

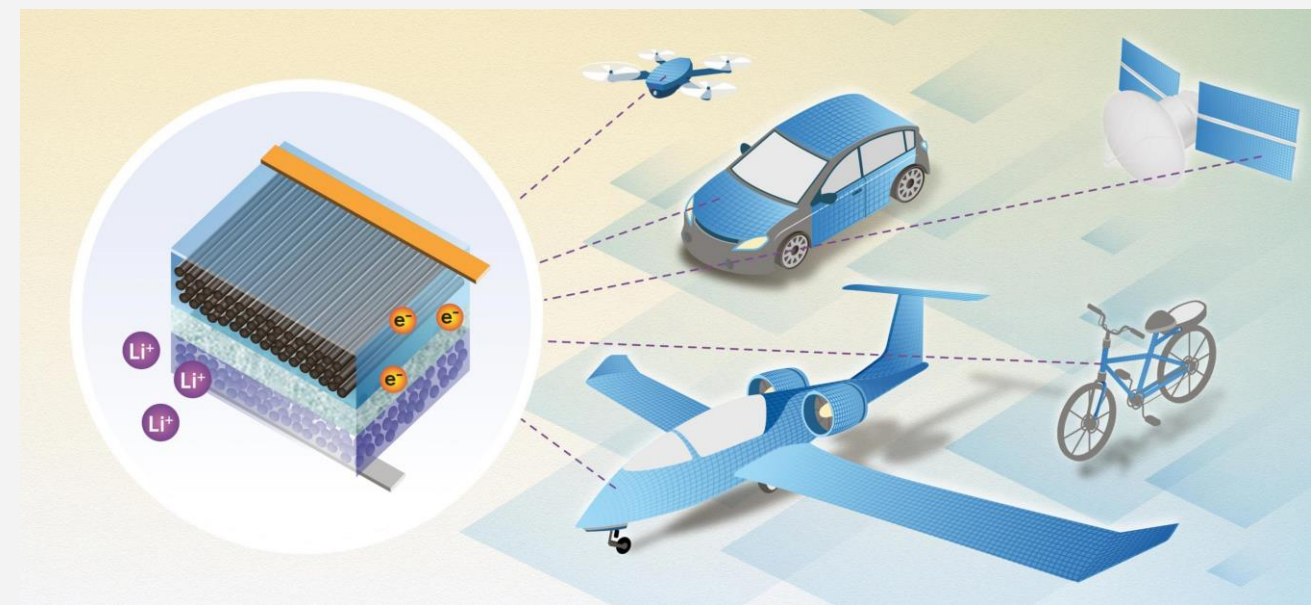
# Hydrated PET-LiClO<sub>4</sub> Electrolyte for Structural Energy Storage

Nathaniel Joyal, Dr. Caiwei Shen (cshen2@umassd.edu)

Department of Mechanical Engineering, University of Massachusetts Dartmouth



## Introduction



### Structural energy storage is to:

- Store electricity in structural components
- Increase system efficiency
- Reduce mass

<https://scitechdaily.com/big-breakthrough-for-massless-energy-storage-structural-battery-that-performs-10x-better-than-all-previous-versions/>

### Choice of mechanism:

- Supercapacitor (safer, longer lifetime than batteries)

