Natural Additive-Enhanced Development of Novel All-Solid-State Batteries for Sustainable and Scalable Energy Storage

Liu, Kathy

In lieu of demands for high-density and lightweight energy storage, rechargeable lithium sulfur (Li-S) batteries hold promise as an efficient and sustainable method to address accelerating rates of energy requirements with the highest theoretical capacity (1675 mAh g-1 and energy density 2600 Wh g-1) of solid-state cathode materials to date. Challenges exist, however, from capacity loss through polysulfide dissolution throughout cycling and the electrically insulating nature of sulfur. Modern approaches suffer in regards to scalability, thus this project presents a novel all-solid-state D-glucose modified Li-S battery to enhance sulfur encapsulation and battery performance in an environmentally and economically sustainable manner. A working all-solid-state battery with modified composite cathode was successfully created showing electrochemical reversibility and good cyclability, meeting the engineering goal of creating an operative secondary battery. Further optimization of battery synthesis parameters to increase sulfur loading and chemical reversibility resulted in remarkable performance and capacity retention over 1000 cycles. Effective reduced cathode active material dissolution and increased reaction rates at the cathode interface were accomplished through D-glucose incorporation, and sulfur loading was enhanced by nickel mesh. Composite materials exhibit advantages of abundance and sustainability, achieving battery efficacy and cost competitive to modern industry cells. Highly flammable liquid electrolytes are also addressed by the all-solid-state design in this project, comprehensively making battery application in electric vehicles, portable electronics, and transportation a more secure, sustainable, and practical solution to overcoming energy demands.

Awards Won:

Intel Foundation Cultural and Scientific Visit to China Award