Multifunctional, Self-Healing Polyelectrolyte Gels for Long-Cycle-Life, High-Capacity Sulfur Cathodes in Li-S Batteries

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

PI/Co-PI: Alex K.-Y. Jen (UWash)/ Jihui Yang (UWash)

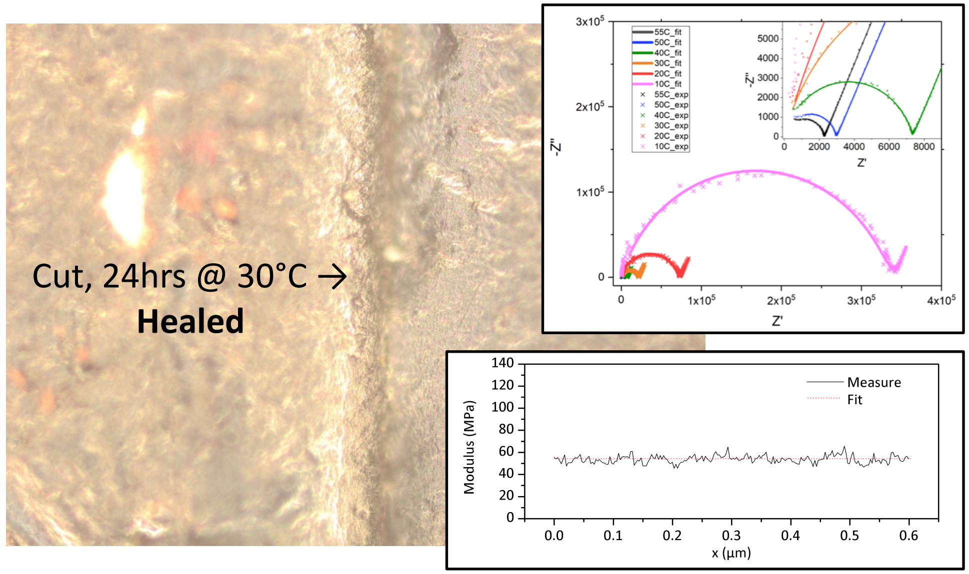
Objective:

Develop novel polyelectrolyte gel cathode designs possessing self-healing and polysulfide-trapping properties, and demonstrate their potential to enable rechargeable Li-S batteries which meet the EV Everywhere blueprint target.

Impact:

- Rational molecular design of gel electrolyte and carbon scaffold improves lithium interface stability, polysulfide containment, and self-healing for electrode integrity
- Engineered gel cathode can greatly improve Li-S battery cyclability
- Low-cost and scalable materials/fabrication enable solution for high-energy-density Li-S EV battery

Molecular Design Enables Li^+ Conductivity and High Stiffness in Self-Healing Composite



Accomplishments (FY 17):

- Designed, studied, and optimized self-healing materials based on π-π interactions
- Demonstrated control over self-healing temperature, tensile modulus, and ionic conductivity of self-healing composites
- Demonstrated ionogel electrolytes with $\sigma > 9\times10^{-4}$ S/cm
- Designed polysulfide-trapping carbon surface modifiers and studied their role in C/S cathode operation
- Demonstrated improved capacity and retention in Li-S cells with surface-modified carbon cathodes

FY 18 Milestones:

- Select a set of gel formulation components to continue optimization around during the second period of study
- Provide detailed cell performance data (capacity and efficiency as a function of cycle number, voltage profiles, self-discharge test results, and other relevant data) for both unoptimized and currently-best materials designs, as well as conclusions regarding the origin of performance details

FY18 Deliverables: Quarterly reports

Funding:

— FY18: $416,667, FY17: $416,667, FY16: $0

New Lamination and doping Concepts for Enhanced Li – S Battery Performance

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

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Objective:

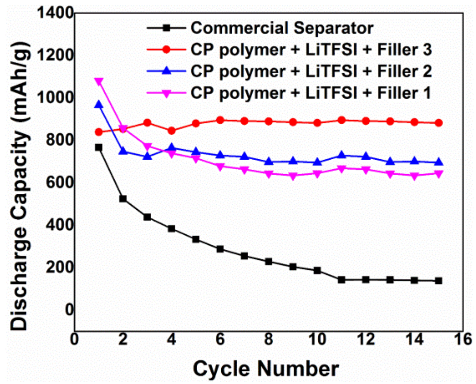
Successfully demonstrate generation of novel approaches using improved lithium ion conductor (LIC) coatings and doping strategies to improve performance of sulfur cathodes for Li-S batteries to achieve the EV everywhere blueprint target.

Impact:

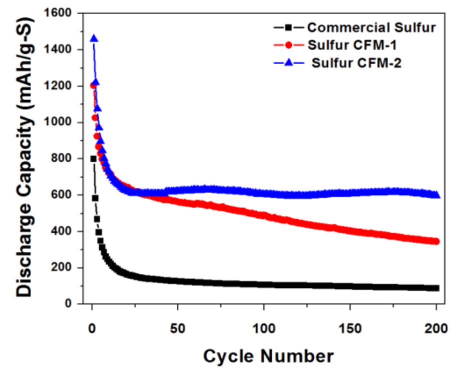
- LIC coatings and complex framework materials (CFM) will help retain polysulfides improving performance
- Theory and experiments will identify and develop doped LICs with much higher Li-ion conduction
- Novel dopants identified by theory and experiments will improve electronic conductivity, rate capability and cyclability

Improved Cycling Behavior

Composite Polymer (CP) Based Sulfur Batteries Showing No Fade



CFM Based Electrodes Demonstrating Minimal Fade Over 300 Cycles



Accomplishments:

- Demonstrate effectiveness of LIC materials in improving sulfur cathode cyclability (4-5 mAh/cm^2).
- Synthesis of high stability flexible sulfur nanowires (~0.003%fade/cycle) and complex framework materials (CFM) with stability over ~300 cycles.
- Development of polymeric LIC systems with doped oxide nanoparticles exhibiting stability over 100 cycles. Composite polymers (CPs) exhibits exception no fade characteristics for commercially obtained sulfur electrodes.
- Identification of doped inorganic LIC systems using first principles and corresponding synthesis of LIC materials displaying ~3 orders of improvement in ionic conductivity.

FY 17 Milestones:

- Synthesis of VACNT and LIC coated chemically synthesized nanosulfur based composite materials
- Design and engineer doped sulfur nanoparticles with improved electronic and ionic conductivity
- Design and engineer high capacity doped LIC coatings on doped nanosulfur

FY17 Deliverables: Quarterly reports, Full cells (4 mAh) meeting the desired deliverables

Funding:

— FY17: $416,687, FY16: $416,687, FY15: $416,687