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Synthesis and Characterization of Proton Exchange Membrane for Fuel Cell Technology

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ABSTRACT

Solid polymer Electrolytes plays important role in the working of fuel cell. Proton conducting electrolyte synthesized using different composition of polyvinyl alcohol and ammonium acetate such as 80:20, and 87.5:12.5 by solution cast technique. Different characterization were carried out such as, Micro-hardness testing, Forier transformation I-R spectrometry(FTIR) Thermogravimetric analysis (TGA), Differential scanning Calorimetry (DSC), These complexes found thermal stability of up to 200^{0}C

Key Wards: Micro-hardness testing, FTIR, TGA DSC.

INTRODUCTION

Fuel cell technology (FCT) fond help full technology to preserve our natural resources, which is global environmental concerns, such as global warming and green house effect. Hydrogen fuel cell is one of the most promising upcoming power source, which is electrochemical device that converts the chemical energy of a fuel directly into electrical energy. Fuel cell has been used for decades on NASA spacecraft now a day' fuel cell are use for power generation in commercial and industrial sectors. The major automakers are working to commercialize a fuel cell car. Miniature fuel cells for cellular phones, laptop computers and portable electronics are on their way to market. Wastewater treatment plants and landfills are using fuel cells to convert the methane gas they produce into electricity. In fuel cell technology, transfer of ions is the fundamental chemical process that creates the electrical energy within the fuel fell. Fuel cell are characterize on the basis of type of electrolyte used, and the type of fuel. Proton Exchange Membrane is a Solid polymer Electrolytes, Proton conducting electrolyte synthesized using different composition of polyvinyl alcohol and ammonium acetate.PEM technology was invented by General Electric and developed a small fuel cell.

MATERIALS AND METHODS

1. Experimental:

1.1 Synthetic Route

Proton conducting thin film of polyvinyl alcohol and ammonium acetate with different compositions were prepared in mole ratio (87.5:12.5) and (80:20) by solution cast technique. Aqueous solutions of polyvinyl alcohol and CH_3COONH_4 mixtures were thoroughly stirred for 8-10 hours at 60-70^{O}C to obtain homogeneous mixture using magnetic stirrer and then left for one week onto glass plate and evaporated slowly at room temperature. The smooth, uniform thin films which are transparent to visible light with good mechanical properties were obtained.

1.2 Experimental Techniques

2.21 Fourier Transformation I-R spectroscopy (FTIR)

Infrared absorption spectra were recorded on SHIMADZU FTIR-8101 system. FT-IR studies were performed at room temperature. Samples were hold in sample holder and placed in the FT-IR system.

2.22 Microhardness Testing

Vickers microhardness method was used to measure the hardness of thin film of polymer electrolytes using SHIMADZU HMV Micro Hardness tester. Vickers hardness is the standard method for measuring the hardness of metals. The surface is subjected to a standard pressure for a standard length of time by means of a pyramid-shaped diamond. The diagonal of the resulting indention is measured under a microscope and the Vickers Hardness value read from a conversion table.

2.23 Differential Scanning calorimetry (DSC)

DSC data were obtained between 30-400^{o}C using a UNIPAN 605M scanning calorimeter at heating rate of 5^{o}C/min. An empty aluminum pan was used as a reference.

2.24 Therogravimetric analysis

TGA characterizations were done using 851^{e} Melter Tolendo thermogravimeter. Within temperature range of 30-200^{o}C. In thermogravimetric analysis the mass changes (Δw) which occur when a sample is heated at a uniform rate are monitored continuously. Instruments have facilities which allow the differential of the mass change with respect to time (dW/dT) to be monitored simultaneously.

RESULTS AND DISCUSSION

PVA, unlike many polymers, is soluble in water. It dissolves in water to a greater or lesser extent according to the degree of hydrolysis and the temperature. An increase in the degree of hydrolysis will result in a reduction of solubility. It dissolves slowly in cold water, but at higher temperatures it goes fairly fast into solution, more so around 363 K. If PVA is added to a fixed quantity of water, the polymer does not dissolve in the water immediately. The globules of PVA first absorb water, swell and get distorted in shape and after a long time go into the solution. As more and more of the polymer is added to water, the time taken for the dissolution of the polymer obviously increases and the mix ultimately assumes soft, dough like consistency.

