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Understanding the Interfacial Structure of the Molten Chloride Salts by in-situ Electrocapillarity and Resonant Soft X-ray Scattering (RSoXS)

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ABSTRACT:

Corrosion control of molten salts towards the structural alloys of Molten Salt Reactors (MSRs) is one of the most challenging issues that can limit the development and deployment of molten salt nuclear reactors despite their immense value in emission-free, clean energy production. To develop effective strategies for corrosion control, understanding the interfacial structures and properties such as specific ion adsorption and surface charge density is required at the atomic and molecular scales. Since there is little knowledge on interfacial properties of molten salts and their correlation to bulk properties, the proposed work aims to bridge this knowledge gap via interface-sensitive in-situ electrocapillarity and Resonant Soft X-ray Scattering (RSoXS) techniques, in complement with electrochemical and spectro-electrochemical properties of dissolved corrosion products in molten salts.

The objective of this work to reveal the interfacial phenomenon of molten salts/metal electrode by (1) Extracting a series of interfacial and electrical double layer (EDL) properties, including interfacial free energy, surface excess of ions, Potential of Zero Charge (PZC), surface charge density, and double layer capacitance from electrocapillary measurement; (2) Determining molten salt speciation near the metal-salt interface and monitor the corrosion layer evolution by time-resolved in-situ pattern enhanced RSoXS; and (3) Correlating the interfacial structure to the thermodynamic and electrochemical properties of molten salts for a better understanding of the corrosion mechanism/kinetics.

The major deliverables and impacts of the proposed research will include: (1) Fundamental electrochemical understanding of EDL properties in molten salt system with/without the corrosion product ions; (2) Interfacial ion speciation and corrosion layer growth kinetics on the typical MSR structure materials in the molten chloride salt systems; (3) Interplay between the interfacial properties and bulk properties based on thermodynamic, electrochemical, and spectroscopic measurements for better understanding the corrosion mechanism/kinetics in the molten chloride salt systems.

The novel approaches developed in this project will serve as a platform to study detailed interfacial structures of the molten salts for better control of molten salt corrosivity. Moreover, this work will educate and train both graduate and undergraduate students in the fields of molten salt chemistry, electrochemistry, surface chemistry, and nuclear materials with state-of-the-art methodologies, which are critical to the future development of sustainable nuclear reactors.