High Operating Temperature Heat Transfer Fluids for Solar Thermal Power Generation

UCLA, UCB, Yale

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PROJECT OBJECTIVES

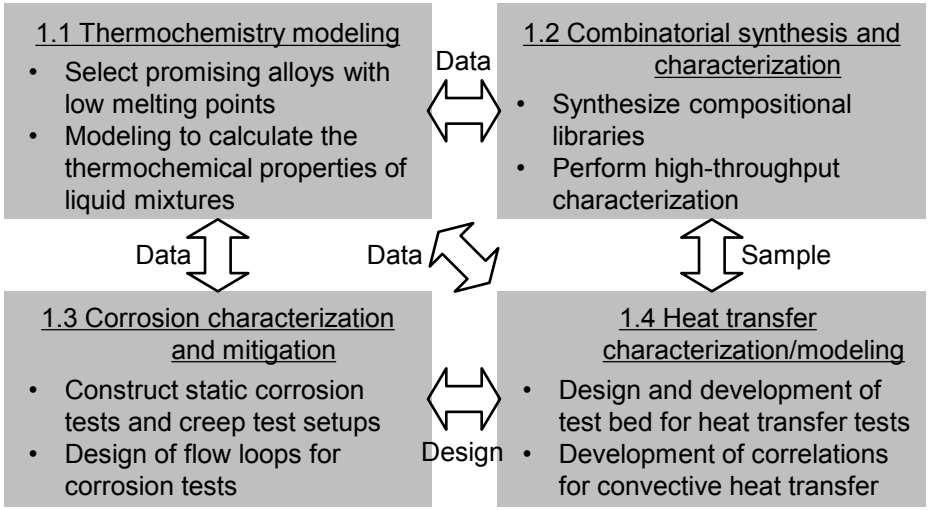
Goal: Develop liquid metals with thermophysical and corrosion properties suitable for use as high temperature (> 800 C) heat transfer fluids. Perform scaled flow loop tests to confirm the effective prevention/mitigation of corrosion and determine the convective heat transfer characteristics.

Innovation: This study employs the synergistic use of the combinatorial material synthesis and high-throughput characterization techniques together with advanced thermochemical modeling to efficiently explore vast compositional spaces.

Milestones:

- Identify at least 5 base alloys of distinctly different elemental compositions with melting points < 300 C
- Validate modeling accuracy to within 10% of the experimental values for melting point, density, and specific heat.
- Validate new static corrosion test setups with oxygen control to within 10% with the data in the existing literature.

APPROACH



KEY RESULTS AND OUTCOMES

1.1 Thermochemistry modeling

Identified promising elements and a preliminary list of ternary alloys for further investigation.

1.2 Combinatorial synthesis and characterization

Prepared a combinatorial library centered around $Mg_{15\text{-}65}Al_{17\text{-}67}Sn_{14\text{-}64}$ (Fig. 1) and characterized microstructures with XRD.

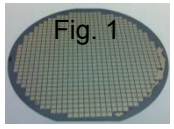


Fig. 1

1.3 Corrosion characterization and mitigation

Constructed an oxygen potential measurement system, static corrosion test setups (Fig. 2), and liquid metal creep test setups.


Fig. 2

1.4 Heat transfer characterization and modeling

Designed a flow loop that will serve as a test bed and an intermediate HEX loop for later high temperature loops.

NEXT MILESTONES

1.1 Thermochemistry modeling

Further Identify alloy systems based on the solubility and oxidation characteristics as well as the melting point.

1.2 Combinatorial synthesis and characterization

- Optimize the characterization systems for melting temperature detection.
- Fabricate and characterize additional compositional libraries.

1.3 Corrosion characterization and mitigation

- Further improve static corrosion testing systems for testing over an extended period of time.
- Perform Data analysis of the micro mechanical testing on the oxide layers.

1.4 Heat transfer characterization and modeling

Complete the construction of the flow loop and perform experiments to measure heat transfer characteristics.