NDnano
Center for Nano Science and Technology

ND*nano* Summer Undergraduate Research
2019 Project Summary

1. Student name & home university:
Ebrima Komma
University of Mississippi (Ole Miss)

2. ND faculty name & department:
Jennifer Schaefer
Department of Chemical and Biomolecular Engineering

3. Summer project title: Solvent-in-Salt Electrolytes for next generation rechargeable lithium batteries

4. Briefly describe new skills you acquired during your summer research:
I can now use a glove box to handle pyrophoric chemicals. I also learned how to use conductivity instruments to measure the conductivity of an electrolyte. After having to read many research articles papers this summer, I can now read a scientific paper quickly and efficiently to get the most important information from the paper

5. Briefly share a practical application/end use of your research:
My research was based on electrolytes for batteries, lithium batteries to be specific. An application or use of my research will be in an actual lithium cell battery.

6. 50- to 75-word abstract of your project:
Organic liquid electrolytes are a key component in commercial lithium ion batteries as they permit conduction of lithium ions between the cathode and anode. Electrolytes that have high ionic conductivity are ideal as they allow the lithium-ion battery to charge/discharge efficiently. However, these electrolytes currently raise safety concerns as they are easily flammable and unstable towards high voltage and temperature. We introduce a new set of Solvent in Salt electrolyte that improves ionic conductivity and solvent stability, by utilizing Li+ containing liquid crystals as the salt

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

1. Liu J, Winkler M, Xia Y, & Schaefer J. “Liquid Crystal Synthesis and Characterization for Lithium Ion Transport” (2018)

2. Suo L, Borodin O, Gao T, Ho J, & Fan X. “Water-in-Salt electrolyte enables high-voltage aqueous Lithium-ion chemistries.” (2015)

3. Suo L, Hu YS, Li H, Armand M & Chen L. “A new class of Solvent-in-Salt electrolytes for high energy rechargeable metallic lithium batteries”. (2013

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

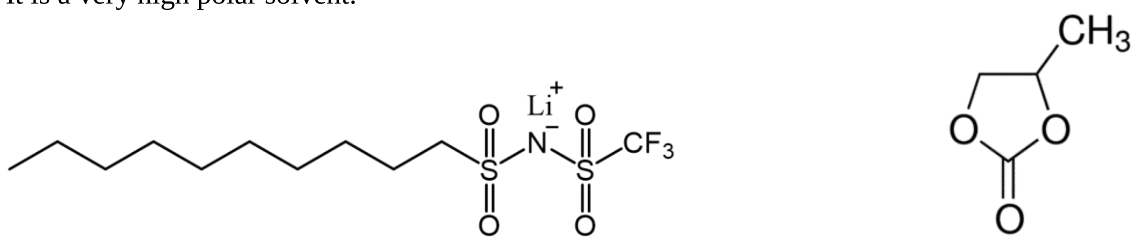
Introduction

Electrolytes serves as catalysts in making a battery conductive by enhancing the movement of ions from the cathode to the anode when on charge and in the opposite when discharging. An electrolyte with high conductivity will enable a faster movement of ions thus enabling the battery to charge/discharge efficiently. However, the high conductivity electrolytes in todays lithium batteries are very flammable and raise safety concerns at high temperatures and voltages. We introduce a new Solvent in Salt electrolyte for lithium batteries with the hopes of producing a high conductivity electrolyte along with a high electrochemical stability, making it safer. The salt electrolyte is a new salt that has been newly synthesized in the lab, so the first step is to collect conductivity data which is what I worked on.

Materials and Sample Preparations

The salt electrolyte is Lithium decyl-trifloumethansulfonimide (Li-C10-TFSI). This electrolyte is a Liquid crystal (LC) molecule, meaning it possess a liquid crystal phase. Liquid crystal is a state of matter between solid and liquid. At this phase, the molecule changes shape as a liquid but still has the molecular alignments of a solid.

The solvent used is propylene carbonate (PC), an organic compound with the molecular formula $C_4H_6O_3$. It is a very high polar solvent.

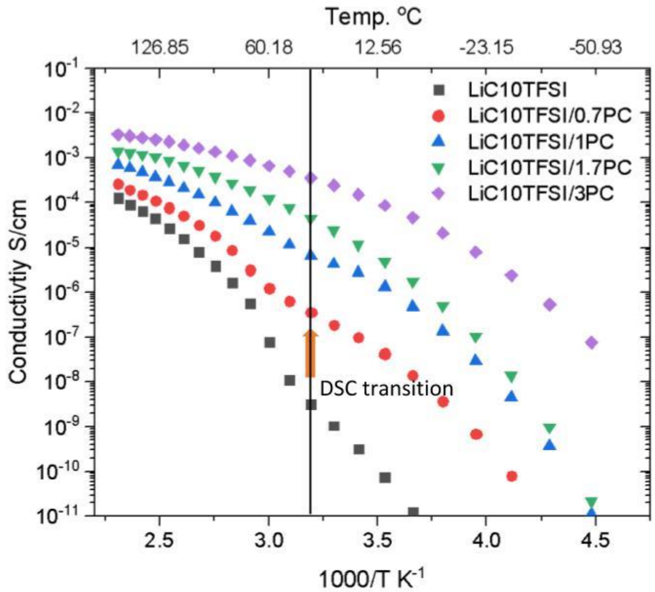


Molecular Structures of LiC10TFSI and PC

In preparing the sample electrolytes, the two compounds are mixed in terms of molar ratios. The LC is weighed into a glass vile first and then PC added to it. the amount of LC is kept constant while PC varies for different samples. Due to high polarity of the solvent, the mixtures are heated in an oven at 100°C until the salt it fully dissolved in the solvent. The samples are cooled to room temperature and Nuclear Magnetic Resonance (NMR) done to confirm the ratios of the compounds in each sample.

Conductivity Data

The conductivity data was collected using a Broadband Dielectric/Impedance Spectrometer with parallel cell electrode arrangement. The data was taken at 10°C intervals from -50°C to 160°C. AC voltage was set to 0.3V and frequency was swept from $3x10^6$ Hz to 0.1 Hz.



Plots of DC conductivity as a function of 1000/T for samples with different ratios of LC to PC

Conclusions

From the conductivity plot, as the amount of PC is increased, the conductivity also increases. There are breaks in the trend for samples with lower ratios of PC (0PC, 0.7PC and 1PC). These samples were crystals at room temperature and there was a phase transition while the conductivity was being taken at higher temperatures. This transition which is shown in the plot as 'DSC transition,' shows the phase change into the liquid crystal state which permits faster ion transport thus increasing conductivity. Future work involves testing the electrochemical window of the sample electrolytes using a lithium coin cells to measure how stable the electrolytes will be.