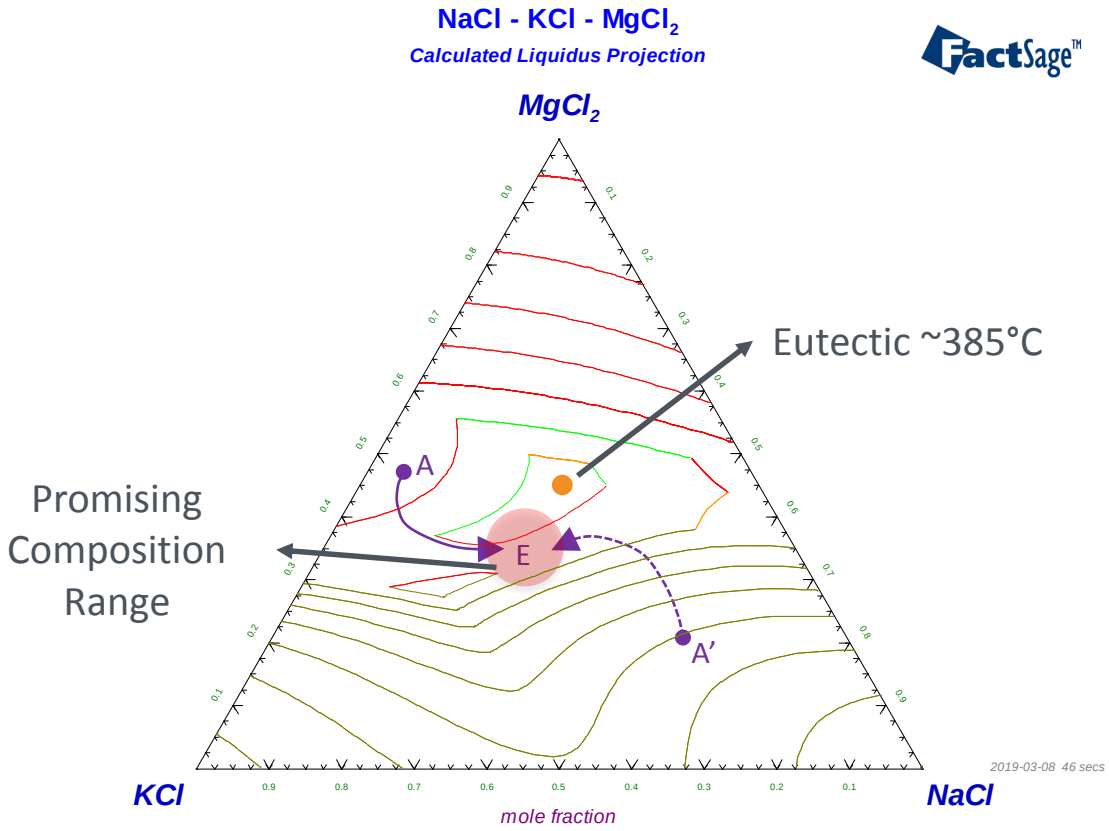
$$MgOHCl = MgO + HCl(g)$$

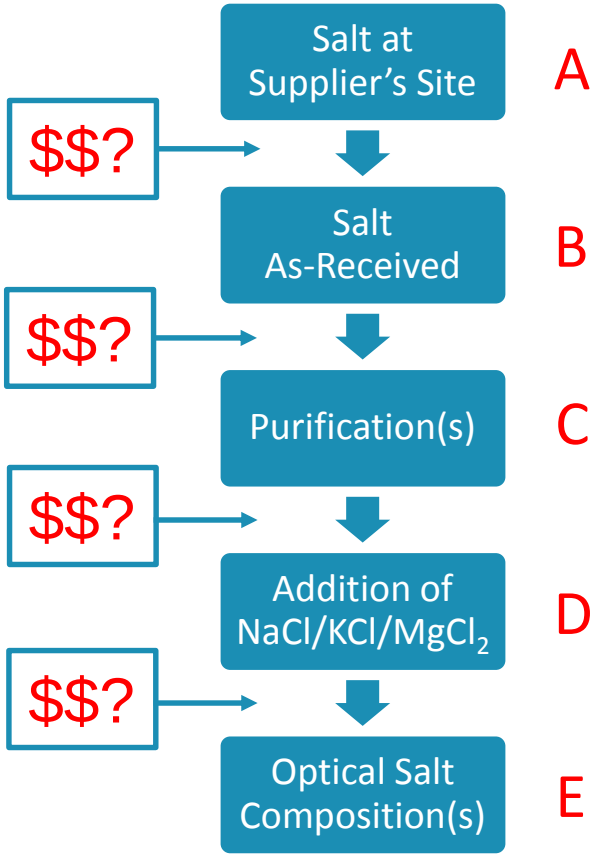
- Recovery of $MgCl_2$ during chemical purification at ~650°–800°C

$$MgOHCl + \frac{1}{2}Mg = MgO + \frac{1}{2}MgCl_2 + \frac{1}{2}H_2(\mathrm{g})$$

- MgOHCl is the major undesired species
  - Its formation by hydrolysis produces HCl(g): corrosion problem
  - Its thermal decomposition produces HCl(g): corrosion problem
  - Its thermal decomposition produces MgO (largely insoluble/non-recoverable): erosion problem

Discovering Route(s) Toward Gen3 Molten Chlorides





Thank You

Questions?

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