

Introduction

Thermoelectric materials have the advantage of converting heat into electricity and can be used for heat flux and temperature sensing. These technologies are based on the Seebeck effect, which is a creation of a voltage from a temperature gradient. The voltage is generated as a result of the diffusion of mobile charge carriers transported by the heat flux. Thermoelectric behavior can exhibit two behaviors: n-type (-) or p-type (+). P-type describes a higher concentration of charge carriers on the hot side when a thermal gradient is applied while n-type describes a higher concentration of charge carriers on the cold side as a result of thermal gradient. Another important quantity is the conductivity which describes the movement of charge carriers across a material as a result of an electric field. Both the conductivity and the Seebeck effect are both inversely related and the design of a thermoelectric material often results in the sacrifice of one property.

Ionic Seebeck coefficients in traditional p-type polymer blends demonstrate unstable, short-lasting ionic conductivities. Many of these polymer blends are polar and can be dissolved in water to increase ion conductivity. Although these ion-conducting polymers can exhibit an increased ionic conductivity and ionic Seebeck effect with the addition of water, tracking and determining the contributions of ionic conductivity, as well as the Seebeck effect, is often unclear and difficult. It is currently unclear the microscopic changes that occur when a thermal gradient is applied to these ion-conducting polymers. Also, ionic contributions from thermal gradients usually fade exponentially so there is no control over how long the ionic contributions can last in these polymers.

Poly(2-(dimethylamino) ethyl methacrylate)methyl chloride quantenary salt, a highly amorphous polymer that consists of a charged side group and a counterion whereby the latter is the only charge carrier in the polymer matrix, is studied to evaluate the ionic conductivity and ionic Seebeck effect. In addition, we want to determine whether the ionic conductivity and Seebeck can be increased in the presence of FeCl₃. Also, we want to understand the mechanism involved in changing the Seebeck coefficient

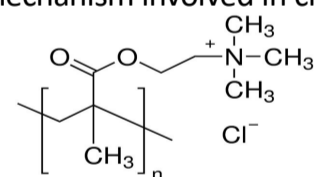


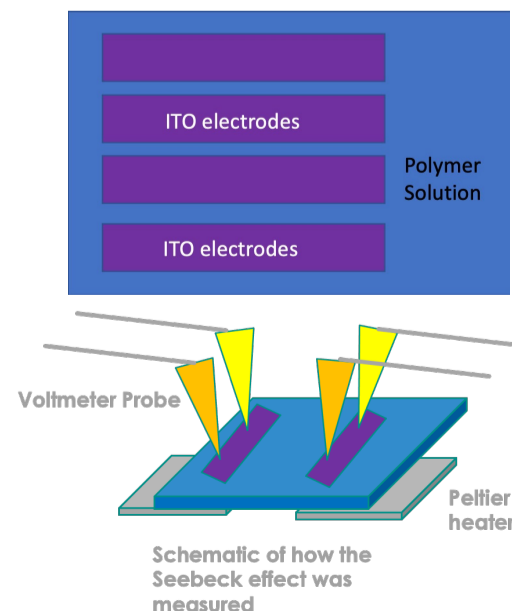
Figure 1: Chemical structure of poly(2-(dimethylamino) ethyl methacrylate)methyl chloride quantenary salt (QS)

Materials and Methods

- Materials**
- Poly(2- dimethylamino)ethyl methacrylate)methyl chloride quantenary salt
 - Methanol
 - Ferric chloride
 - ITO/glass substrate
 - SpinCoater Machine
 - Acetone
 - Isopropyl
 - Seebeck Instrument
 - Four-point Probe
 - Ultrasonic Cleaner
 - Ozone Cleaner

Methods
Glass substrates with ITO electrodes used
QS dissolved in methanol

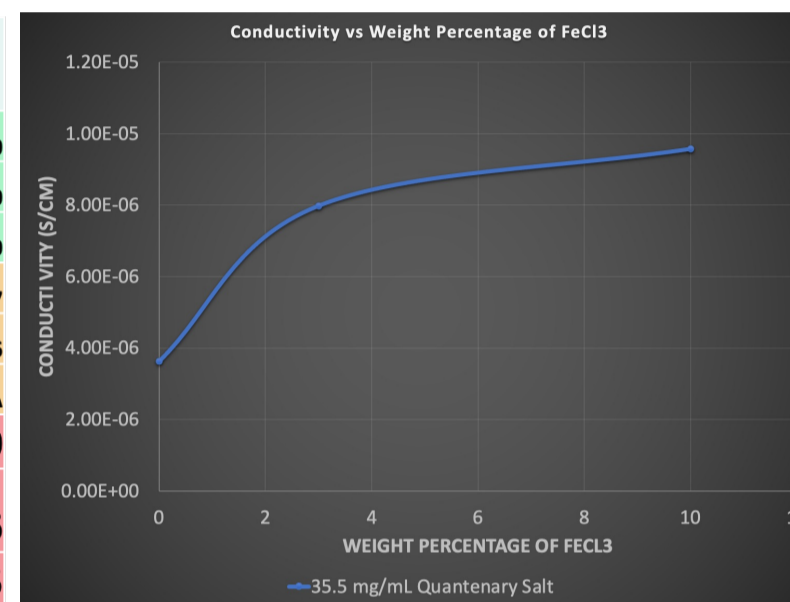
- Samples at 20 mg/mL and 35.5 mg/mL
1. Prepared solutions in a glovebox
 2. Solutions heated at 40°C and placed in Ultrasonic Cleaner for 30 min.
 3. Spincoating Parameters: 2000 rpm for 1 min.
 4. Solutions annealed for 1 hr at 67-68 °C and stored in glovebox
 5. Measure Seebeck and conductivity
 6. Measure conductivity using four point probe



