Physics-based Formulation of Tailored Ionic Liquid (IL) Mixtures for Spacecraft Thermal Control

PI: Prof. Sayan Biswas
Department of Mechanical Engineering
Plasma Power Propulsion Lab (3P Lab)
https://3p.umn.edu/

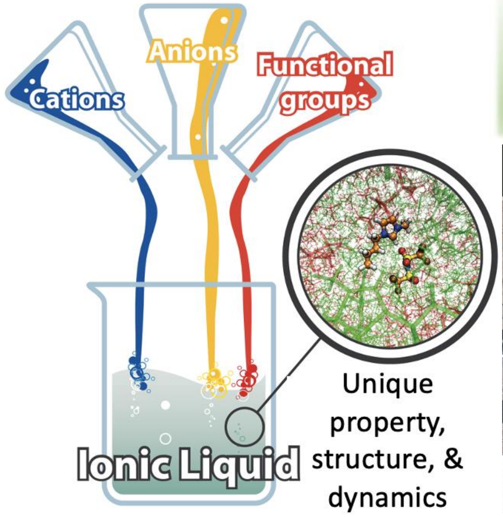
UNIVERSITY OF MINNESOTA

Research Objectives

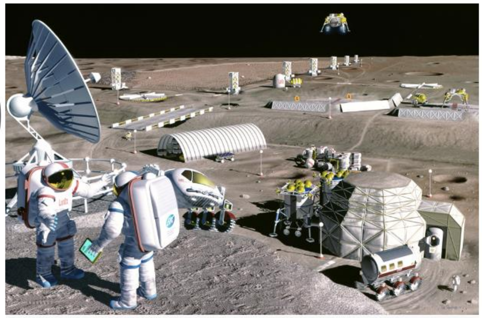
Goal: Develop a physics-based systematic approach to design eutectic IL mixtures with extremely low melting point (< 150 K).

Innovation: A single-fluid, single-phase coolant that remains liquid below 150 K and has a negligible vapor pressure can simplify spacecraft thermal management, resulting in improved efficiency, flexibility, and safety.

Comparison to SOA: No available refrigerants (ammonia, water, ethylene glycol, HFE-7200, fluorinert, PCM, HFC) provides a *single solution* to challenging space missions, e.g., extremely cold lunar nights or low-power periods (due to high freezing points), long interplanetary trips (due to high vapor pressure and potential for leaks), and high-temperature conditions closer to the sun (due to low boiling temperatures).



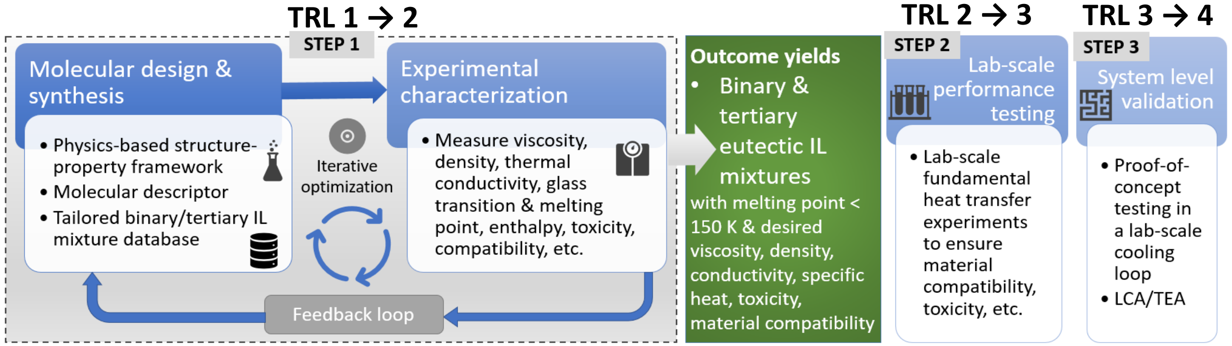
Physics-based modeling and testing of eutectic IL mixtures as future space coolant



NASA's lunar exploration concept

Approach

TRL Start: TRL 1. Identify, select, synthesize, and characterize promising eutectic IL mixtures. **TRL End:** TRL 4. Component and system level proof-of-concept performance validation in the laboratory environment.



Potential Impact

Space Exploration Benefits: Ionic liquids (ILs) offer the potential for improved thermal control in a wide temperature range, including interplanetary missions. The efficiency of an IL coolant can result in lower power consumption and longer mission lifetimes. ILs have reduced toxicity and are compatible with existing cooling hardware, which could enhance crew safety and mission success.

Other Benefits: With the expansion of the nanosatellite and microsatellite industry, high-power payloads with smaller form factors will face surface area limitations for radiators to dissipate heat, would make eutectic IL liquid coolant a mission-critical technology for many future space missions; thereby opening up many new areas for space exploration.