Identification of the Structure and Electrical Conductivity of Sodium Hypophosphate Polymer Electrolytes

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Abstract: Sodium hypophosphate is primarily used to enhance protonic ion transport in materials. Polyvinyl chloride and polyvinyl pyrrolidone are combined with sodium hypophosphate to form a water-absorbent blend polymer for use as a polymeric membrane in electrochemical device applications. Solution casting procedures are used to create the different compositions of solid electrolytes. FTIR spectroscopy is used to characterise the structural-functional groups of produced polymer matrices. The sample's electrical conductivity is assessed using a cole-cole plot of impedance data at various temperatures. Electrical conductivity values on the order of 10-6 Scm-1 are calculated.

Keywords—Solid electrolyte, PVA, PVP, FTIR, Impedance, Activation energy

INTRODUCTION

Unpolluted energy is essential for human well-being, the reduction of poverty, and the growth of the global economy. There is a drawback to the current trend of using traditional energy sources, namely the production of polluting gases such as carbon dioxide and sulphur[1]. Efficient use of electrochemical energy systems as a renewable energy source is possible since traditional sources such as fossil fuels, coal, gas, and others are becoming more scarce. Batteries, fuel cells, and supercapacitors are the best energy conversion electrochemical sources [2–5]. In electrical device applications, many types of solid-state batteries are more suitable. A solid electrolyte is a critical component in all electrochemical devices [6–9] if the device is to achieve its technical features. Ionic conductivity (10-3Scm-1) that is closest to that of a liquid electrolyte, Ion transference number (tion) that is closest to one, high chemical, thermal, and electrochemical stabilities, high mechanical strength, and compatibility with electrode materials are just a few of the attributes that it should have. Due to the remarkable properties including fabrication flexibility, ease of forming, less weight, and improved chemical and thermal stability with an extended shelf life Polymer electrolytes in solid-state batteries, asymmetric and symmetric supercapacitors, as well as DMFC and Proton exchange membrane fuel cells, are increasingly often used in these applications.[13] The growth of electrochemical devices involves several different types of ionic conducting films like H+ and Na+ and Li and K and Cu and Ag, etc. films. More metal phosphates provide the best OH groups and less oxygen deficit, resulting in superior protonic conductivity. Multiple approaches were used to create polymer electrolytes, including synthesis of new polymers, blends of two or more polymers, cross-linking polymers, the addition of plasticizers to a polymer, a method known as "phase-inversion," incorporating metal salts into a polymer, and the addition of some inorganic fillers to the polymer matrix to increase amorphousness. The ionic conductivity of blended polymers, in addition to reducing poor mechanical stability, solvent volatileness and chemical instability, has been improved. Solid electrolytes made of PVA and PVP polymers are becoming increasingly effective [14].

PVA and PVP polymer matrices were created in varying compositions to improve the electrical characteristics of the film. FTIR is used to characterise the structure of the produced films, and their dielectric characteristics are analysed.

I. EXPERIMENTAL

A. *Sample preparation*

The solution casting process is used to create polymer blend electrolytes with a Stoichiometric ratio of 50% polyvinyl alcohol, 50% polyvinyl pyrrolidone, and x wt percent (1,2,3,4 and 5) sodium hypo phosphate. Distilled water dissolves PVA and PVP powders separately due to their differing chemical makeup. A and B are the names of these items. This solution is known as C, which stands for Sodium hypophosphate.

To make a clear solution, combine all of the precursor solutions in a 100-millilitre beaker and constantly stir. The final clear solution is continually stirred at a temperature of 60 degrees Celsius. In the oven, the sol becomes a gel and dries. Several ways may be used to distinguish the dried film that is created as a film. All dried salt mixed blend polymer films were found to be amorphous using X-ray Diffraction. By using Fourier transform Infrared spectroscopy, structural identification is carried out.

II. RESULTS AND DISCUSSION

A. Fourier Transform Infrared spectroscopy

Analyzing Fourier Transform Infrared Spectroscopy allows us to determine the structure and created functional groups. A "SHIMADZU IR tracer 100" spectrometer with a resolution of 4cm-1 is used to analyse FTIR transmission spectra. Plotted in the range of 4000cm-1 to 400cm-1 are the spectra.

