Comparison studies of blend and unblend GPE systems: Ionic conductivity, structural and morphological properties

Siti Mariam Samin\textsuperscript{1,a}, Mazwan Mansor\textsuperscript{2,b}, Khairul Bahiyah Md. Isa\textsuperscript{3,c} and Zurina Osman\textsuperscript{4,d}

\textsuperscript{1}Physics Department, University of Malaya, 50603 Kuala Lumpur, Malaysia
\textsuperscript{a}cikyam_88@yahoo.com, \textsuperscript{b}maz45wan@yahoo.com, \textsuperscript{c}wippynie@yahoo.com, \textsuperscript{d}zurinaosman@um.edu.my

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Abstract: Studies on comparison of blend and unblend PMMA-based gel polymer electrolytes containing LiClO\textsubscript{4} salt with EC and PC as plasticizing solvent is reported. The GPE samples are prepared by varying the salt concentrations from 5 wt.% to 30 wt.% At room temperature, PVdF-HFP/PMMA blend GPE exhibits the highest conductivity of \(4.71 \times 10^{-3}\) S cm\(^{-1}\) containing 25 wt.% of LiClO\textsubscript{4} salt while the highest conductivity for unblend GPE is \(3.34 \times 10^{-3}\) S cm\(^{-1}\) containing 20 wt.% of LiClO\textsubscript{4} salt. The amorphous nature and morphological properties between LiClO\textsubscript{4} salt, EC and PC in the blend and unblend GPE systems have been validated using XRD and FESEM analysis.

1.0 Introduction

In the recent years, the progress on the portable consumer electronics devices has hastened the development of new batteries with high energy density. Therefore, it is crucial to develop suitable electrolyte for conventional secondary’s batteries which provide good lithium surface stability, high electrochemical stability and high ionic conductivity [1-3].

Several researchers have studied the gel polymer electrolyte (GPE) as the most promising polymer electrolyte to meet the above requirements [4-5]. Conventionally, the gel-type polymer electrolyte are obtained by trapping a liquid electrolyte in a host polymer matrixes such as polymethylmethacrylate (PMMA) [5], polyacrylonitrile (PAN) [6], polyethylene oxide (PEO) [7], and even co-polymer such as poly vinylidenefluoride-hexafluoropropylene (PVdF-HFP) [8]. Among them, PMMA-based gel electrolyte structure is the most beneficial to ionic conduction and has shown excellent interfacial stability towards lithium metal as reported by Appetecchi et al. [9]. At the same time, chemical cross-linking of PMMA can remarkably increase the electrolyte solution retention ability as well as suppress lithium dendrite formation [10].

However, the drawbacks of this type of polymer electrolyte is their poorer mechanical stabilities and inability to form a free standing film with high content of organic solvent when compared solid polymer electrolyte (SPE) as reported by Kulkarni [11]. One of the approached to solve these problems is by blending two-phase of GPE such as PMMA with copolymer PVdF-HFP. HFP helps to generate amorphous domains in an otherwise predominantly crystalline PVdF structure. The porous nature of PVdF-HFP polymer sample helps to trap large amount of liquid electrolyte, which leads to higher conductivity [12-13]. In conjunction with this, the ionic conductivity of these polymer electrolytes can be considerably enhanced by adding low molecular weight organic solvent such as ethylene carbonate (EC) and propylene carbonate (PC) into the system as reported in our previous work [14]. Among lithium salts used in GPEs, lithium perchlorate (LiClO\textsubscript{4}) is more favourable due to its highly soluble in organic and even water, less hygroscopic and does not undergo oxidation on the anode [15].

In this work, we compared the ionic conductivity of blend and unblend PMMA-based GPEs by using LiClO\textsubscript{4} salt dissolved in approrite binary of EC and PC as solvent plasticizer. The amorphous phase and the interactions between the polymer and LiClO\textsubscript{4} salt and between the polymer and the solvent plasticizers have been analyze using X-ray Diffraction (XRD) while the FESEM analysis was carried out to investigate the structural and compexion features of the GPE films.