International Journal of Scientific Research in Science and Technology

Available online at : www.ijsrst.com

OPEN ACCESS

Print ISSN: 2395-6011 | Online ISSN: 2395-602X

doi : https://doi.org/10.32628/IJSRST

Conductivity Study of PVA Doped With Phosphoric Acid Polymer Electrolyte System

S. P. Bakde[1], S. R. Jadhao[2]

[1]Department of Physics, Shri R. R. Lahoti Science College Morshi, Dist. Amravati, Maharashtra, India

[2]Department of Physics, Nehru Mahavidyalaya , Arts, Commerce, Science College, Nerparsopant, Dist. Amravati, Maharashtra, India

ARTICLEINFO

Article History:

Published : 12 March 2025

Publication Issue :

Volume 12, Issue 8

March-April-2025

Page Number :

209-213

ABSTRACT

The addition of acidic molecules significantly increases the ionic conductivity of the polymer matrix due to the formation of proton-conducting pathways within the PVA structure, thereby transforming the inherently insulating PVA into a potential material. When acid was added to a pure PVA solution, the electrical conductivity of the combined solutions rise. The dc conductivity of PVA is found to be increasing as the concentration of phosphoric acid increases. An ion conducting polymer electrolyte based on poly (vinyl alcohol) PVA complexes with phosphoric acid is prepared using solution cast technique.

Keywords: PVA, Electrical conductivity, Dielectric Properties.

I. INTRODUCTION

Polymers have poor ionic conductivity and are good insulators. Electrical conduction in polymers has been researched recently in order to understand the nature of charge transport [1]. For the charge transmission, several conduction mechanism types have been proposed [2]. To create solid polymer proton conductors, several research groups have looked into different combinations of polymers and acids or acid salts. [3]. Phosphoric acid (H3PO4) is one example of an acid group donor that may be used as a dopant to increase the conductivity of a PVA mixture [4].

Research on polymer film PVA-H3PO4 complexes has shown that when the concentration of H3PO4 with the H+ ion increases, so does the amorphous structure of PVA [5]. Prior research has demonstrated that PVA film exhibits good conducting properties when combined with phosphoric acid [6]. As the amount of phosphoric acid in the blend grows, so does the conductivity of the polymer film [7]. It was also discovered that the resultant polymer films have favorable mechanical and thermal characteristics [8, 9].

II. EXPERIMENTAL TECHNIQUE:

Polyvinyl alcohol with molecular weight 125,000 (AR grade Sd fine), phosphoric acid (AR grade merck), and deionized distilled water as a solvent have been used to prepare proton conducting solid polymer electrolyte by solution cast technique. In this method PVA and phosphoric acid have been dissolved separately in deionized distilled water by mole percent. Then different molar ratio of H3PO4 in PVA and the solution is stirred well using magnetic stirred, until homogeneous solution was formed. These homogeneous solution was casted in petri dish and evaporated slowly at room temperature. The film have been formed with uniformed thickness.

