

A New Highly Conductive Organic-inorganic Polymer Electrolyte with Cyanuric Chloride as Double Core Element

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The development of polymer electrolytes has drawn the great attention of researchers from all over the globe due to the many potential applications in electrochemical devices such as lithium ion batteries, dye-sensitized solar cells (DSSCs), electrochromic devices and electric double layer capacitor (EDLC) [1,2]. Especially, Solid polymer electrolytes have received much interest due to leak proof, non-flammability and good mechanical strength compared to liquid electrolytes. However, good ionic conductivity value can be achieved at high temperatures only. To overcome this problem, most research has focused on modification of polymer properties that exhibit high ionic conductivities at room temperature [3,4].

With the above objectives, a new hyperbranched organic-inorganic hybrid electrolyte doped with LiClO₄ and based on triblock co-polymer poly(propylene glycol)-*block*-poly(ethylene glycol)-*block*-poly(propylene glycol) bis(2-aminopropyl ether) (ED2003), poly(ethylene glycol) diglycidyl ether (PEGDGE), 2,4,6-trichloro-1,3,5-triazine (cyanuric chloride, CC) and 3-(glycidyloxypropyl)-trimethoxysilane (GLYMO) has been synthesized by sol-gel process. The structural and dynamic properties of the organic-inorganic hybrid electrolytes thus obtained were systematically investigated by a variety of experimental techniques. The resulting hybrid electrolytes were designated as PCEG-*x*, where *x* (salt composition) indicates the number of ether oxygen atoms (only for polymer) per Li⁺ cation.

The temperature dependence of ionic conductivity of the PCEG-*x* hybrid electrolytes system with various [O]/[Li] ratios is shown in Figure 1. The synthesized hybrid electrolytes possess maximum ionic conductivity value of $9.5 \times 10^{-5} \text{ S cm}^{-1}$ at 30 °C and $4.8 \times 10^{-4} \text{ S cm}^{-1}$ at 80 °C for [O]/[Li] ratio of 32. The plots exhibit Vogel-Tamman-Fulcher (VTF) like behavior, indicating that the ion transport in the present hybrid electrolyte is mainly dependent on the polymer segmental motion. Moreover, the calculated value of the pseudo-activation energy is in the range of 0.06-0.09 eV, in good agreement with the previously reported literature, indicative of higher mobility of the ions in hybrid electrolytes [5, 6].

¹³C cross-polarization magic angle spinning NMR results from variable contact time measurements along with 2D wide-line separation NMR indicated a decrease in the mobility of the polymer chains as the salt content was increased, consistent with the increase in *T_g* of the hybrid electrolytes as observed by DSC measurement. Solid-state ⁷Li NMR characterization was performed to study ionic mobility by measuring spectral line widths and diffusion coefficients. The results of the lithium diffusion coefficient measurements indicated that the ionic conductivity in the present electrolytes was mainly

dominated by the mobility of the lithium cations [7].

The electrochemical stability window is found to be in the range of 4.0–5.0 V (Figure 2), which ensures that the present hybrid electrolyte is a potential polymer electrolyte for solid-state rechargeable lithium ion batteries [8].

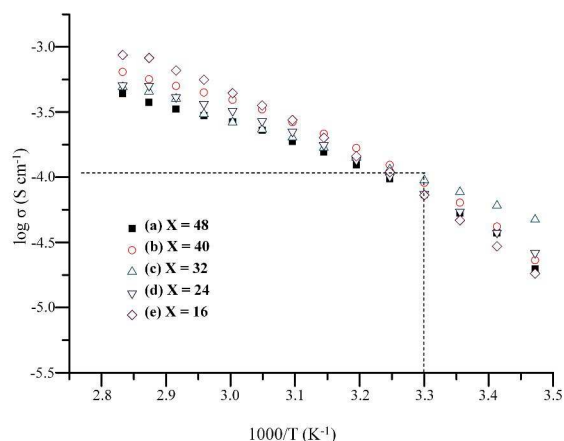


Figure 1. Temperature dependence of ionic conductivity of PCEG-*x* hybrid electrolytes with [O]/[Li] ratios, *x* = (a) 48, (b) 40, (c) 36, (d) 24 and (d) 16.

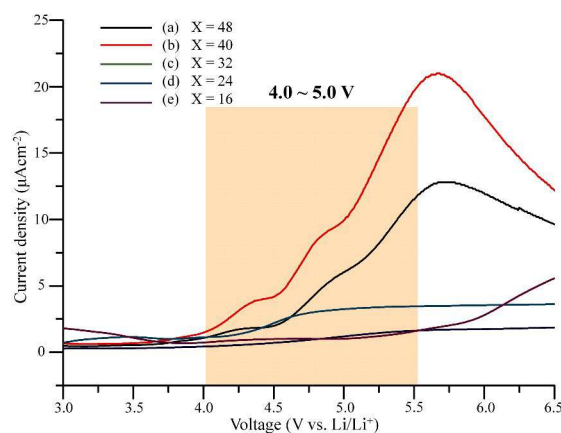


Figure 2. Linear sweep voltammetry curves of the cell prepared with PCEG-*x* hybrid electrolytes with various [O]/[Li] ratios, *x* = (a) 48, (b) 40, (c) 32, (d) 24 and (e) 16.

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