Influence Of Acid Concentration on The Electrical Behavior of Polyvinyl Alcohol

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Abstract—**The influence of acid concentration on the DC electrical conductivity of Polyvinyl alcohol (PVA) has been systematically investigated. PVA films were prepared using the solution casting method with acid concentrations. The DC conductivity was obtained from current-voltage characteristics by using two probe techniques in the different temperature range. The results indicate a significant enhancement in conductivity with increasing acid concentration. This behavior is attributed to the increased availability of mobile charge carriers and the formation of protonic conduction pathways within the polymer matrix. The temperature dependence of DC conductivity follows Arrhenius behavior. Activation energy decreases with increasing acid concentration, suggesting improved charge transport.**

Index Terms—**Polyvinyl alcohol, Acid Concentration, DC conductivity.**

I. INTRODUCTION:

The rapid development of portable, flexible and wearable electronic devices has intensified the search for polymer-based materials with variable electrical properties. Among various polymers, Polyvinyl alcohol (PVA) has attracted considerable attention due to its low cost, nontoxicity, good mechanical strength, and excellent film forming capability. However, PVA exhibits low electrical conductivity, which limits its direct application in electronic and electrochemical devices [1-4].

To overcome this limitation, several strategies such as salt doping, acid doping and polymer blending have been employed to enhance the electrical behaviour of PVA. Acid doping particularly effective as acids introduce mobile protons into the polymer matrix, facilitating ionic conduction through hydrogen bonding and segmental motion of the polymer chains [5-10]. The interaction between acid molecules and the hydroxyl groups of PVA disrupts its crystalline regions, increases amorphous content, and enhances chain flexibility, thereby improving charge carrier mobility and overall electrical conductivity [11-14].

II. EXPERIMENTAL TECHNIQUE:

PVA was dissolved in distilled water under constant stirring at elevated temperature until a clear homogeneous solution was obtained. The acid dopant was then added in varying concentrations to the PVA solution and stirred continuously to ensure uniform dispersion. The resulting solution was cast into clean glass Petri dishes and dried at room temperature to form flexible films. The dried films were peeled off and stored in dust free chamber for further investigation. The film has been formed with uniformed thickness. DC electrical conductivity has been measured for various concentrations at different temperatures (313K- 353K) and voltages.

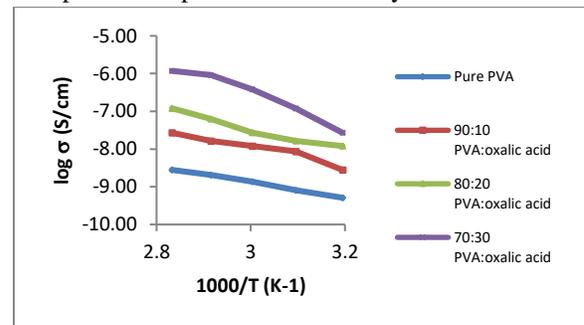## III. RESULTS AND DISCUSSION:

Temperature dependent conductivity:

Figure 1: Variation of Conductivity σ vs 1000/T plots for PVA:Oxalic acid

The conductivity of the PVA films doped with Oxalic acid increased with temperature, exhibiting the typical behavior of thermally activated conductivity. The DC conductivity showed a significant enhancement as the Oxalic acid concentration increased, indicating that the presence of Oxalic acid contributed to the increased ionic mobility within the polymer matrix. Similar behavior has been reported for several polymer electrolyte systems, including PVA-based electrolytes [15,16].

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:

$$\sigma = \sigma_o \exp(-E_a/kT)$$

Where σ_o is the pre-exponential factor, E_a is the activation energy and k is the Boltzmann constant. 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 [17].

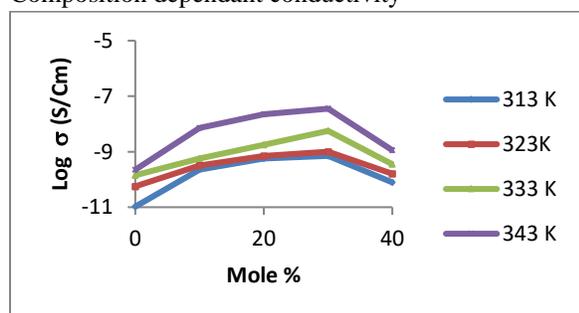Composition dependant conductivity

Figure 2: Composition vs conductivity

Figure 2 illustrates the variation of DC conductivity (σ) as a function of Oxalic acid content (by weight percentage) in Polyvinyl alcohol (PVA) at different temperatures. It is observed that the conductivity increases with increasing acid concentration, reaches a maximum value, and subsequently decreases at higher dopant concentrations. The initial enhancement in ionic conductivity with increasing dopant concentration is mainly attributed to the rise in the number of mobile ionic charge carriers. Ion transport in polymer electrolytes occurs through a liquid-like mechanism, where the movement of ions within the polymer matrix is facilitated by large-amplitude segmental motion of the polymer chains [18,19].

IV. CONCLUSION

The present study confirms that acid concentration plays a critical role in controlling the electrical behavior of polyvinyl alcohol. Acid doping significantly enhances the electrical conductivity of PVA by increasing proton density and ionic mobility through strong ion–polymer interactions. An optimum acid concentration results in maximum conductivity, whereas further addition leads to saturation or a slight decrease due to ion aggregation and reduced polymer chain flexibility. These findings demonstrate that controlled acid doping is an effective strategy for tailoring the electrical properties of PVA for electrochemical and energy storage applications.

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