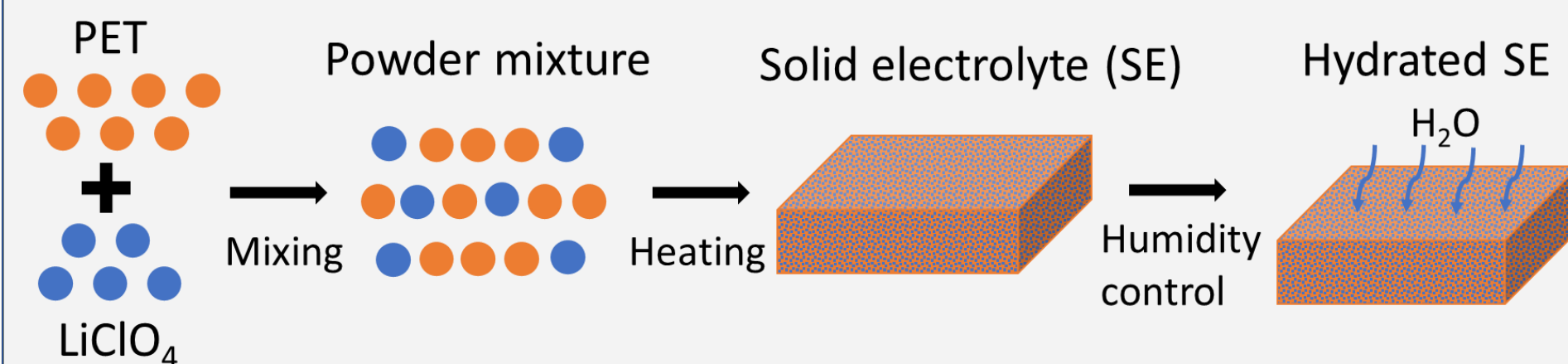
### Bottleneck:

- Solid electrolytes are either too weak or too “insulating” (low ionic conductivity)



[https://vinatech.en.ecplaza.net/products/supercapacitor\\_890037/](https://vinatech.en.ecplaza.net/products/supercapacitor_890037/)

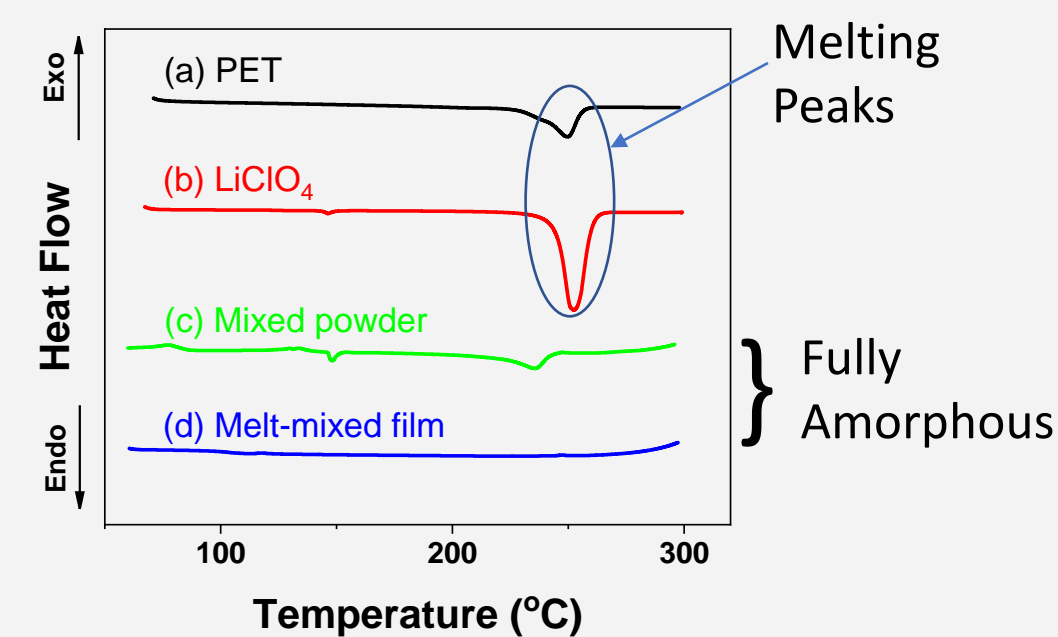
## New Solid Electrolyte Design



- Use a strong base polymer (Polyethylene terephthalate, PET)
- Use a compatible salt (LiClO<sub>4</sub>) to provide ions
- Melt the components to form single-phase solid solution
- Hydrate the salt (LiClO<sub>4</sub>·3H<sub>2</sub>O, also solid-state) to improve ion conduction without lowering mechanical properties

