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Synthesis and characterization of ionic liquid and hydroxyapatite nano-filler based sodium ion conducting gel polymer electrolytes

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Interesting property such as high abundance and non-toxic character of sodium and high storage capacity and durability of sodium batteries make them an attractive energy storage system and a potential alternative to lithium batteries. Electrolyte is an important component of a battery system that controls electrochemistry between electrodes and affects electrochemical performance of batteries. Presently various types of electrolytes are being commercially used for battery applications but there are many problems associated with these electrolytes. In order to modify the properties of electrolytes, development of composite gel polymer electrolytes (CGPEs) are one of the approaches in that direction, specially it improves electrochemical properties of porous polymer electrolytes. In this work, synthesis and characterization of novel sodium ion-conducting nanocomposite gel polymer electrolytes based on poly(vinylidene fluride-co-hexafluoropropylene) (PVdF-HFP) are presented. The free standing flexible membranes of the CGPEs were prepared from solution-cast method. Nanosized hydroxyapatite (HAp) particles were used as the active filler and 1-butyl-3-methylimidazolium trifluoromethanesulfonate (BMIMTf) ionic liquid (IL) was used as an additive. Various physical and electrochemical analysis were demonstrated to use these membranes as promising electrolytes in rechargeable sodium batteries. Among studied samples, addition of 7 wt.% HAp shows the maximum ionic conductivity with the value of 1.7 mS cm^{-1} at room temperature (~27 ^{o}C). The ion/filler-polymer interactions and possible conformational changers in the host polymer due to dispersion of nano-sized HAp particles were examined by Fourier transform infrared (FTIR) and X-ray diffraction (XRD) methods. Our FTIR results showed considerable changes in the wavenumber regions of 500-700 cm^{-1} and 900-1150 cm^{-1} due to the changes of CF_3 and SO_3 asymmetric/symmetric vibrational bands with HAp particles. In addition, PO^{4-} anion vibrations of HAp were also influenced by ion-ion interactions mainly for the vibrational bands at 560-640, 963 and 1028 to 1110 cm^{-1}. The collected XRD spectra showed clear crystallinity change with increasing amorphous nature of the CGPEs when nanoparticle addition of 7 wt.%. The main changers were found in the 2θ value between 10 and 30^{o}. The results obtained in the present study have shown that the presence of IL and addition of nano-sized ceramic fillers can be optimized the overall physico-chemical properties of PVdF-HFP based electrospun membranes.

Keywords: Sodium batteries, Nanocomposite gel polymer electrolytes, Hydroxyapatite nano fillers, Ionic liquid, Infrared (IR) spectroscopy, Ionic conductivity