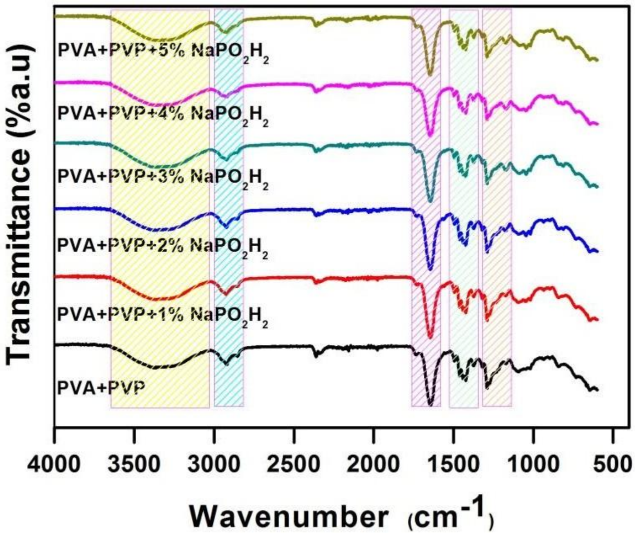

Fig.1. FTIR spectra for various compositions of sodium hypo phosphatemixed blend polymer films.

Figure 1 depicts the infrared spectra of sodium hypophosphate mixed 50PVA:50PVP polymer blends with varying compositions of IR spectra. In the mixed polymer electrolyte system, the typical prominent OH stretching vibration wide band of pure PVA was found in the area of 3595-3065 cm-1. Stretching of the PVP matrix is responsible for the bands detected in the 3000-2850 cm-1 range[15]. There are shifts in the mix polymer system and its composition that cause the IR bands at 600-850 cm-1 to be attributed to C-H asymmetric stretching and C-H rocking of pure PVA[16]. PVA backbone acetyl groups are shown to have C-O stretching in the area at 1080 cm-1 [17]. [18] The distinctive vibration of CH deformation of cyclic CH2 groups may be seen in the area of 1400- 1500 cm-1 in Figure 1. This band of 1550 – 1700 cm-1 is attributable to the PVP's C-O and N-C contributions [15]. In increasing concentrations, the bands are slightly shifted towards lower frequencies.

B. Impedance spectroscopy

The microstructure of polymer materials is the focus of impedance spectroscopy. At room temperature, Fig. 2 depicts the complex impedance curve of sodium hypo phosphate mixed PVA/PVP with various compositions. Non-Debye behaviour may be shown in these cole-cole plots of polymer-blend materials, as they display an inclination semicircle instead of a circle. The parallel combination of resistance and capacitance is a good analogy. At lower frequencies, one minor inclined spike is begun for sodium hypo phosphate mixed blend polymer matrices containing 1wt percent, 2wt per cent, 3wt percent, and 5wt percent. A parallel combination of capacitance and resistance is also a serial combination of capacitance. By looking at the lower frequency of the cole-cole plot of complex impedance, we may deduce the bulk resistance from the intersection of the semi-circle on the real axis. The bulk impedance of the 5wt% sodium hypophosphate mixed blend polymer system is 40617, which is lower than any other. NaPO2H2 mixed polymer blend electrolytes may be estimated using the formula l/RbA, where "l" is the film thickness, "A" is the film area, and "Rb" is the bulk resistance of the material.

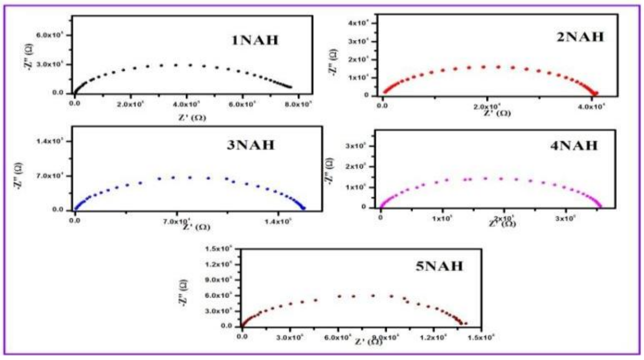

Fig.2. Cole – Cole plot for Various compositions of sodium hypo phosphate mixed PVA and PVP blend polymer sample.

At ambient temperature, the electrical conductivity of the 2wt% sodium hypophosphate mixed blend polymer system is 1.1810-6 Scm-1.

