

The Preparation and Characterization of a New ORMOSIL Membrane for Lithium Battery Applications

James D. Kinder, William Bennett¹
 NASA Glenn Research Center
 Brookpark, OH 44135

The increased power demands of today's electronic devices have intensified the research in both industry and academia in the area of rechargeable lithium-ion batteries. There is especially an interest in constructing a lithium battery that incorporates a solid polymer electrolyte. A lithium battery that utilizes a solid polymer electrolyte offers many advantages over liquid electrolyte based batteries such as a decrease in heat, safety, and environmental hazards with an increase in design flexibility and predicted power density.

One of the most common material that has been studied as a solid electrolyte for lithium batteries is poly(ethylene oxide) (PEO). To construct a solid polymer electrolyte, high molecular weight PEO is mixed with a lithium salt to form an electrolyte with a relatively high ionic conductivity ($>10^{-4} \text{ Scm}^{-1}$, 70 °C). A few disadvantages of the PEO based systems are poor mechanical stability and a significant decrease in ionic conductivity at temperatures below approximately 65 °C due to a crystallization transition of the PEO. Various approaches have been investigated to eliminate or reduce the loss in ionic conductivity due to crystalline transitions in PEO salt complexes by incorporating plasticizers, hyperbranched polymers, and use of nanoparticle additives.

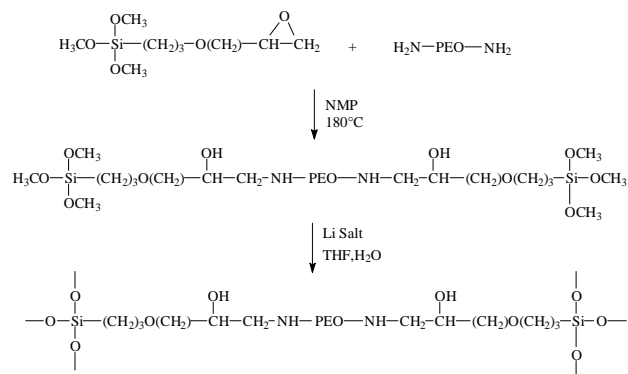
We wish to report the synthesis and characterization of a new type Organically Modified Silicate (ORMOSIL) xerogel polymer for application as a solid electrolyte for lithium battery applications. The films are synthesized by reacting 3-Glycidoxypropyl-trimethoxysilane with high molecular weight polyetherdiamine to form a β -hydroxyamine silane monomer. Lithium sulfonamide salt is added to a THF solution of the monomer at various ethylene oxide oxygen (EO) to lithium ratios. The β -hydroxyamine silane monomer is then crosslinked by the hydrolysis of the methoxysilane groups to form a flexible xerogel film upon the removal of the solvent (Scheme 1).

Ionic conductivity was measured over a range of temperature using electrochemical impedance methods. A plot of the fitted Arrhenius relationships along with the data points for GLYMO-2000 with varying levels of lithium salt concentrations is shown in Fig. 5. The conductivity was measured over the range 0°C to 80°C, allowing at least one-hour of equilibration time between measurements.

The electrochemical stability window was measured to determine the compatibility of the solid electrolyte with various electrode materials. The potential stability of the GLYMO-2000 20:1 EO to lithium film was evaluated by cyclic voltammetry using a Pt working electrode and a lithium disk as a pseudo reference electrode at 60 °C.

The transport properties of the electrolyte were investigated using a small symmetric Li / SPE / Li coin cell. Cation transference number and salt diffusion

coefficient were measured by d.c. current techniques and restricted diffusion measurements. Following transport measurements, the symmetric coin cell was equilibrated overnight at 60°C and then cycled galvanostatically at $\pm 100 \text{ uA}$ in one-hour intervals. This test included a one-hour rest after polarization. Galvanostatic cycles showed good uniformity from cycle-to-cycle, giving evidence that a stable interface has been formed. Concentration gradients build within the SPE during each galvanostatic step, causing the cell to polarize from approximately 70 mV initially, to 140 mV after one hour. The cell voltage relaxed slowly during the one-hour rest and never returns to 0 Volts.



Scheme 1

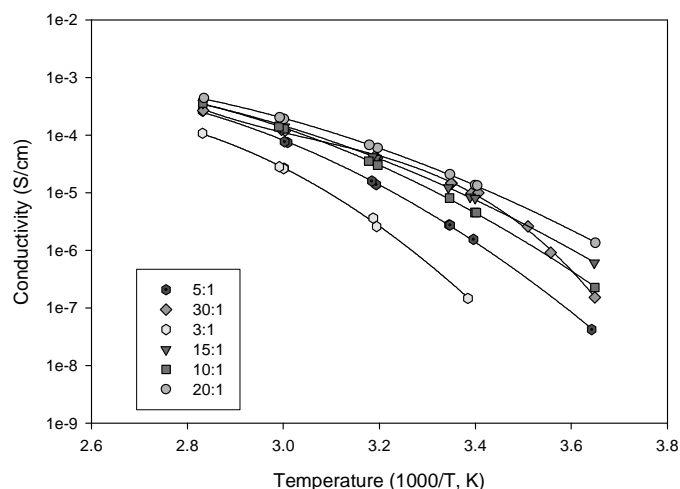


Table 1

1. Employed by QSS Group, Inc.