Polymer Gel Electrolytes Prepared from P(EG-co-PG) and Their Nanocomposites Using Organically Modified Montmorillonite

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ABSTRACT: Polymer gel electrolytes were prepared by thermal crosslinking reaction of a series of acrylic end-capped poly(ethylene glycol) and poly(propylene glycol) [P(EG-co-PG)] having various geometries and molecular weights. Acrylic end-capped prepolymers were prepared by the esterification of low molecular weight (Mn: 1900–5000) P(EG-co-PG) with acrylic acid. The linear increase in the ionic conductivity of polymer gel electrolyte films was observed with increasing temperature. The increase in the conductivity was also monitored by increasing the molecular weight of precursor polymer. Nanocomposite electrolytes were prepared by the addition of 5 wt % of organically modified layered silicate (montmorillonite) into the gel polymer electrolytes. The enhancement of the ionic conductivity as well as mechanical properties was observed in the nanocomposite systems. © 2003 Wiley Periodicals, Inc. J Appl Polym Sci 91: 894–899, 2004

Key words: polymer gel electrolyte; poly(EG-co-PG); nanocomposite

INTRODUCTION

Many types of ionically conducting polymers, generally classified as polymer electrolytes, have been developed and characterized in recent years.1–3 Special interest today is focused on the polymer systems having high ionic conductivity as well as desirable mechanical stability at ambient temperature. They are applied for separators in high-power, versatile, rechargeable lithium batteries.4–6 Polyether-based solid electrolytes are one of the most intensively studied ionic conductors.7 A target ionic conductivity of $10^{-3} \text{ S/cm}$ at ambient temperatures is required in the area of rechargeable batteries. In general, the increase in the ionic conductivity is observed with an increase in the molecular mobility of lithium salts. To enhance the ionic conductivity, the crystallinity of the polymer matrix should be lowered by adding proper solvents or plasticizers for facile movement of ions. However, the incorporation of liquid plasticizers results in worsening of mechanical properties and increased reactivity toward the metal electrode. Therefore, the key issue to develop polymer electrolyte systems is having high ionic conductivity, desirable mechanical properties, as well as proper electrochemical stability.

For this purpose, the gel-type polymer electrolyte has been introduced as a possible candidate to fulfill the optimum properties. The gel-type electrolytes are obtained by the immobilization of liquid solutions of lithium salts in polymer matrices. Because the liquid electrolyte molecules can solvate lithium ions, coordinating polymers such as poly(ethylene oxide) (PEO) may be replaced by mechanically tough polymers such as polyvinylidene fluoride (PVDF), polyacrylonitrile, and poly(methyl methacrylate). A small amount of solvent can be incorporated into the gel polymers, which successfully reduces the glass transition temperature of the polymer and hence increases the ionic mobility at a given temperature. However, gel electrolyte systems also suffer the disadvantages of worsening the mechanical properties, releasing the volatiles, and increasing the reactivity toward the metal electrode. To compensate the disadvantage of the above-mentioned gel electrolyte systems, chemically crosslinked permanent networks systems were introduced by Kono et al.8–12 The chemically crosslinked permanent network provides the systems with enhanced mechanical properties as well as better capability of storing liquid electrolytes.

It has been known that the formation of composite polymeric electrolytes by adding inorganic fillers to polymer electrolyte systems as a third component is one of the most effective ways of preparing highly conductive polyether solid electrolytes while retaining...