III.RESULT AND DISCUSSION

1. Temperature Dependant DC conductivity:

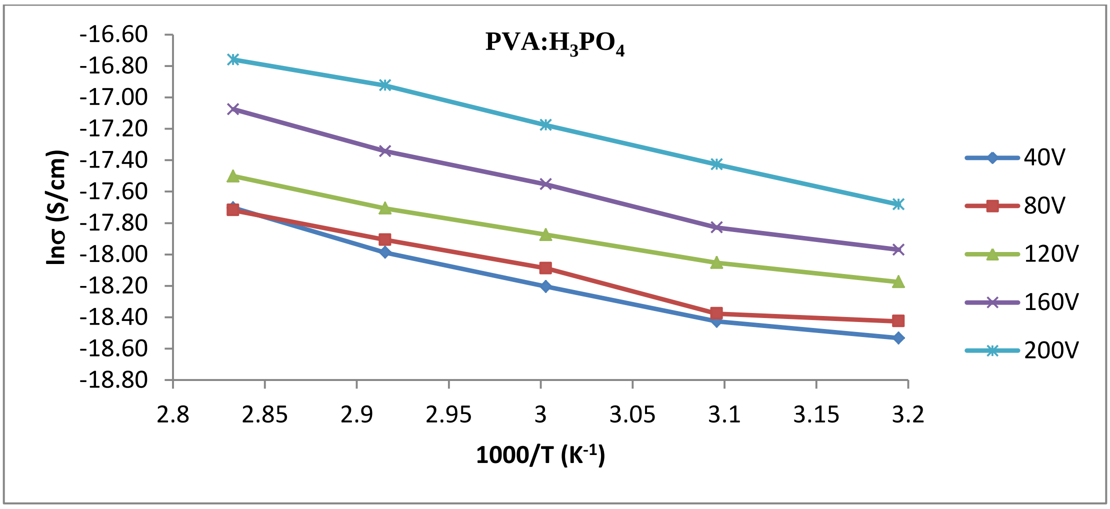

Figure 1: Variation of conductivity ln (σ) with temperature at different voltages (Arrhenius plots) for PVA with 25 mole % of Phosphoric acid.

The conductivity of the PVA films doped with phosphoric acid increased with temperature, exhibiting the typical behavior of thermally activated conductivity. The DC conductivity showed a significant enhancement as the phosphoric acid concentration increased, indicating that the presence of phosphoric acid contributed to the increased ionic mobility within the polymer matrix.

To better understand the conduction mechanism, the temperature dependence of the DC conductivity was analyzed using an Arrhenius plot. The DC conductivity can be described by the Arrhenius equation:

$$\sigma_T = \sigma_0 \exp(-E_a/KT)$$

Where σ_0 is the pre exponential factor, Ea is the activation energy and K is the Boltzmann constant [10-11]. The activation energy, Ea is calculated for prepared polymer electrolyte by linear fit of the Arrhenius plot. It is found that the activation energy decreases with increase of acid concentration in all polymer electrolytes. Increase in the electrical conductivity and decrease in the activation energy value of polymer electrolytes can be explain on the basis that the polymer films are known to be a mixture of amorphous and crystalline region and the conductivity behavior of such films may be dominated by the properties of amorphous region. The amorphous nature provides a bigger free volume in polymer electrolytes system with increase in temperature [12].

2. Frequency dependent conductivity

The variation of the conductivity as a function of frequency for different concentration of polymer electrolyte has been shown in fig 2.

The conductivity of polymer changes with frequency according to Jonschen's universal power law [13].

$\sigma_{ac}(\omega)=\sigma_t-\sigma_{(d.c.)}=A\omega^s$

Where (A) is a constant independent on temperature, ($\omega = 2*\pi*f$) and (s) is the frequency exponent

