ABSTRACT

The focus of the present investigation is to find out the cost effective hybrid polymer electrolyte for lithium battery for which the techniques such as blending, plasticization and incorporation of nanofillers have been implemented. Lithium battery has been constructed using the obtained polymer electrolyte (possessing highest ionic conductivity, higher thermal and good mechanical stability) and its electrochemical behavior has been studied. The thesis comprises of following eight chapters.

Chapter 1- Introduction

It deals with overview of batteries, it’s classification, it’s components such as cathode, anode and electrolyte. Electrolyte in particular has been discussed in detail like advantages of using solid polymer electrolyte over liquid electrolyte, methods to enhance the ionic conductivity of polymer electrolytes like blending, plasticization, incorporation of nanofillers and the essential criteria for polymer electrolyte preparation have been discussed in detail.

Chapter-2- Literature survey

In this chapter detailed literature survey has been made on lithium ion conducting polymer electrolytes for lithium ion battery applications. Based on the literature survey PVA and PVdF have been chosen as the host polymer for the present investigation.

Chapter 3- Experimental Techniques

It deals with the preparation of polymer electrolyte using solution casting technique. Characterization tools such as XRD, FTIR, AC Impedance Spectroscopy, DSC, TG-DTA, Mechanical strength measurement, LSV and CV used to analyze the structural, vibrational, electrical, thermal, mechanical and electrochemical properties of polymer electrolyte have been discussed in this chapter. Construction of coin cell using the hybrid polymer electrolyte has been discussed.
Chapter 4
Section 1: Preparation and Optimization of Blend Polymer Electrolytes [PVA:PVdF]

In this section three composition of PVA:PVdF:LiCF$_3$SO$_3$ (90:10:1, 80:20:1, 70:30:1) blend polymer electrolyte have been prepared. Blending technique has been chosen in the present investigation. This is because blending of two or more polymers is a well-established technique for obtaining materials with combined superior properties with good mechanical stability and higher ionic conductivity. The main advantages of the blend systems are simplicity of preparation and ease of control of physical properties by compositional change. The best composition of 80PVA:20PVdF:1LiCF$_3$SO$_3$ (BPE) possessing high ionic conductivity has been considered as the optimized system for further investigation.

Section 2: Effect of LiCF$_3$SO$_3$ on PVA:PVdF Blend Polymer Electrolyte

Section 2 explains the preparation of different concentration of LiCF$_3$SO$_3$ [5,10,15 and 20 (in mol%)] doped BPE polymer electrolyte. LiCF$_3$SO$_3$ has been preferred in the present study, because lithium is the lightest among all metals and it has small ionic radii of 0.6 Å. In particular, sulfonate (-SO$_3$) group in LiCF$_3$SO$_3$ is good anion of choice because it is highly resistant to oxidation, thermally stable, nontoxic and insensitive to ambient moisture as compared with other lithium salts. Prepared samples are characterized using XRD, FTIR, AC Impedance Spectroscopy, DSC, TG-DTA, mechanical strength measurement, LSV and CV techniques. 80PVA:20PVDF:15LiCF$_3$SO$_3$ blend polymer electrolyte (BPE-I) has been considered as the optimized system for further investigation.

Chapter 5 – Studies of Gel Polymer Electrolyte [(100-x) (BPE-I): xEC (x=10,20,30 and 40 in mol%)]

Chapter 5 deals with plasticized polymer electrolyte, wherein different concentration of EC is added in the optimized blend polymer electrolyte (BPE-I). The effect on the structural, vibrational, electrical, thermal, mechanical and electrochemical properties has been discussed. In this case, EC
has been chosen as the plasticizer because it possesses higher dielectric constant and high boiling point than all other plasticizers which favors high ionic conductivity. The optimized gel polymer electrolyte is 70(BPE-I):30EC (GPE-I).

**Chapter 6 – Effect of SiO₂ Nanofillers on 80PVA:20PVdF:15LiCF₃SO₃ Blend Polymer Electrolyte  [BPE-I:xSiO₂ (x=2,4,6,8 and 10 in mol%)]**

Chapter 6 deals with different concentration of SiO₂ nanoparticles doped in BPE-I nanocomposite polymer electrolyte. Incorporation of inert nanofiller in polymer matrix enhances the ionic conductivity and mechanical stability of polymer electrolyte. In this study, nano SiO₂ was chosen for the preparation of nanocomposite polymer electrolyte due to uniform particle size and low density with good thermal & mechanical stability. 8 mol% SiO₂ doped nanocomposite polymer electrolyte (NCPE-I) has been found as the optimized system.

**Chapter 7 – Effect of TiO₂ Nanofillers on 80PVA:20PVdF:15LiCF₃SO₃ Blend Polymer Electrolyte  [BPE-I:xTiO₂ (x=2,4,6 and 8 in mol%)]**

Chapter 7 deals with the effect of different concentration of TiO₂ nanoparticles in BPE-I polymer electrolyte system. Highest ionic conductivity obtained in the SiO₂ nanofiller doped system (NCPE-I) is found to be $1.6 \times 10^{-4}$ Scm⁻¹ at 303K. With the expectation of obtaining still more enhanced ionic conductivity, nano TiO₂ has been incorporated in the BPE-I. 4mol% TiO₂ doped system has been found as the optimized system and it possess highest ionic conductivity of $3.7 \times 10^{-3}$ Scm⁻¹. In the present investigation, among all the optimized polymer electrolytes in each series (BPE-I, GPE-I and NCPE-I, NCPE-II), it is concluded that NCPE-II is the hybrid polymer electrolyte. Hence coin cell has been constructed using the hybrid polymer electrolyte (NCPE-I) with the cell configuration of LiCoO₂/optimized polymer electrolyte/Li.

**Chapter 8 - Overall summary and conclusion**

In this Chapter, the conclusion of the present investigation has been discussed. The future work has also been briefly explained in this chapter.