

Tailor-made fumed silica-based nano-composite polymer electrolytes consisting of BmImTFSI ionic liquid

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Received: 15 September 2011 / Accepted: 15 February 2012 / Published online: 6 March 2012
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Abstract In this work, nano-sized fumed silica (SiO_2) was embedded in poly(methyl methacrylate) (PMMA)–poly(vinyl chloride) (PVC) blend with 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl imide) (BmImTFSI) as ionic liquid. These composite polymer electrolytes (CPEs) were prepared by solution casting technique. The samples followed Arrhenius behavior in the temperature-dependence of ionic conductivity and further proved the ionic hopping mechanism in the polymer electrolyte. It is suggested the formation of three-dimensional polymer network among the aggregates weakens the interaction of polar group of the polymer backbone and initiates the ionic decoupling process. The mobile ions from adjacent sites would occupy this vacant site and reform the interactive bond with the polymer backbone whereby the ionic hopping mechanism is generated. The activation energy (E_a) is further determined. The higher the ionic conductivity, the lower the activation energy. The maximum ionic conductivity of $(8.26 \pm 0.02) \text{ mScm}^{-1}$ was achieved at 80°C upon inclusion of 8 wt% of SiO_2 . X-ray diffraction (XRD) analysis revealed the higher amorphous region with increasing SiO_2 mass loadings. The coherence length is further determined by using Debye–Scherrer equation. Higher amorphous region in the polymer matrix is conferred by showing the lower coherent length. Scanning electron microscopy (SEM) was applied to examine the morphology of polymer electrolytes. Based on the differential scanning calorimetry (DSC) study, glass transition temperature (T_g) and melting temperature (T_m) were

decreased. Highly flexible polymer chain is produced when the T_g was lowered down. On the other hand, thermal stability of polymer electrolytes was increased by SiO_2 dispersion, as depicted in thermogravimetric analysis (TGA).

Keywords Composite polymer electrolytes · Temperature dependent-ionic conductivity · XRD · SEM · Thermal studies

Introduction

Polymer electrolyte is a prospective candidate to replace the conventional liquid electrolyte because of its intrinsic properties, for instance, excellent safety performance, wider operating temperature range, good chemical, electrochemical and photochemical stabilities, as well as, low volatility [1, 2]. High ionic conductivity is an important aspect in the development of polymer electrolyte. Many approaches have been accomplished in order to enhance the ionic conductivity of polymer electrolyte. Polymer blending [3, 4], using comb-branched copolymers [5], cross-linking of polymer matrices [6], using binary salt systems [7], applying different preparation methods [8], and incorporation of additives, such as plasticizers [9, 10] and inorganic fillers [11, 12], are the alternative ways to improve the ionic conductivity of polymer electrolyte. Polymer blending is an extensive way to complement advantages of each compartment, improve the electrical behavior and enhance the physical properties of polymer electrolytes [13]. Therefore, blending of polymethylmethacrylate (PMMA) and polyvinylchloride (PVC) was employed in this work. In general, PMMA exhibits higher ionic conductivity; however, it has weaker mechanical

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