# Role Of Acid Concentration in Modifying the Electrical Behavior of Polyvinyl Alcohol

S. R. Jadhao
*Department of Physics*
*Nehru Arts, Commerce and Science College, Nerparsopant, Dist. Yavatmal, (M.S.) India*
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***Abstract*—The effect of acid concentration on the electrical conductivity of polyvinyl alcohol (PVA) has been explored. PVA films doped with different acid concentrations were prepared using the solution cast technique. AC conductivity measurements were carried out over a wide frequency and temperature range. The results show that AC conductivity increases with increasing frequency and acid concentration.**

***Index Terms*—Polyvinyl alcohol, AC conductivity, dielectric study.**

## I. INTRODUCTION

The swift advancement of portable, flexible, and wearable electronics has driven the demand for polymer-based materials featuring tunable electrical characteristics. Among the diverse range of polymers available, Polyvinyl alcohol (PVA) has emerged as a prominent candidate owing to its cost-effectiveness, non-toxic nature, robust mechanical strength, and superior film-forming properties [1-4]. Nevertheless, the intrinsic electrical conductivity of pristine PVA is quite low, which restricts its immediate utility in electronic and electrochemical systems.

To address this challenge, various techniques including salt doping, acid incorporation, and polymer blending have been utilized to optimize the electrical performance of PVA. Acid doping is especially efficient, as it introduces mobile protons into the polymer framework. This facilitates ionic conduction by leveraging hydrogen bonding and the segmental dynamics of the polymer chains. The chemical interaction between the acid molecules and the hydroxyl groups of the PVA backbone disrupts the crystalline domains, thereby expanding the amorphous regions and increasing chain flexibility. These structural modifications ultimately enhance charge carrier mobility and significantly elevate the overall electrical conductivity [5-14].

## II. EXPERIMENTAL TECHNIQUE

The solution casting method was employed to prepare the polymer electrolyte films. Initially, Polyvinyl Alcohol (PVA) was dissolved in distilled water at an elevated temperature while being subjected to constant stirring until a clear, homogeneous solution was achieved. Subsequently, the acid dopant was introduced into the PVA solution at varying concentrations, with continuous stirring maintained to ensure uniform dispersion of the dopant molecules.

The resulting viscous mixtures were cast onto clean glass Petri dishes and allowed to dry at room temperature, yielding flexible films. Once fully dehydrated, the films were carefully peeled from the substrate and stored in a dust-free chamber to prevent contamination prior to further investigation. The thickness of the resulting films was found to be uniform across all samples.

## III. RESULT AND DISCUSSION

### AC CONDUCTIVITY ANALYSIS

AC conductivity measurements offer critical insights into the charge transport dynamics within the polymer films. The AC conductivity ($\sigma_{ac}$) of the prepared membranes was determined using the fundamental relation

$\sigma_{ac} = \varepsilon_0 \omega \varepsilon''$

where $\epsilon_0$ represents the permittivity of free space and $\omega$ is the angular frequency. The frequency-dependent variation of AC conductivity for both pristine PVA and oxalic acid-doped polymer electrolyte membranes is illustrated in Fig. 1a. A consistent rise in conductivity with increasing frequency was observed across all samples. [15-16]

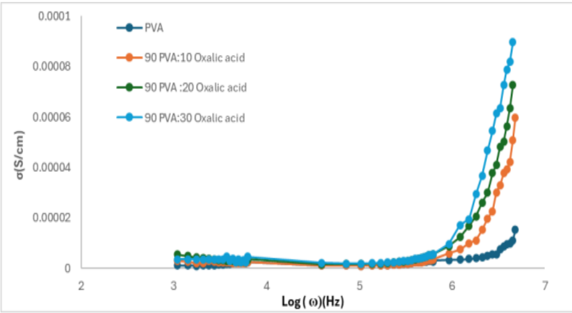


Fig. 1a shows the variation of ac conductivity as function of frequency for different concentration of Oxalic acid

This enhancement in AC conductivity is primarily attributed to the integration of carboxylic acid into the PVA matrix, which elevates the concentration of free ions and, subsequently, the density of mobile charge carriers.

DIELECTRIC STUDIES

Dielectric spectroscopy is a powerful diagnostic tool for explain conduction mechanisms and ion-polymer interactions in electrolyte membranes. Under the influence of an external electric field, these materials experience electrical polarization. The dielectric response is typically characterized by the complex permittivity ($\varepsilon^*$), defined as:

$\varepsilon^* = \varepsilon' + j\varepsilon''$

In this expression, the real part (ε') represents the dielectric constant, indicating the energy stored through polarization, while the imaginary part (ε'') signifies the dielectric loss, reflecting the energy dissipated within the material.

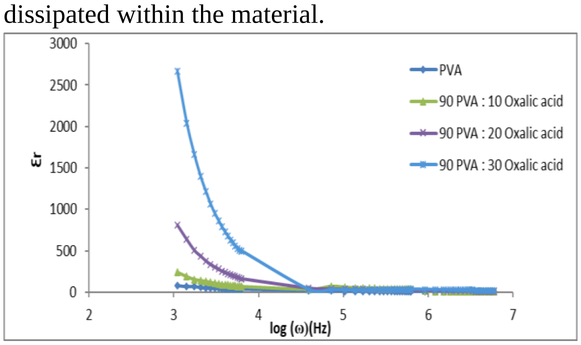


Fig. 2a shows the variation of dielectric constant as function of frequency for different concentration of Oxalic acid

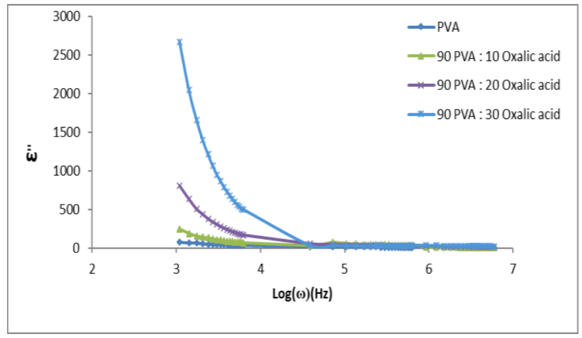


Fig. 2b shows the variation of dielectric loss as function of frequency for different concentration of Oxalic acid

Fig. 2a and Fig. 2b depict the frequency dependence of the dielectric constant and dielectric loss for various Oxalic acid concentrations. Both parameters exhibit high values at lower frequencies, followed by a decrease that asymptotically approaches a constant value at higher frequencies. The elevated dielectric values in the low-frequency regime are a result of electrode polarization, caused by the accumulation of charge carriers at the electrode-electrolyte interface. This localized accumulation reduces the effective number of dipoles capable of aligning with the rapidly oscillating electric field at higher frequencies. [17-19] Additionally, the observed increase in ε' and ε'' with higher dopant concentration confirms an increase in the total number of dipoles and charge carriers contributing to the material's overall polarization.

## IV. CONCLUSION

In this study, Polyvinyl Alcohol (PVA) films incorporated with varying concentrations of Oxalic acid were successfully synthesized, and their electrical characteristics were comprehensively evaluated. The experimental data revealed that the AC conductivity of the film's scales positively with both frequency and dopant concentration. This enhancement is primarily driven by the increased density of mobile ions and the expansion of amorphous regions within the polymer matrix, which facilitates superior ionic mobility.

Furthermore, dielectric investigations highlighted characteristic relaxation behavior, with a distinct dominance of electrode polarization in the low-frequency regime. The significant improvement in the electrical and dielectric responses confirms that Oxalic acid-doped PVA is a highly viable and promising candidate for the development of advanced polymer electrolyte systems.

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