NDnano
Notre Dame Nanoscience and Technology

NDnano Summer Undergraduate Research
2023 Project Summary

1. Student name & home university:
Katherine Zinkan, University of Notre Dame

2. ND faculty name & department:
Dr. Jennifer Schaefer, Chemical and Biomolecular Engineering

3. Summer project title: Polymers in Next-Generation Rechargeable Batteries

4. Briefly describe new skills you acquired during your summer research:
This summer, I learned about lithium sulfur batteries, specifically focusing on polymer interlayers in solid state electrolytes to improve the ability of batteries to be discharged and recharged effectively. I learned polymerization techniques, as well as characterizing these films through Nuclear Magnetic Resonance (NMR), Differential Scanning Calorimetry (DSC), X-Ray Fluorescence Spectroscopy (XRF), and Sulfur Elemental Analysis.

5. Briefly share a practical application/end use of your research:
The goal of my research is to improve the rechargeability of lithium sulfur batteries.

6. 50- to 75-word abstract of your project:
Lithium sulfur batteries with solid polymer electrolytes are potential future-generation devices for energy storage due to sulfur's high energy density and affordability. Additionally, solid electrolytes have improved safety. However, polysulfides, lithium sulfur battery reaction intermediates, move through the electrolyte which decreases the charge capacity of these batteries. This work focuses on making a polymer interlayer within the electrolyte to block polysulfide movement. This allows more sulfur utilization during battery discharge to maintain the energy dispensed during each cycle.

7. References for papers, posters, or presentations of your research:

One-page project summary that describes problem, project goal and your activities / results:

Renewable energy is becoming increasingly important as society transitions away from using fossil fuels to power our lives. Batteries, specifically rechargeable batteries, are utilized in a variety of contexts, including electric vehicles, and may be used more in aircraft and transport of goods in the future. Important factors of rechargeable batteries include energy density, longevity, affordability, and safety. My project works with lithium sulfur batteries, which are used because sulfur has a high theoretical energy density and is an abundant and relatively inexpensive material. My project works with solid polymer electrolytes, which were chosen because they are safer than batteries with liquid electrolytes.

However, a major issue that lithium sulfur batteries face is the movement of polysulfides through the electrolyte. Sulfur begins in the cathode region of the battery. As the battery is discharged, these sulfur species are reduced through polysulfide intermediates (Li_2S_x where x=2-8) to Li_2S. Then, they are oxidized back to S_8 upon the recharging of the battery. However, some of these polysulfide intermediates can move through the electrolyte towards the anode. There, they can't be oxidized back to S_8 and can also block lithium movement. This decreases the discharge capacity of the battery. Blocking this polysulfide shuttle is critical to having long-lasting lithium sulfur batteries.

My project focused on designing a polymer interlayer to block the movement of polysulfides.