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Electrical and di-electrical properties of PVA:PEG:CH_3COONH_4

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In this present communication the electrical properties of the new set of solid blend polymer electrolyte membranes have been investigated where the variation of conductivity with salt concentration from 10 wt% to 30 wt% has also been verified. To attain these notable electrical properties a very new combination of polymeric materials viz. polyvinyl alcohol (PVA) and polyethylene glycol (PEG) materials were considered which further been doped with ammonium acetate (CH_3COONH_4) in order to enhance the conductivity and other parameters. The dielectric permittivity, dielectric loss and ac conductivity of PVA:PEG has been observed to increase along with the addition of ammonium acetate at the frequency range of 42 Hz–100 kHz and the temperature range of 308–353 K. The ac conductivity σ_{ac} was found to obey the power law $A\omega^s$. The frequency exponential factor s was calculated and it was found to be in the range between 0.432 and 0.69 which was dependent on the ammonium acetate.

Keywords: Polymer blend, ac conductivity, dc conductivity, dielectric constant, dielectric loss.

Introduction

Polymer films had been extensively studied for electrical conductivity studies due to their potential applications in various electrochemical devices solid state batteries, super capacitors, fuel cells, electro chromic displays devices, sensors[1]. The physical mixture of two or more homo polymers produces polymer blends. It is possible to prepare polymer blend electrolytes by combining suitable homo polymers, with enhanced properties than any of its basic homo polymers[2]. The PVA is the preferable polymer among the different kinds of polymers due to its high thermal stability and dielectric strength, dopant dependent electrical properties and good charge storage capacity. PEG is a water soluble linear polymer used in many applications.

In this paper, the dielectric permittivity, dielectric loss, ac and dc conductivity of PVA+ PEG doped with CH_3COONH_4 at different temperatures and frequencies has been carried out to understand the role of dopant when added in varying concentrations to a polymer matrix.

Experimental

The solid polymer electrolyte of pure (PVA + PEG) (50:50) with ammonium acetate were prepared in different concentration (90:10), (80:20), (70:30) by solution casting technique. In this technique, PVA and PEG were dissolving in water. After dissolving, mix with ammonium acetate salt then stirred at 60°C by a magnetic stirrer for 3 days until highly homogeneous solution was formed. This solution was then taken in a petri dish, kept in a hot air oven for 12 h at 60°C temperature. The dried blend solid polymer electrolyte films were formed. These films peeled off from the petri dish.

The sample was kept in between two silver plates which act as electrodes. The impedance measurements were made using a HIOKI 3532-50, LCR Hi tester interface to a computer in the frequency range of 42 Hz to 5 M Hz. The temperature range is 308–353 K. The current was monitored as a function of temperature using a Keithly 6514 electrometer.

Results and discussion

The electrical parameters such as dielectric constant ε' and dielectric loss ε'' and ac conductivity σ_{ac} of PVA + PEG

+ CH_3COONH_4 blend polymer electrolyte for different compositions were obtained at a frequency range from 42 Hz to 100 kHz and temperature range from 308 K to 353 K. Ammonium acetate concentration increases, the electrical conductivity and the polar characteristics of PVA and PEG host blend polymer increases.

The results are obtained at a temperature 308 K are presented in Fig. 1. In this plot the variation of dielectric constant with frequency can be explained in terms of the relaxation time. At low frequencies, the electric dipoles have sufficient time to support with the field before the field change its direction. As a result the dielectric constant is high. At high frequencies the dielectric constant value decreases due to short time existing for the dipole to arrange in a line[3]. From the figure, the addition of salt increases the dielectric constant.

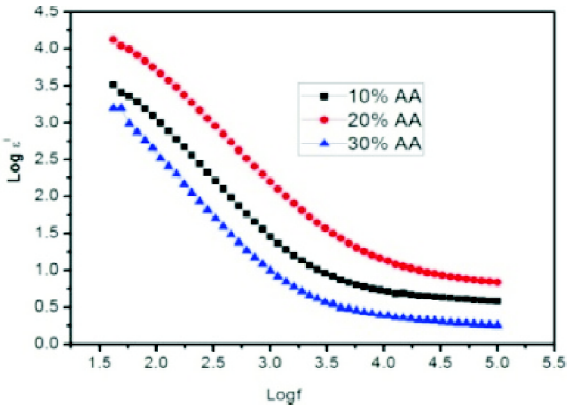

Fig. 1. Variation of ε' with frequency for PVA-PEG-CH_3COONH_4 polymer electrolytes at 308 K.