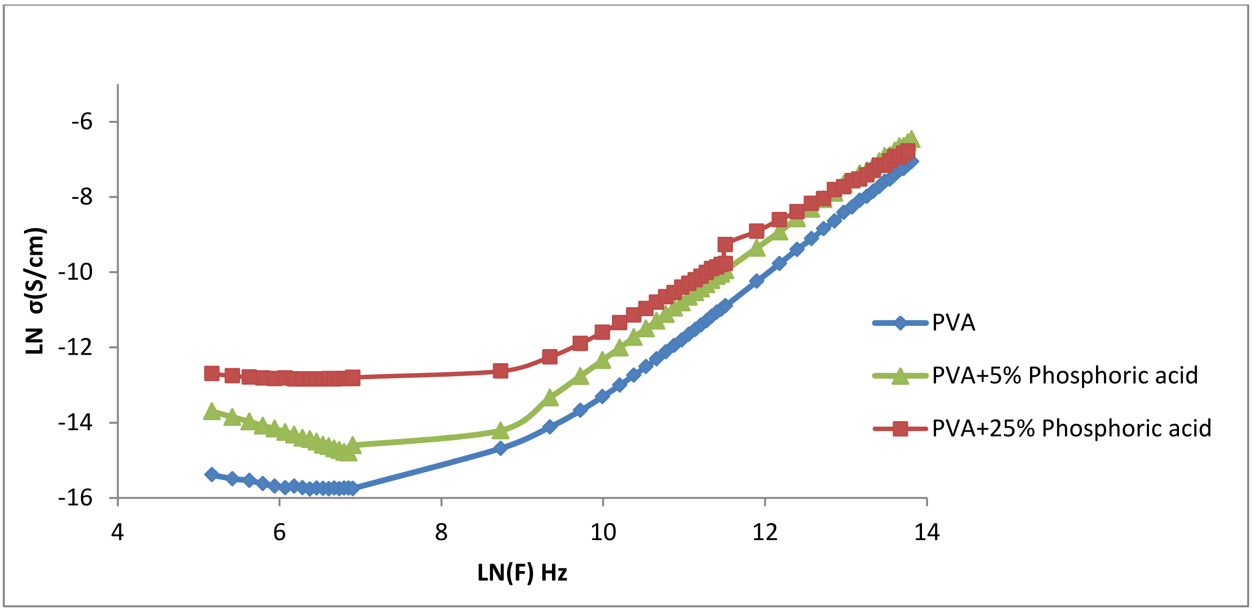

Fig 2. The variation of AC conductivity with frequency for pure PVA and PVA dopped with phosphoric acid.

Fig. 2 shows the frequency depends on the total conductivity measured for pure polyvinyl alcohol and doped with phosphoric acid with different concentration at room temperature. It was observed that the conductivity increased with the frequency because the rate of polymerization is higher with increasing concentration of phosphoric acid.

3. Frequency dependent dielectric constant and dielectric loss

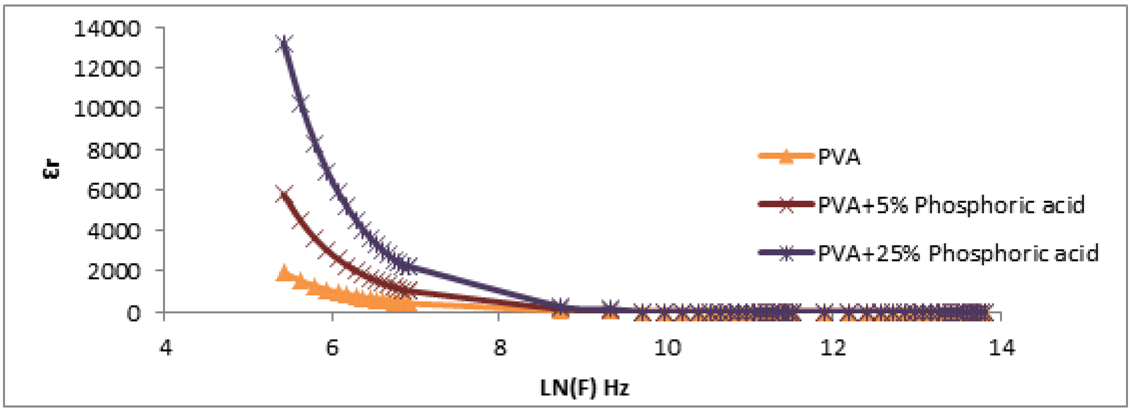

Fig 3.1. The variation of dielectric constant with frequency for pure PVA and PVA with dopped phosphoric acid

