Studies of Ionic Conductivity and Dielectric Behavior in Polyacrylonitrile Based Solid Polymer Electrolytes

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\textbf{Abstract.} The solid polymer electrolyte films consisting of polyacrylonitrile (PAN) as the host polymer, lithium triflate (LiCF\textsubscript{3}SO\textsubscript{3}) and sodium triflate (NaCF\textsubscript{3}SO\textsubscript{3}) as dopant salts were prepared by the solution cast technique. The pure PAN film was prepared as a reference. The films were characterized using a.c. impedance spectroscopy. At room temperature, the highest conductivity for the sample from the (PAN+LiCF\textsubscript{3}SO\textsubscript{3}) system and the (PAN+NaCF\textsubscript{3}SO\textsubscript{3}) system is 3.04 x 10^{-4} S cm\textsuperscript{-1} and 7.13 x 10^{-4} S cm\textsuperscript{-1}, respectively. The temperature dependence of ionic conductivity for the highest conducting film from both systems follows the Arrhenius equation in the temperature range of 303 K to 353 K. The frequency dependence of ionic conductivity, $\sigma$, complex permittivity, $\varepsilon^*$, and complex electrical modulus, $M^*$ were studied at different temperatures. The ionic conductivity and the dielectric behavior are described in terms of ion diffusion and polarization.

\textbf{Introduction}

Solid polymer electrolytes (SPEs) formed by the dissolution of alkali metal salts in a polymer matrix have been proposed as a substitute for the liquid electrolyte in electrochemical devices such as batteries, fuel cells, sensors and electrochromic displays [1-4]. The use of SPEs makes the fabrication of safe batteries with high energy density possible and allows the development of thin batteries with flexibility of design. Many research works [5-8] have been conducted to obtain polymer electrolytes with high ionic conductivity and good mechanical properties as well as good electrochemical stabilities.

The two important contributions to ionic conductivity are charge carrier concentration and ionic mobility. Research efforts have been focused on cation - anion interactions [9] and cation - polymer interactions [10], which appear to play critical roles in the mechanism of ion transport. Both cation - anion and cation - polymer interactions presumably affect the ionic mobilities. Cation - anion interactions are expected to also perform a major role in determining the number of effective charge carriers.

The study of dielectric relaxation phenomena in SPEs is a powerful approach for understanding of the ion transport behavior and obtaining the information about the characteristics of ionic and molecular interactions [11]. The ion transport property depends on various factors like the degree of salt dissociation and its concentration, dielectric constant of host polymer, degree of ion aggregation, and mobility of polymer chains [12]. The dielectric relaxation and frequency dependent conductivity are both sensitive to the motion of charged species of the polymer electrolytes.

In the present work, the effects of salts with different cation on the ionic conductivity and the dielectric behavior of the PAN based polymer electrolytes will be discussed. The comparison between the (PAN+LiCF\textsubscript{3}SO\textsubscript{3}) and (PAN+NaCF\textsubscript{3}SO\textsubscript{3}) systems is made.