Investigation of PEG-2HEA-IBA Network-Forming Solid Polymer Electrolytes for Lithium Batteries

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Nowadays, the most popular class of devices to store energy are batteries. Historical evolution and research in the field of batteries, mostly focused on the increase in the energy density, leaded the discovery of lithium ion batteries (LIB); where applications are spacing from computer and phones to electric vehicles.

A current issue with LIB is the risk of spontaneous ignition and in worst cases explosions. The ground reason for this phenomenon to happen is found to be related to the flammability nature of the liquid electrolyte. Substitution of the liquid electrolyte with a solid polymer electrolyte (SPE) is the path investigated in this project with the intent of increasing the safety of lithium ion batteries. The characteristics of liquid electrolyte have to be maintained in the solid material, where the chemical, electrochemical and thermal stabilities are assured by the solid nature of the material. However, SPE's ionic conductivity values are generally in the range of 10^{-5} / 10^{-6} S cm^{-1}, few orders of magnitude lower compared to liquid electrolytes conductivity values, typically of 10^{-3} S cm^{-1}.

This project is focusing on the conductivity and the mechanical properties maximization of the polymeric network for a new type of SPE composed of poly (ethylene glycol) (PEG), 2-hydroxyethyl acrylate (2HEA), and isobornyl acrylate (IBA) monomeric units doped with lithium bis-trifluoromethanesulfonimide (LiTFSI) salt. Optimized PEG-2HEA polymeric network with salt content represented by r = 7% LiTFSI showed ionic conductivity of $7.4*10^{-4}$ S cm^{-1} at 95°C, elastic modulus of 1.6 MPa at 25°C, and thermal stability up to 220°C. Improvement in the elastic modulus was achieved by the addition of IBA monomeric unit within the polymeric network, optimally when half of the volume fraction of 2HEA monomer was substituted with IBA. However, the increase in the elastic modulus until 12 MPa at 25°C referenced to a decrease in the conductivity to $2.6*10^{-4}$ S cm^{-1} at 95°C. Maximal electrochemical stability around 5 V vs Li/Li$^+$ was assured from cyclic voltammetry analysis. Observation of side reaction peaks around 1 V vs Li/Li$^+$ were investigated and assigned to the 2HEA monomeric unit.

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