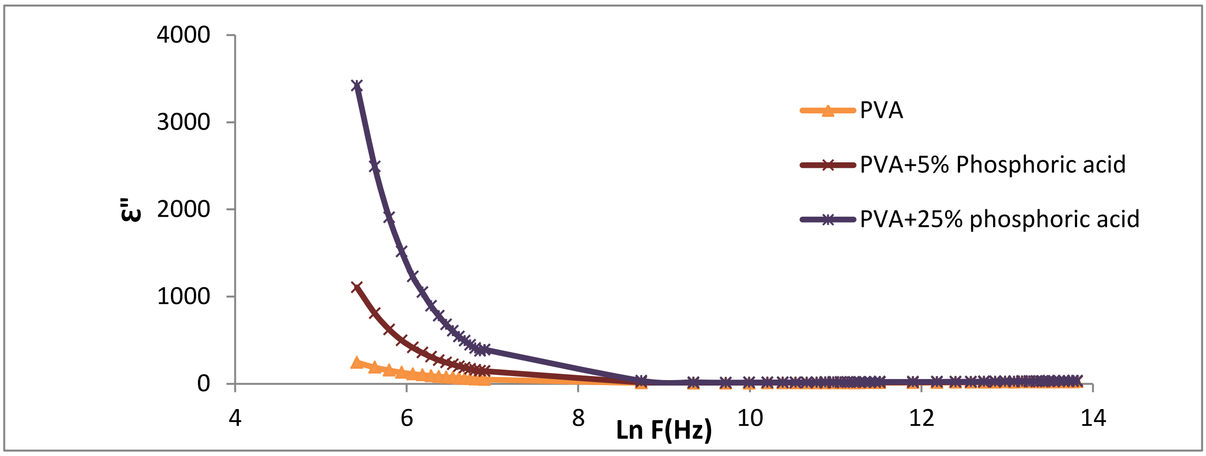

Fig 3.2. The variation of dielectric loss with frequency for pure PVA and PVA with dopped phosphoric acid

Fig 3.1 shows the frequency dependence on dielectric constant. It is clear from the figure (εr) decreases with the increase in frequency. The decrease of (εr) with frequency can be explained as follows: at low frequencies, (εr) for polar materials are due to the contribution of multi-component of polarize ability deformational polarization (electronic, ionic, orientation, and interfacial). When the frequency is increased, the dipole will no longer be able to rotate sufficiently rapidly. So their oscillations being to be lag behind those of the field. As the frequency is further increased, the dipole will be completely unable to follow the field and the orientation stopped, so (εr) decreases at a higher frequency approaching a constant value due to the interfacial polarization . The dielectric loss as a function of frequency is shown in Fig. 3.2, shows the dependence of (ε”) on the frequency at room temperature. It is found to be decreases with the increases in the frequency. The origins of the dielectric losses are the conduction losses [14].

IV. CONCLUSION :

The concentration of phosphoric acid rise, the DC conductivity significantly improved, suggesting that phosphoric acids presence facilitated the increased ionic mobility in the polymer matrix. With an increase in frequency, PVA–H3PO4 electrolytes conductivity also rose. It has been discovered that ionic conductivity increases with phosphoric acid concentration because the rate of polymerization increases as phosphoric acid concentration rises. It was discovered that when the frequency increased, the dielectric constant (εr) decreased. It was also discovered that when the frequency increased, the dielectric loss (ε") reduced.

V. REFERENCES

[1]. N. Nagaraj , V. Subba Reddy, A. K. Sharma, V. V. R Narasimha Rao, Journal of Power Sources, (2002), 112, 326.
[2]. P. Dutta, S. Biswas, M. Ghosh, S. Chatterjee, Synthetic Metales, (2001), 122, 455.
[3]. S. Shabanpanah, A. Omrani, M., M. Lakouraj, Polym. , (2019), 22, 130–139.
[4]. C. C. Yang, Int. J. Hydrog. Energy, (2011), 36, 4419–4431.
[5]. N. N. Verawati, J. Lensa, Kependidikan Fis., (2020) , 8, 48–54.
[6]. D. A. Quintana, E. Baca, E. Mosquera, R. A. Vargas, J. E. Diosa, Ionics, (2018), 25, 1131–1136.
[7]. T. G. Lazareva, O. V. Yakovleva, E. V. Shinkareva, Russ. J. Appl. Chem., (2002), 75, 965–968.
[8]. T. Xu, J. Z. Chen, W. Han, Z. Li, G. Yu, Part. Sci. Technol., (2010), 28, 539–546.

[9]. F. Chen, P. Liu, Macromol. Res., (2011), 19, 883–890.
[10]. S. D. Druger, A. Nitzam, M. A. Ratner, J Chem Physics, (1983), 79, 3133.
[11]. K. K. Maurya, S. A. Hashmi, S. A. Chandra, J. Phys Soc. Janpan ,(1992), 61,1709.
[12]. M. S. Michael, M. M. E. Jacob, S. R. S Prabaharan, S. Radhakrishna Solid State Ionics, 98 (3-4), 167.
[13]. Joshi J. M. and Sinha V. K., Journal of Carbohydrates Polymer, (2007), 67, 427- 435.
[14]. Zareh E. H., Moghadam P. N., Azariyan E., and Sharifia I., Iranian Polymer Journal, (2011), 20(4), 319-328.