Optimizing the Electrochemical Performance of Imidazolium-Based Polymeric Ionic Liquids by Varying Tethering Groups

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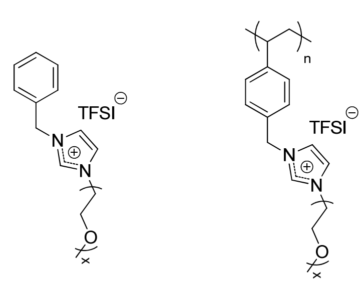
Due to the drawbacks of conventional organic liquid electrolytes, such as leakage, volatility, flammability, and toxicity, the synthesis of solvent-free electrolyte materials has been studied world-wide in order to develop high-efficient and low-cost electrochemical devices with sufficient long-term stability. Among the novel electrolytes, solid-state polymer electrolytes, in particular, ionic liquids (ILs) and poly(ionic liquid)s (PILs), offering low vapor pressure, non-flammability, high ionic conductivity, a high electrochemical window, and high stability, represent an important class of materials for electrochemical applications. An important property that defines the ion conductivity of ILs in electrochemical devices is the glass transition temperature (Tg) with a low Tg IL expected to have a higher ion mobility, which translates to a higher conductivity.

This work is focused on the synthesis and characterization of imidazolium (Im) based IL model compounds and their corresponding polymeric ionic liquids (PILs) with various tethering groups. Poly(ethylene oxide)s (PEOs), considered to be promising candidates for this purpose, were attached as tethering groups to imidazolium cations in order to optimize the glass transition temperatures (Tg) and ionic conductivities of the ionic liquids. A series of IL model compounds were first synthesized with altered lengths of PEO attached on the imidazole. The thermophysical and electrochemical properties of ionic liquids, including density, viscosity, conductivity, glass-transition temperature (Tg), melting and decomposition, were characterized in order to investigate the effect of ILs' tethering groups. The ultimate objective of this work is to synthesize polymers for electrolyte applications based on the model compounds with optimized properties.



x = 1, 2, 3, 8, 12, 17

Scheme 1. Structures of ILs (left) and PILs (right) synthesized in this work

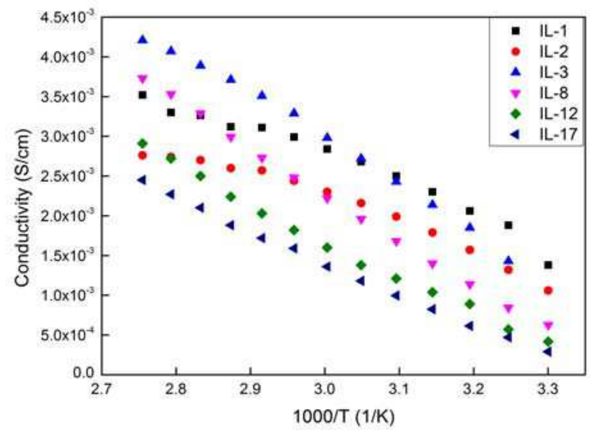


Figure 1. Temperature dependent ionic conductivity results of ionic liquid model compounds with altered PEO tethering groups.

Compound	Tg (°C)	Conductivity in 30°C (S/cm)
IL-1	-65.9	1.38×10^{-3}
IL-2	-64.7	1.06×10^{-3}
IL-3	-63.6	1.19×10^{-3}
IL-8	-55.0	6.26×10^{-4}
IL-12	-54.4	4.18×10^{-4}
IL-17	-57.4	2.90×10^{-4}

Table 1. Glass transition temperature (Tg) and room temperature conductivity of ionic liquid model compounds with altered PEO tethering groups.

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