**Abstract:** The use of a solid polymer electrolyte instead of the conventional liquid or gel electrolyte can drastically improve the safety aspects of a Li-ion battery. However, existing PEO-based solid electrolytes do not meet the functional performance requirements. At low temperatures, the conductivity is poor due to the presence of crystalline PEO segments, which restrict the lithium ion mobility. This limits the useful operating temperature of Li-ion polymer batteries to between 70°C and 100°C, which excludes the use of solid polymer based batteries in room temperature commercial applications. A novel nanocomposite organic/inorganic hybrid material has been identified as a potential solid polymer electrolyte system that can exhibit high Li-ion conductivity at room temperature and below, along with good mechanical properties. The presence of inorganic moieties in the material inhibits the crystallization of PEO chains, which leads to increased low temperature ionic conductivity as well as increased lithium transference numbers. In addition, inorganic sulfide-based solid electrolyte was successfully synthesized, characterized and assembled in a Li-ion cell using the LCD cathode. The Galvanostatic cycling results of the cell showed a comparable performance to the conventional liquid-based LCD battery.

**Background & Objectives**

- Lithium ion batteries widely used in consumer applications: Solvent leakage and flammability of conventional liquid electrolytes
- Current solid state electrolytes suffer from low ionic conductivity, inferior rate capability, and interfacial instability
- Objective of the program is to develop solid state organic and inorganic electrolyte that has enhanced ionic conductivity

**I. Organic Solid Electrolyte**

**Synthesized Co-polymer**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Li+ Mobility (cm²/s)</th>
<th>Li+ Diffusion (cm²/s)</th>
<th>Cl- Mobility (cm²/s)</th>
<th>Cl- Diffusion (cm²/s)</th>
<th>Ionic Conductivity (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample A</td>
<td>0.5</td>
<td>0.2</td>
<td>0.1</td>
<td>0.05</td>
<td>0.7</td>
</tr>
<tr>
<td>Sample B</td>
<td>0.6</td>
<td>0.3</td>
<td>0.15</td>
<td>0.06</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Membrane Fabrication**

- Solution casting
- Lithium salt:Li2O2S
- Solvent: DMF
- Polymer/salt ratio: 6/1, 5/1, 4/1

**DSC of Polymer/Li Salt Complex**

**II. Inorganic Solid Electrolyte**

**Conclusions on Organic Solid Electrolyte**

- Introduction of inorganic segments into PEO chains disrupts crystallization of PEO and results in a hybrid copolymer/Li ion complex that is amorphous
- The H series of hybrid copolymer/Li ion complex has significantly improved conductivity over PEO and M series
- Room temperature conductivity still needs to be improved for practical applications

**Summary & Conclusions**

- Successful synthesis and scale-up of the solid electrolyte
- Demonstrated the effect of electrolyte content, rate, and electrolyte content on the cell performance
- RT reversible cycling of the all solid state cell
- Comparable performance to liquid-based electrolyte however with much higher safety

**Future Work**

- Exploring the new cathode chemistries with higher capacity and higher voltage
- Improving the rate capability of the solid state battery at RT
- Low and high temperature performance testing of the solid state battery

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