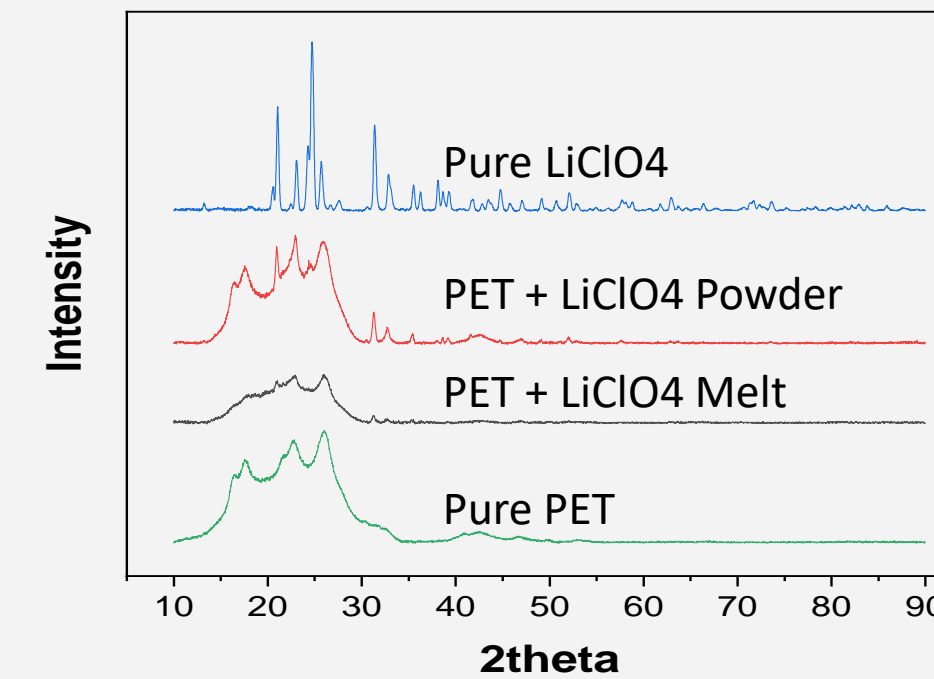
## Material Characterization

### Differential scanning calorimetry (DSC)



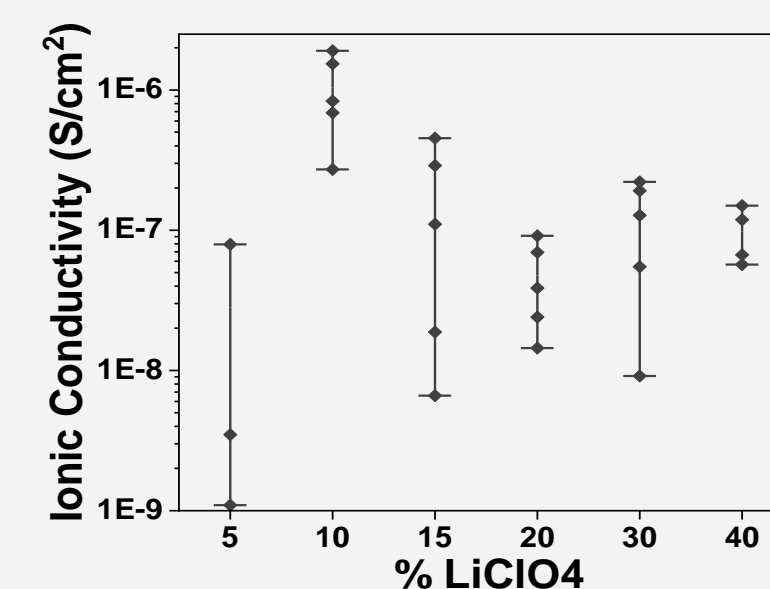
- Both tests reveal that the designed electrolyte is amorphous phase

