SLATT UNDERGRADUATE RESEARCH FELLOWSHIP
FINAL REPORT

SCHOLAR NAME:	Hannah Collins
FACULTY ADVISOR:	Dr. Jennifer Schaefer
PROJECT PERIOD:	Fall Semester 2020
PROJECT TITLE:	Structure-property relationship study of metal ion transport in ionic liquid crystals
CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):	**( ) Energy Conversion and Efficiency** **( ) Sustainable and Secure Nuclear** **(*) Smart Storage and Distribution** **( ) Transformation Solar** **( ) Sustainable Bio/Fossil Fuels** **( ) Transformative Wind**

MAJOR GOALS AND ACCOMPLISHMENTS

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Synthesize Surfactant with methylsulfonyl head group	The addition of the desired methylsulfonyl group to the alkyl chain was a success. This synthesis was verified via proton NMR and mass spectrometry.	100%
Conductivity and Thermal Property Measurements of Surfactant and mixture with Lithium salt	Thermal property measurements with differential scanning calorimetry (DSC) were begun before the end of the semester in addition to two runs of the sample in the dielectric spectrometer with the unmixed molecule.	~20%

RESEARCH OUTPUT

CATEGORY	INFORMATION
EXTERNAL PROPOSALS SUBMITTED	
EXTERNAL AWARDS RECEIVED	
JOURNAL ARTICLES IN PROCESS OR PUBLISHED	
BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH	
PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH	
AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT	
INTERNAL COLLABORATIONS FOSTERED	
EXTERNAL COLLABORATIONS FOSTERED	
WEBSITE(S) FEATURING RESEARCH PROJECT	
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	

RESEARCH EXPERIENCE

Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

Despite the pandemic-related challenges of this fall semester, I had an amazing research experience and thoroughly enjoyed the beginnings of this project. I learned a lot about how to conduct research and collaborate with the graduate students I worked with and appreciated their help with all of my questions and guidance about my undergraduate research and research path looking forwards. I look forward to continuing data collection and drawing some conclusions about the conductive properties of the materials being studied in the spring.

FINAL WRITTEN REPORT

The objective of the research project was to investigate liquid crystal compounds or solid polymer-type materials as electrolytes for use in lithium-ion batteries. Solid polymer electrolytes have the potential to vastly improve battery technology in areas such as safety, conductivity, and energy density. Study of potential electrolyte materials involves research on ion transport mechanisms and conductivity properties. Liquid crystal states and morphologies of these materials at different temperatures provide the potential for ion clusters and channels that could improve transport mechanisms.

The project goal was to synthesize a surfactant molecule with a high dielectric moment group on the end, in this case a polar methylsulfonyl group, and to investigate the effects of this group on ion transport and thermal properties, such as liquid crystal behavior. By identifying successful synthetic steps and routes for this process, this polar group could be attached to other molecules or monomers in future materials. Properties of this molecule would be measured independently and in a mixture with LiC18TFSI to be used as liquid crystal electrolytes. Incorporating the surfactant molecule or the polar methylsulfonyl group on other molecules in electrolytes could improve ion dissociation and have favorable effects on conductivity.

During the semester, a successful synthetic route was identified to attach the polar methylsulfonyl head group to an 18-carbon alkyl chain. Measurements on both thermal and dielectric properties were begun towards the end of the semester. The sample was measured using differential scanning calorimetry (DSC) to identify the stable temperature range of the compound, phase changes, and potential liquid crystal states. Cycles from -50°C to 250°C indicated stability at these temperatures and peaks indicating phase changes were observed (see Figure 1). Next steps include further analysis of DSC data and liquid crystal behavior, in addition to determination of dielectric constants for the pure molecule and its mixture with LiC18TFSI with dielectric spectrometry.

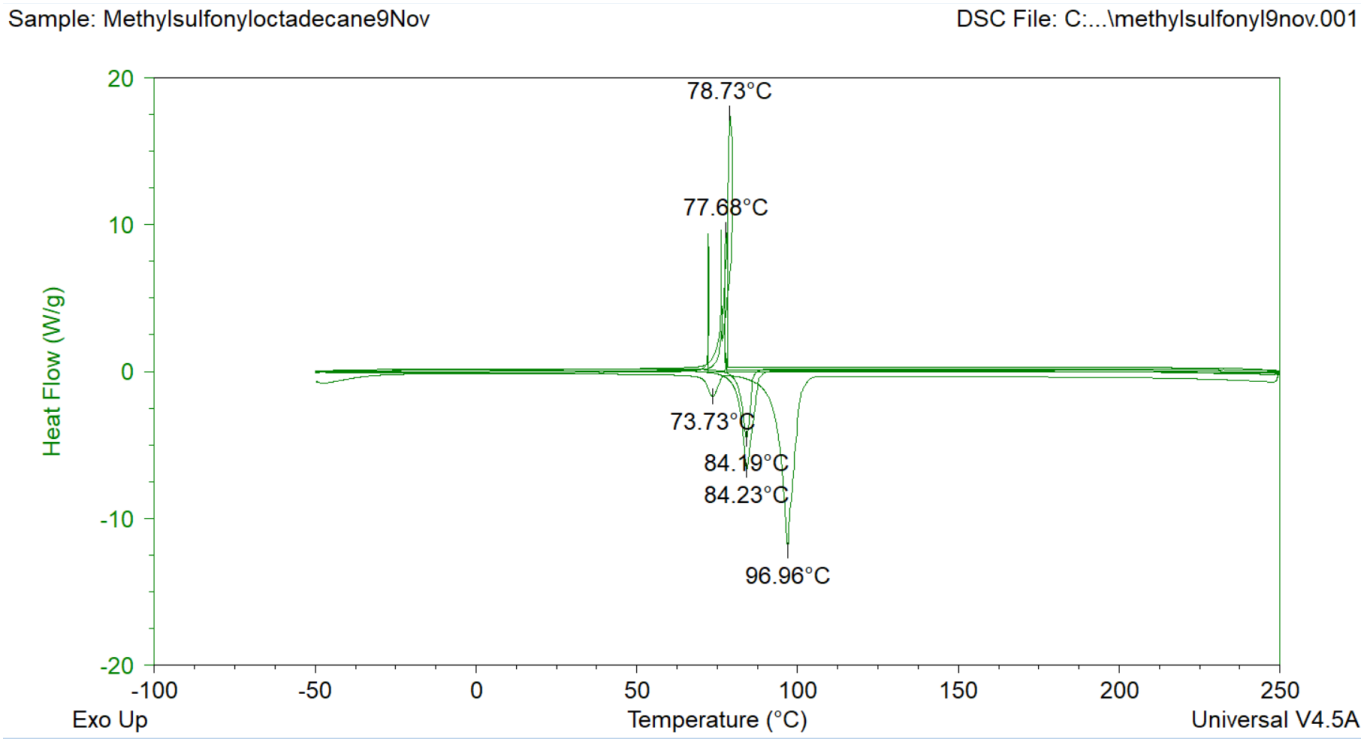

Figure 1. DSC data for 5.30mg of the methylsulfonyl surfactant showing three cycles from -50°C to 250°C.