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Investigator: Li Tan

Position Title: Associate Professor

Department: Mechanical & Materials Engineering

Email: ltan4@unl.edu

Phone: (402) 472-4018

Webpage: http://ncmn.unl.edu/faculty/tan

Passivated Liquid Alloy as Hybrid Anode for Membrane-Free, Non-Aqueous Redox Flow Batteries

Abstract.

Lightweight but electrochemically reactive metals such as lithium (Li), magnesium (Mg), or aluminum (Al) will be dissolved in eutectic alloy of gallium and indium (commercially dubbed as Galinstan, with a melting point of -19^{o}C) to form a flow-able, multi-metal or hybrid anode Once the surface of the liquid alloy is passivated by a thin layer of organic or inorganic compound, this hybrid anode will be employed in redox flow batteries to react with non-aqueous catholytes. Electrochemically, the anode will donate electrons to external circuit, with metal ions generated and transported to catholyte; the catholyte will gain electrons from the external circuit and donate counter ions to pair with newly formed metal cations. This flow-able, hybrid anode design offers three merits to redox flow batteries: (1) an easy-to-configure, membrane-free setup to allow efficient electrochemical reactions; (2) removal of solid metal dendrites and volume expansion induced structure cracking during battery charging; and (3) a complete decoupling between the power and energy density. We also proposed transmission electron microscopy (TEM) and peridynamics modeling to reveal dual roles of the liquid anode, one on the prevention of metallic dendrites and the other on the details of ion transport through multiple interfaces.

Overall, this new design will offer a cost-effective and game-changing solution to off-grid electrical energy consumptions, where high power and high energy density can be achieved with a rather simple design and without long-term capacity decay issues. In this full proposal, reasons for the need of such a new design, highlights of state-of-the art literatures, itemized tasks over the next 2 years, and proof-of-concept data will all be provided.