In Fig. 2, the dielectric loss is high at low frequencies and it decreases as frequency increases. The higher values of dielectric constant and dielectric loss for 20% ammonium acetate composition are due to the enhanced charge carrier density at the space charge accumulation region[4].

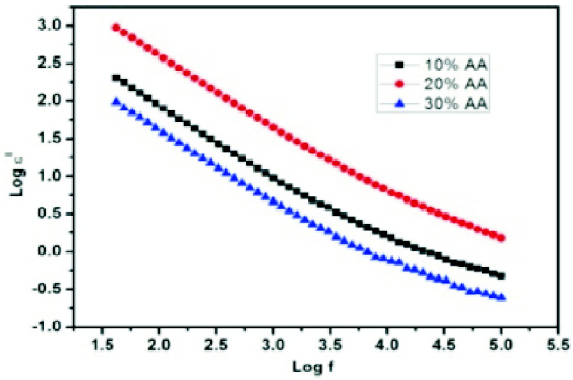

Fig. 2. Variation of ε'' with frequency for PVA-PEG-CH_3COONH_4 polymer electrolytes at 308 K.

The variation of ac conductivity with frequency is as shown in Fig. 3. AC conductivity increases as frequency increases for all compositions and high conductivity exists for 80:20 film compositions. Since the ammonium acetate concentration is increased, the salt molecules fill the gap separating the two neighboring states and hence the potential barrier width is decreased between them. Thus the assignment of charge carriers is promoted between two states.

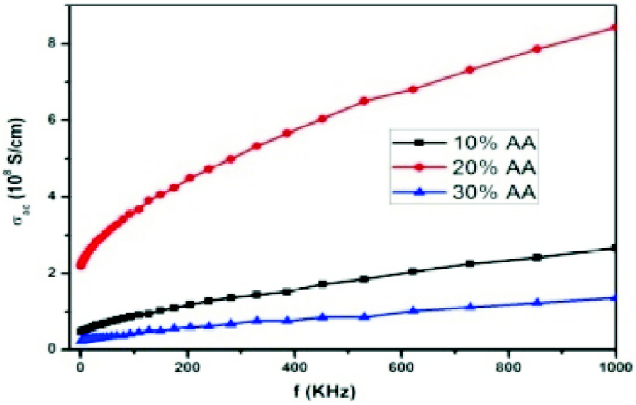

Fig. 3. Variation of σ_{ac} with frequency for PVA-PEG-CH_3COONH_4 polymer electrolyte films.

Fig. 4 gives the value of frequency exponent 's' for different CH_3COONH_4 concentrations which are evaluated from linear slope of log σ_{ac} against log ω. The 's' value decreases with increase in CH_3COONH_4 contents at 308 K. From these values, it is confirmed that ac conductivity σ_{ac} obeys power law and the values of 's' are within $0 < s < 1$.

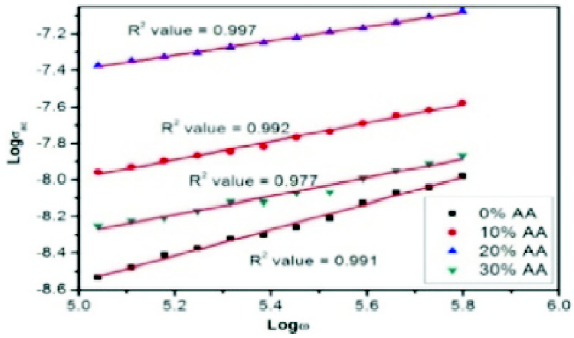

Fig. 4. Dependence of ac conductivity on the frequency at temperature 308 K.

Conclusions

Solid polymer blend electrolyte films based on PVA and PEG doped with different wt% ratios of CH_3COONH_4 were prepared using solution casting technique. PVA + PEG + CH_3COONH_4 (40 + 40 + 20) blend electrolyte film exhibits high dielectric constant, high dielectric loss and high ac conductivity. The ac conductivity obeys the power law $\sigma \infty \omega^s$.

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