CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
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Project Number
S0622

Project Title
Exploring the Effect of Lanthanum Nitrate, La(NO3)3, with a Pyrrolidinium Ionic Liquid Electrolyte in a Li-S Battery

Abstract

Objectives/Goals

In an increasingly unsustainable world, the demand for high-performing, rechargeable batteries is increasing. Lithium ion batteries, specifically, have been the subject of much research as their high energy density and long cycle life are suitable for a variety of applications.
The main problem, however, is the decomposition reaction between the surface of the anode and the electrolyte, which creates insoluble polysulfides on the anode surface. This passivation layer, also known as the Solid-Electrolyte Interface (SEI), prevents the efficient intercalation of lithium ions into the anode and cathode structures, causing degradation of the battery system over long term cycling. The introduction of lanthanum nitrate into the electrolyte system will reduce this "polysulfide shuttle effect" by creating metal or alloy layers on the lithium anode surface.

Methods/Materials

A sulfur/carbon composite was synthesized to maximize lithium ion intercalation at the cathode surface. Nanoporous carbon with a hexagonally ordered mesostructure was synthesized via an SBA-15 hard plate. To first synthesize the silica template, Pluronic P123, TEOS, and HCl reacted to form a precipitate which was filtered and washed with ethanol. The resulting powder was soaked in mixtures of H2SO4 and sucrose at varying concentrations. Pyrolysis was performed to solidify the carbon nanotubes within the shell. However, further research is necessary to determine how this cathode structure, and the subsequent increased battery efficiency, will work with in conjunction with lanthanum nitrate to optimize the SEI.
In order to measure the effectiveness of lanthanum nitrate in this battery system, CR2032 coin cells will be used. A standard DME:DOL electrolyte will be used as a control, to measure against the pyrrolidinium based electrolyte. Lithium metal will be used on the anode surface, coin cell construction will be followed. Battery testing will go as follows: for SEI understanding, I will conduct XPS analysis, sputtering/ depth profiling to receive data on the SEI chemical makeup after long term cycling, and energy dispersive spectroscopy to determine the distribution of elemental lanthanum on the anode surface. Lastly, to test general battery efficiency, I will conduct Electrochemical Impedance Spectroscopy (EIS) with a 3-cell-geometry to measure the resistance of lithium ion charge transfer.

Summary Statement

I am building a more efficient lithium-sulfur battery by introducing a chemical species, lanthanum nitrate, into the electrolyte system to break down insoluble polysulfides on the battery surface that cause long term capacity fade.

Help Received

My chemistry teacher helped me set up the CMK-3 reactions and work with dangerous materials like HF. E-mentors from UC Santa Cruz and San Jose State University answered preliminary questions on anode synthesis and SEI morphology.