### X-ray diffraction (XRD)



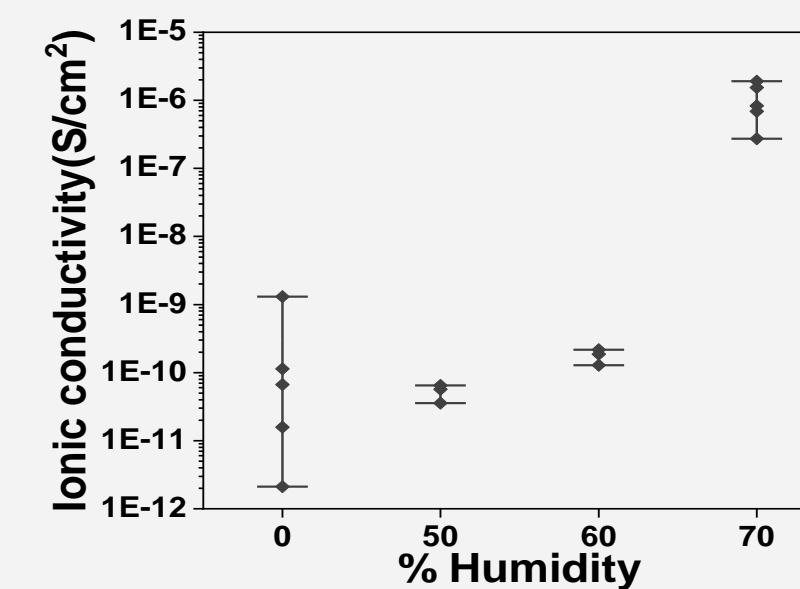
## Electrochemical Testing

### Ionic conductivity vs LiClO<sub>4</sub> Composition

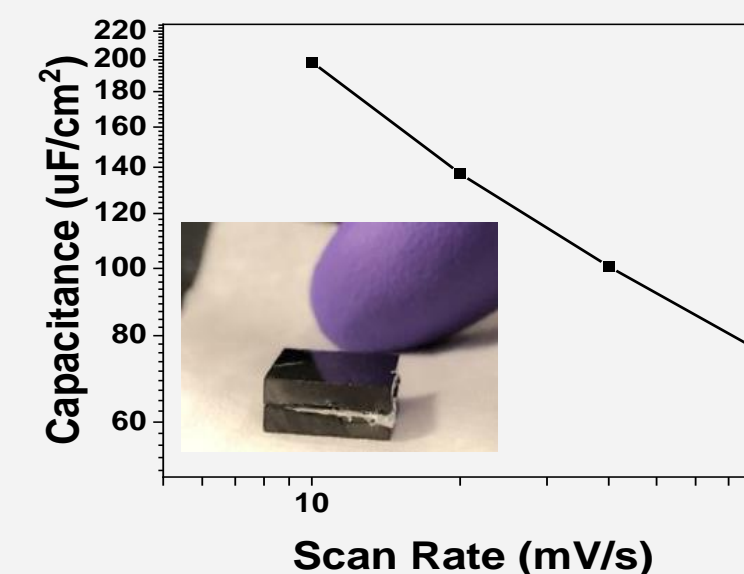


- Tested the effects of Lithium salt content and humidity treatment on the electrochemical performance of the electrolyte
- Peak performance at 10% salt content and treated at 70% humidity