Results

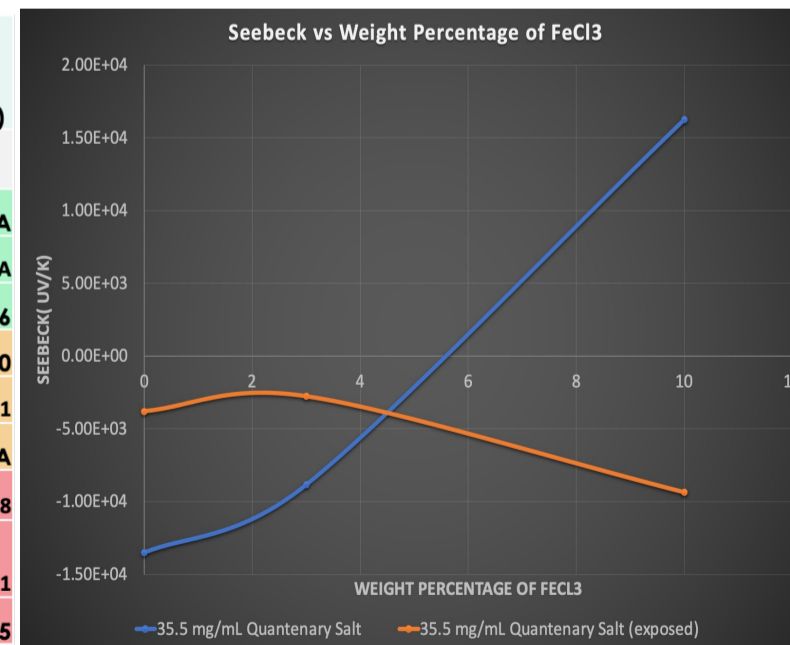
Conductivity and Resistance

Composition	Conc (mg/mL)	Resistance(MΩ) (1/Conductance)
QS	20	800 -1000
QS+3%wt FeCl ₃	20	>1000
QS + 10wt% FeCl ₃	20	>1000
QS	35.5	2.5 - 2.7
QS+3%wt FeCl ₃	35.5	2.0 - 2.6
QS + 10wt% FeCl ₃	35.5	N/A
QS	35.5	470
QS+3%wt FeCl ₃	35.5	296
QS+10wt%	35.5	246 - 255



Seebeck Effect

Composition	Conc (mg/mL)	Seebeck (uV/K) (Later was remeasured)	
		First Pair of Electrodes	Second Pair of Electrodes
QS	20	-25887	N/A
QS+3%wt FeCl ₃	20	38485	N/A
QS+10wt%	20	-184469	-7076
QS	35.5	-52800	-75300
QS+3%wt FeCl ₃	35.5	-571	+2351
QS + 10wt%	35.5	N/A	N/A
QS	35.5	-11028	-7168
QS+3%wt FeCl ₃	35.5	-6879	-10001
QS+10wt%	35.5	+13298	+43425



Conclusions

- The amount of the FeCl₃ dopant can change the Seebeck behavior of the polymer from n-type to p-type due to the FeCl₃ reacting with the chloride ion to form a FeCl₄ complex
- Increasing FeCl₃ content can increase the ionic conductivity of QS
- Exposure to the environment can lead to the polymer reacting with the water vapor or other molecules in the atmosphere that can lead to a decrease in the overall magnitude of Seebeck coefficient and ambiguous Seebeck sign.

Future Work

- The actual mechanism by which the FeCl₄ complex changes the Seebeck coefficient is unclear. It is possible that local reorganization is occurring locally to allow movement of ions across the polymer matrix.
 - Take scanning electron microscopic images of the samples to detect any aggregations when a thermal gradient is applied
- Mixing of two amorphous polymers and incorporating the dopant FeCl₃ to determine how the local reorganization in these amorphous polymers affects its electrical properties
- This work could help us design a better anion exchange membrane or thermoelectric medium for incorporation in heat-harvesting technology

References

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