3.1 Fourier Transformation I-R spectroscopy

FTIR spectroscopy is important for the investigation of polymer structure. Since it provide the information about the complexation and interactions between the various constituents in the

polymer electrolyte. These interactions can induce changes in the vibrational modes of the molecules in the polymer electrolyte [1]. An FTIR spectrum of the polymer complex is shown in Fig. 3.1

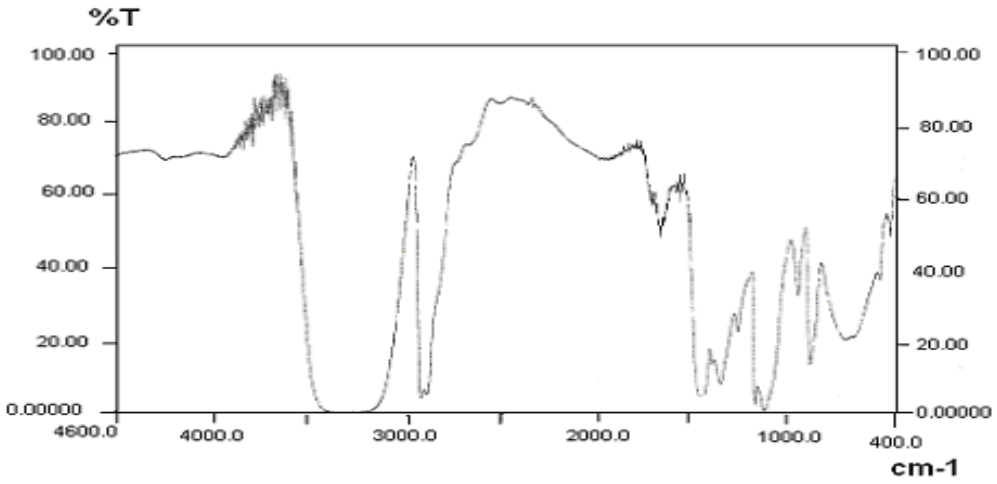


Fig. 3.1: FTIR spectra of PVA doped with ammonium acetate complexes

The absorption peaks of PVA at 2910-2943 cm^{-1}, 1655-1718 cm^{-1} are assigned to C-H stretching and C=O stretching respectively. The characteristic peak at 1620 cm^{-1} for PVA gets shifted to 1637 cm^{-1} for the complexed film. This confirms the complexation process in the polymer electrolyte system.

3.2 Differential scanning calorimetry

Fig.(2.21 and 2.22) shows a typical plot of the DSC curves for the PVA and PVA doped with 12.5 mole% CH_3COONH_4 which have been recorded on the heating run from 25ºC to 400ºC at a rate of 5°C min^{-1}. It has been observed that the glass transition temperature of pure PVA is 70ºC. The addition of ammonium acetate to the PVA decreases the glass transition temperature of PVA. The glass transition temperature of the PVA doped with 12.5 mole% ammonium acetate is found to be 32 ºC. This decrease in the glass transition temperature can be due to the plasticization of the electrolyte. So with the addition of salt, amorphous character of electrolyte membrane increases [3]. The plasticization effect is related to a weakening of the dipole-dipole interactions between the PVA chains due to the presence of salt [1]. The low glass transition temperature causes the higher segmental motion of the polymer electrolyte.