The electrical conductivity of polymer matrices of all compositions is also shown graphically for a variety of heat treatment temperatures. All compositions see a rise in conductivity as temperatures rise. Figure 3 depicts log-T vs. 1000/T graphs for different sodium hypophosphate-mixed PVA–PVP polymer system compositions. To compute activation energy, plotting a linear curve yields a slope.

The curve of electrical conductivity computed at different temperatures is shown in Figure 3. Because of the increase in electrical conductivity, it has formed a straight line. Formula T = 0*exp (-Ea/KT) is used to compute the activation energy by the slope of a straight line. This polymer electrolyte system has an activation energy of0.668557eV for sodium hypophosphate combined with PVA and PVP. The decreased energy achieved implies that enough gaps have been generated to enhance ion mobility over long distances. As a result, this composition has the highest possible electrical conductivity.

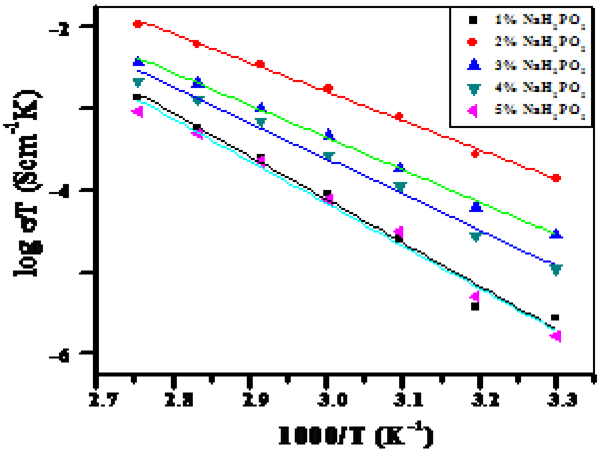

Fig.3. logσT vs 1000/T for all the compositions of sodium hypophosphate mixed PVA/PVP blend polymer electrolyte.

C. AC conductivity studies

For 50PVA/50PVP doped with various weight percents of NaPO2H2, the log vs. log curve shown in Fig. 4 was produced at various temperatures. There are two separate regimes in the frequency dependence of conductivity, the low-frequency plateau zone and ii) the high-frequency dispersion region, as seen in fig. 4. Frequency-independent conductivity (o) or dc is found at the plateau. By extending the conductivity value to the zero frequency, the (o) value is produced. At frequencies between 10-6 and 10-8 Scm-1, the conductivity values derived from conductivity-frequency plots were in excellent agreement with those from impedance analysis.

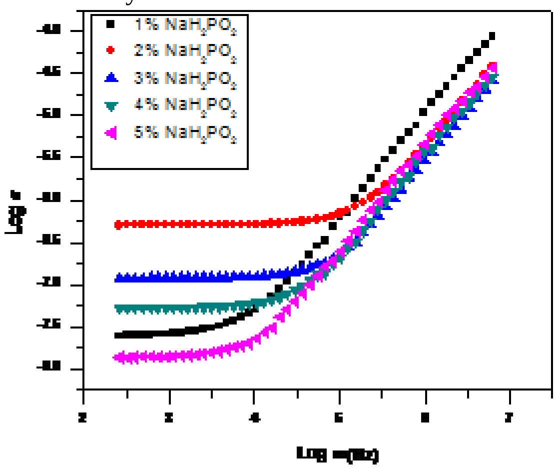

Fig.4. Conductivity as a function of frequency plot for Various compositions of sodium hypo phosphate mixed PVA and PVP blendpolymer sample.

III. CONCLUSION

The solution-casting approach was used to manufacture sodium hypo phosphate combined with different PVA and PVP compositions. Sodium hypophosphite salt mixed blend polymer samples reveal the amorphous nature of the blend polymer and all of the different compositions. IR bands identify the confirmation of functional groups in polymer electrolytes. We also analyse bulk impedance using semicircular plots of cole-cole produced for all compositions. 2wt percent sodium hypophosphate mixed polymers have the highest electrical conductivity. Temperature-dependent activation energy (0.66%): 1.1810-6 Scm-1 at room temperature. Because of its excellent electrical conductivity, it may be used as a solid electrolyte for electrochemical device applications.

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