ABSTRACT

The use of inorganic nanomaterials as fillers in the preparation of polymer composites has attracted increasing interest owing to their unique properties and numerous potential applications in automotive, aerospace, construction and electronic industries, fuel cells and electro chromic windows. Presently, much attention has been paid in employing nanocomposites for rechargeable lithium batteries. As compared with the aqueous batteries, the Li-ion battery leads to an increase of 100–150% on storage capability of energy per unit weight and volume. Nevertheless, some disadvantages arise, related to low energy and power density, large volume change on reaction, safety and costs. The aforesaid shortcomings can be reduced by the application of nanotechnology to the field of rechargeable batteries.

Polymer electrolytes exhibit interesting properties like size flexibility, transparency, light weight, feasibility of thin film formation and elasticity. The development of a successful solid state lithium battery depends on the choice of suitable host polymer matrix. At ambient temperature, the ionic conductivity of solid polymer electrolyte has not reached an appreciable value and further poor mechanical strength of polymer hinders the usage of free standing electrolytes. Various techniques have been employed to enhance the conductivity and mechanical strength of
polymer electrolytes at room temperature. One such widely used method is to incorporate nanofillers in the polymer matrix. The nanofillers suppress the crystalline nature of polymer and improve the mechanical strength and binding properties of polymer matrix.

In the present study, an attempt has been made to improve the ionic conductivity of the polymer electrolytes by incorporating nano biofillers to the polymer matrix. The polymer matrix selected is poly ethylene oxide (PEO), one of the most studied polymer host in the preparation of polymer electrolyte. The polymeric chain of PEO is capable of wrapping around lithium cations, creating coordination bonds and promoting dissolution and ionization of a lithium salt. PEO-based polymer electrolyte exhibits sufficient mechanical properties to act as an electrolyte in a cell, however the electrical conductivity, electrochemical and transport properties are inferior and needs improvement. PEO usually has low conductivity at room temperature. The incorporation of nanomaterials in polymer electrolytes increases the electrical conductivity of these materials at room temperature from 10 to 100 times compare with the corresponding undispersed system.

Chitin and chitosan are linear biopolymers having immense structures, multidimensional properties, well specified functional groups with wide range of applications in variety of fields. Chitosan (poly-(1-4)-2-amino-2-deoxy-\(\beta\)-D-glucan), chitin (poly-n-acetyl-(1-4)-2-amino-2-deoxy-\(\beta\)-D-glucan) and hydroxy apatite are natural cationic biopolymers with several polar groups (OH, NH\(_2\) and PO\(_4\)\(_{3-}\)), which can act as electron donors and interact with inorganic salts.
The aim of the present work is directed towards preparation and characterization of polymer electrolytes incorporated with various nano bio-fillers [such as nanochitosan (NC), chitin nanofibers (CNF), nano hydroxyapatite (nHAp)]. The effect of nano bio-fillers such as NC, CNF and nHAp on structural, thermal, morphological, electrical, electrochemical and interfacial properties of lithium ion conducting (LiTf and LiBOB as salt) PEO based NCPEs system. The free standing films of NCPEs have been prepared by membrane hot-press technique. The temperature dependence of conductivity of NCPEs was found to follow VTF behavior. Among the three types of nano bio-fillers (NC/CNF/nHAp) incorporated NCPEs, NC incorporated polymer electrolytes yielded maximum ionic conductivity and rose to the order of $10^{-3}$ S/cm. This may be due to the fact that it easily form dative bond with polymer compared to other two fillers. The mobility of ions in polymer matrix has been confirmed by cyclic voltammetry and the impedance spectroscopy measurements. The electrochemical stability window (ESW) of NCPEs electrolytes has been found to be $\sim 3$ V. The effect of nano bio-fillers (NC/CNF/nHAp) on the performance of Li/NCPE/Li symmetric cells has been analyzed at 60 °C continuously for ten days by lithium compatibility analysis.

The effects of succinonitrile (SN) and nanofillers (NC/CNF/nHAp) on structural, thermal, electrical, electrochemical and interfacial properties of PEO-LiX (X=Tf, BOB) electrolytes were analyzed. The highest conductivity of the PNCPEs obtained as $10^{-2.8}$ S/cm at 333 K for the electrolytes with 8% NC and 2% SN. The PNCPEs possess better interfacial resistance $R_\text{i}$ value compared to PEO-LiX complex as evident by compatibility analysis.