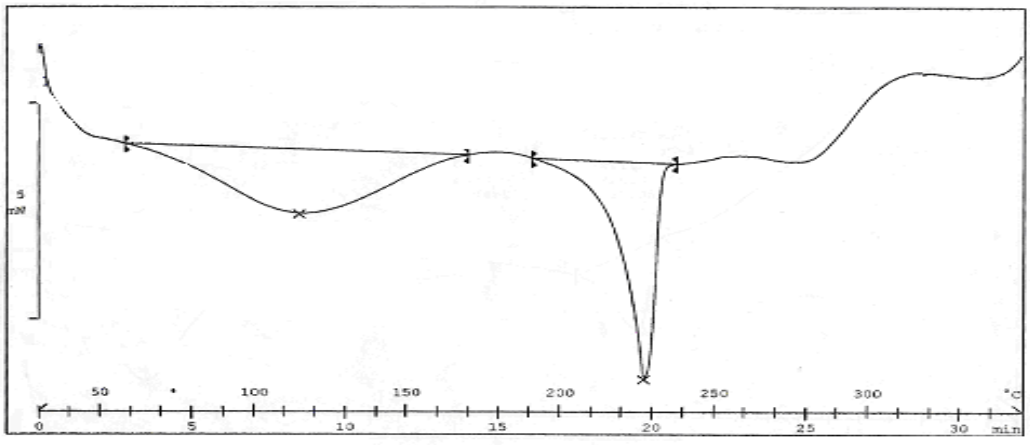


Fig. 3.21: DSC traces of the PVA doped with ammonium acetate in 87.5-12.5 mole%

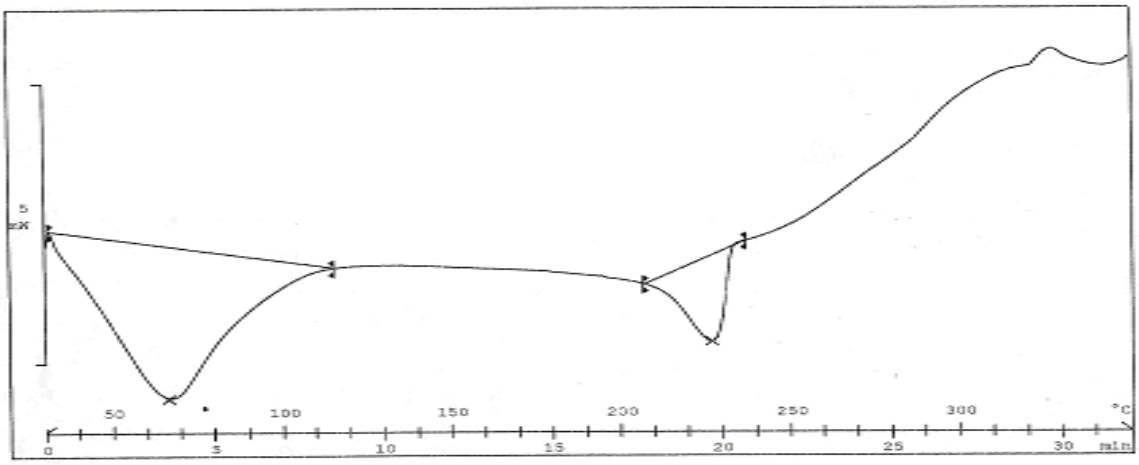


Fig. 3.22: DSC traces of the PVA doped with ammonium acetate in 80-20 mole%

3.3 Therogravimetric analysis

Thermal analysis of the complexes was carried out to investigate their thermal stability. The results are shown in Fig. (3.31 & 3.32). The PVA:CH_3COONH_4 complexes show a weight loss near room temperature is due to dehydration.[4] These complexes show decrease in weight and has thermal stability up to 200°C.

Fig. 3.31: TGA traces of the PVA doped with ammonium acetate in 87.5-12.5 mole%

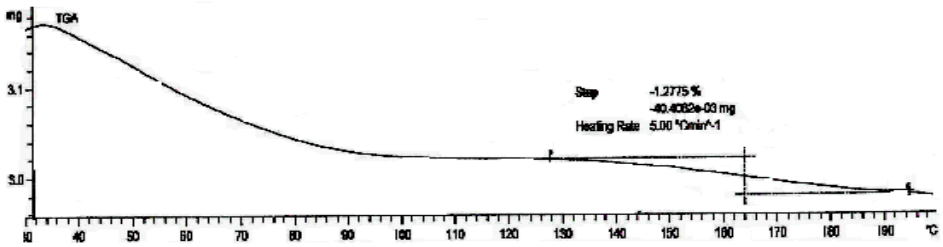
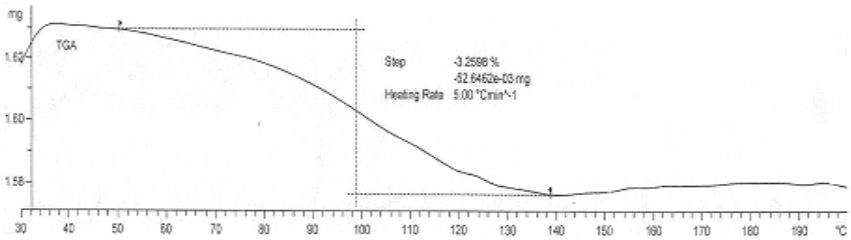


Fig. 3.32: TGA traces of the PVA doped with ammonium acetate in 80-20 mole%



3.4 Microhardness Testing

Micro-hardness testing was carried out with standered load and for standered length of time. Microhardness number for PVA doped with 12.5 mole% ammonium acetate is found to be 31.386, where for 20 mole% ammonium acetate it is found to be 10.57. this shows that microhardness value decreases with increase in salt concentration.

CONCLUSION

Polymer electrolyte of PVA complexed with CH_3COONH_4 has been prepared by the solution cast technique. FTIR spectrum confirms the complexation of the polymer electrolyte. Micro hardness No. decreases with increase in concentration of salt. DSC curve shows that the glass transition temperature decreases with addition of ammonium acetate, which is due to the plasticization effect [1]. TGA curve shows the weight loss near room temperature, which is due to removal of water [4] and membrane shows thermal stability up to 165°C.

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