

Preparation and characterization of PVP-based polymer electrolytes for solid-state battery applications

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Abstract Sodium ion conducting polymer electrolyte films based on poly(vinyl pyrrolidone) (PVP) were prepared using solution casting technique. Structural characterization was performed using X-ray diffraction (XRD) technique. Increase in amorphous phase with the increase of dopant concentration was observed. Temperature dependence of electrical conductivity was performed using AC impedance analyzing technique in the frequency range of 0.1 KHz to 1 MHz. Activation energy values were evaluated, as well. Optical absorption studies were carried out in the wavelength range 200–600 nm. Absorption edge, direct band gap, and indirect band gap values were also evaluated. Optical absorption edge and optical band gap (both direct and indirect) showed decreasing trend with increasing the concentration of the dopant. Dominant conducting species in the present electrolyte system was determined using Wagner polarization technique and dominant conducting species were found to be ions rather than electrons. Solid-state batteries were developed using the present solid polymer electrolyte system and discharge characteristics over the load of 100 k Ω . Cell parameters, e.g., open circuit voltage, short circuit current, current density, power density were evaluated, too. Among these

cells, the cell made up of PVP/NaI (70/30) ratio for electrolyte was found to be more stable than the other two cells PVP/NaI (90/10) and (80/20) ratios and the obtained results were comparable with the results achieved by other studies.

Keywords PVP electrolytes · XRD · Electrical conductivity · Optical properties · Transference number · Battery

Introduction

Recently, polymer batteries prepared with polymer electrolytes (PEs) were widely explored due to its adaptation to various geometries, environmental and safety issues [1]. Main advantages of polymer electrolytes are their favorable electrical, optical and mechanical properties, ease of fabrication in thin film forms and ability to form effective electrode–electrolyte contacts [2]. Choice of the polymer host depends mainly on the characteristics such as: (1) presence of a sequential polar group with large sufficient electron donor power to form coordination with cations; (2) a low hindrance to bond rotations, thereby favoring easier segmental motion; (3) a suitable distance between coordinating centers, to form multiple intra-polymer ion bonds.

In an attempt to study the possibility of fabricating electrochemical cells based on polymers other than widely studied polymers such as poly(ethylene oxide) (PEO) and poly(propylene oxide) (PPO), studies have been undertaken on electrochemical cells based on poly(vinylidene fluoride) (PVDF), poly(vinyl pyrrolidone) (PVP), poly(vinyl alcohol) (PVA), and poly(vinyl chloride) (PVC) polymers [3–6]. Recent studies have dominated lithium ion conducting systems for their potential use in solid-state batteries with high cell voltages and energy densities. A few attempts have tried

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