Halide and Oxy-Halide Eutectic Systems for High Performance High Temperature Heat Transfer Fluids

SunShot U.S. Department of Energy

THE UNIVERSITY OF ARIZONA

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PROJECT OBJECTIVES

Goal: This project seeks to optimize ternary and quaternary compositions of alkali halides (ionic salts) and metal halides (covalent salts) in a eutectic system in order to develop a high temperature heat transfer fluid that has a low melting point (250°C), high temperature (800°C) thermal stability, as well as favorable thermal and transport properties.

Innovation: Alkali-Halide/Metal-Halide systems offer the design tunability to achieve integrated optimization. Oxy-Lewis acid/base and network-forming additives will be added into the system to reduce the vapor pressure and corrosion, and deliver favorable thermal and transport properties. Our target salts will also have favorable economics: low cost and wide availability.

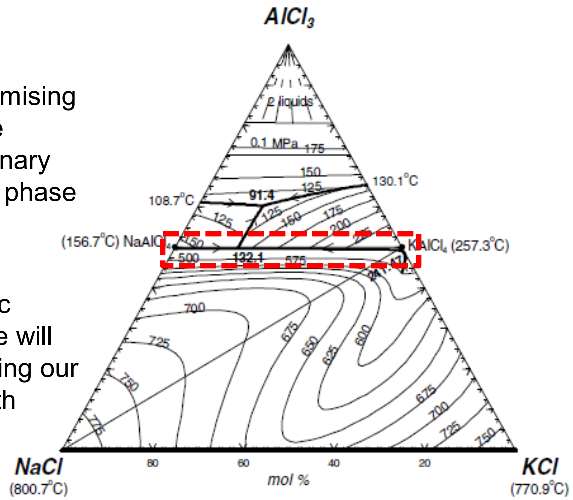
Milestones: Promising compositions, although not in a wide window, for HTF applications were identified in the KCl-NaCl-$AlCl_3$ ternary system.

APPROACH

- Numerical simulation and combined DSC/TGA/Raman experimental tests and analysis to study salt mixture melting and stability temperatures are being employed to screen out salt candidates.
- Experimental test systems are under development for high temperature corrosion analysis and test.
- High temperature fluid properties (salts mixtures with or without additives) are mainly experimentally measured with the assistance of theoretical analysis and prediction.

KEY RESULTS AND OUTCOMES

- Based on our initial salt screening efforts, both simulations and tests, promising compositions lie along the $NaAlCl_4$-$KAlCl_4$ pseudo binary joint, as highlighted in the phase diagram at right.
- These initial findings lend confidence to our scientific approach, and suggest we will be successful in engineering our candidate molten salts with DOE target objectives.



NEXT MILESTONES

- Conduct DSC/TGA tests for the primary target salt ($AlCl_3$:KCl:NaCl = 50:15:35) at temperatures up to 1000°C and experimentally map out the phase diagram of the ternary system. This will substantially decide the first candidate salt system.
- Establish the corrosion rate for Stainless Steel and Hastelloy at high temperatures (250–650°C for Stainless Steel and 500–1300°C for Hastelloy) by using traditional gravimetric weight loss measurements and Impedance Analysis.
- Continue collaborations with Oak Ridge National Laboratory to redesign the sample cell in its laser flash instrument for use with molten salts to better measure their thermal conductivity at high temperatures.
- Viscosities of the primary target salt mixtures will also be measured.