Nature-Based Solid Polymer Electrolytes for Improved Safety, Sustainability, and Efficiency in High-Performance Rechargeable Batteries

Liu, Kathy

Sustainable battery innovation is crucial for meeting increasing energy demands. Redesigning battery liquid electrolytes into solid polymer electrolytes (SPEs) can drastically improve safety by preventing battery fires caused by flammable liquids, decrease cost, and enable lightweight and flexible designs. SPEs also are important for realizing much higher capacity lithium sulfur (Li-S) batteries (theoretical capacity 1675 mAh g-1 compared to 170 for current Li-ion) by resolving poor cycling caused by polysulfide dissolution in liquid electrolytes. However, SPE application is barred by lower electrochemical performance and poorly scalable processes. Thus, this project presents a novel high-performance SPE synthesized from sucrose focusing on environmental and economic sustainability. Electrolyte synthesis cross-linking was developed and optimized, resulting in higher Li+ ion mobility than most SPEs and liquid electrolytes, and remarkable near 100-fold ionic conductivity improvement compared to polyethylene oxide, the most popularly researched SPE host. Notably, the SPE exhibits excellent electrochemical properties at room temperature and across a wide temperature range, meeting diverse battery application needs. Structural characterization confirmed successfully enhanced ion conduction sites from simple cross-linking. Further SPE analysis in all-solid-state Li-S batteries produced impressive performance and capacity retention over hundreds of cycles at both 25 and 45 C, indicating the SPE’s efficacy as electrolyte and Li-S reaction stabilizer. Leveraging a sucrose base demonstrates a uniquely efficient, low-cost, and environmentally friendly SPE host, setting forth scalability with high capability for more powerful, secure, and sustainable next-generation energy storage.