### Ionic conductivity vs Humidity (10% LiClO<sub>4</sub>)

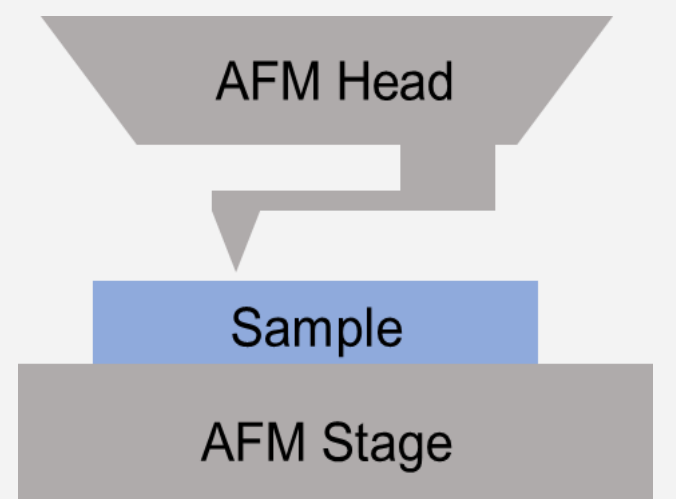
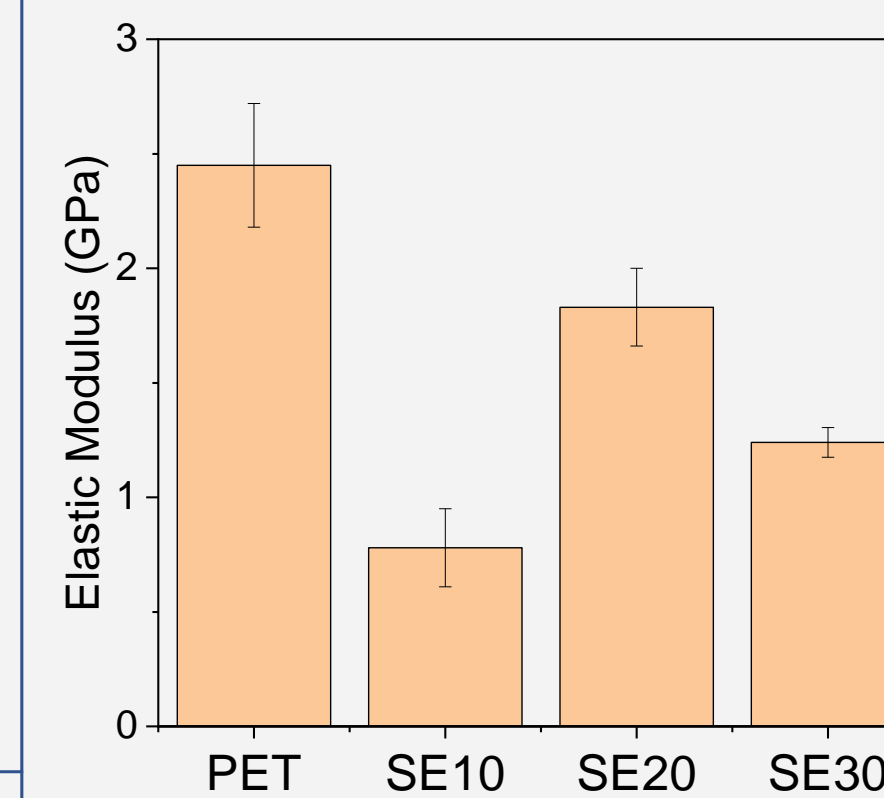


### Capacitance vs Scan Rate



## Mechanical Testing

### Elastic Modulus



Elastic modulus was calculated through nano-indentation performed by an atomic force microscope (AFM)

## Conclusions

- Created all-solid-state structural electrolyte through the formation of a **solid solution**
- Electrolyte hydration drastically improves electrochemical performance (**4 orders of magnitude increase in ionic conductivity**)
- Attained good electrochemical and mechanical performance (**achieved capacitance of ~ an elastic modulus of ~0.8 GPa**)

## Acknowledgments

This research work is supported by UMass Dartmouth's Marine and Undersea Technology (MUST) Research Program funded by the Office of Naval Research (ONR) under Grant No. N00014-20-1-2170.

<https://must.umassd.edu/>