DIELECTRIC STUDY OF ETHYL CELLULOSE (EC) AND POLY METHYL METHACRYLATE (PMMA) DOPED WITH OXALIC ACID (OA) POLYBLENDS

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Abstract
AC electrical conductivity studies are aimed at understanding the origin of the charge carrying species, their numbers and the way in which they move through the bulk of the material. Polymers like Ethyl Cellulose (EC) and Poly Methyl Methacrylate very small and their mobility is very low. AC electrical properties of Ethyl Cellulose (EC), Poly Methyl Methacrylate (PMMA) doped with Oxalic Acid (OA) pure and their polyblends film prepared by isothermal evaporation technique have been investigated as a function of temperature, electric field and frequency, dielectric constant and dielectric loss tangent to study the mechanism of electrical conduction. The current was measured by applying the frequency in the range 1KHz -1MHz at various constant temperatures (313-353 K). The AC electrical conductivity of polyblend is increasing with increasing frequency of applied electric field. Dielectric constant increases with increase of temperature.
***Keywords**: Dielectric, tetrahydrofuran, ethyl cellulose, poly methyl methacrylate, AC conductivity.*

1. Introduction

Polymer blends have garnered significant attention in materials science due to their ability to exhibit enhanced physicochemical properties by combining the advantageous characteristics of individual polymeric components. [1]. Polymers, like other insulating materials such as glass and ceramics, act as dielectrics by preventing current flow and storing electrical energy when placed in an electric field. The a.c. electrical conductivity studies are aimed at understanding the origin of the charge carrying species, their numbers and the way in which they move through the bulk of the material. These parameters are related to the chemical composition, microstructure and morphology of the material [2]. Among such blends, Ethyl Cellulose (EC) and Poly methyl methacrylate (PMMA) constitute a promising system owing to their complementary structural and functional attributes. EC, a semi-crystalline polymer, is known for its excellent film-forming ability, thermal stability, and biocompatibility, whereas PMMA, an amorphous polymer, provides superior optical transparency and mechanical robustness. The blending of these polymers facilitates the development of materials with tailored electrical and dielectric properties, making them suitable for various technological applications [3]. In the present investigation, the a.c. conductivity of Ethyl Cellulose (EC), Poly Methyl Methacrylate (PMMA) doped with different ratios of Oxalic Acid (OA) blend was measured to identify the mechanism of electrical conduction. The dielectric constants have been measured for different temperatures. A good number of reports [4,5] on the theory of electrical conduction and experimental findings have appeared in a number of such blends. Polymers like Ethyl Cellulose (EC) and Poly Methyl Methacrylate (PMMA) being essentially insulating materials, the number of free charge carriers is very small and their mobility is very low. In an electric field, it is expected that a redistribution of charges that are mobile enough to respond to the time scale of the applied field, may occur.

2. Experimental

In the present work, Isothermal Evaporation Technique has been used, as it is best suited to the laboratory. The different quantities of given substances have been used for preparing film of thickness. The two polymers, EC and PMMA polymer blends were prepared in weight ratios (1:1) and doped with oxalic acid in concentrations (0%, 5%). The two polymers PMMA or Ethyl Cellulose (EC) were pure were taken in 1:1 ratio were dissolved in the common solvent THF (10 ml). And their blends were taken in 1:3 ratio dissolved in the common solvent THF (15 ml). The solution was kept for 3-4 days to allow polymers to dissolve completely to yield uniform solution. A glass (15 cm X 15 cm) thoroughly cleaned with water and later with was used as a substrate. To achieve perfect levelling (and uniformity in thickness of the film), a pool of mercury was used in a plastic tray. It was, thereafter, allowed to evaporate in air at room temperature. Further, it was dried for 48 h to remove any traces of solvent. The dry film was removed from the plate and cut into pieces (samples) of desired size. The films of other samples were prepared by the same method [6].

These thin films were synthesized using the isothermal evaporation technique, ensuring uniform thickness and composition.

AC Conductivity Measurement

The film sample was loaded into the sample holder in oven. The a. c. frequencies were applied (in the range 1KHz-1MHz) across the sample by using the 4284 A precision LCR meter (20Hz-1MHz) supplied by Agilent Technologies, Singapore. The corresponding dielectric constants were measured by using LCR meter [7]. From the dielectric data, the AC conductivity of the samples was calculated by using relation,

$$\sigma_{ac} = f\,\varepsilon'\,\tan\delta / 1.8\times10^{10}$$

Supplied by Mitutoyo Corporation Japan, was for the measurement of thickness of sample thin film. It is measuring range is 0-25mm with resolution 0.001mm.

3. Results and discussion

In our study, we observed for Ethyl Cellulose (EC) and Poly Methyl Methacrylate (PMMA) there is decrease of dielectric constant with increase in frequency. The dielectric constant of Ethyl Cellulose (EC) and Poly Methyl Methacrylate (PMMA) 0% and 5% of Oxalic Acid (OA) at constant temperature, Dielectric Constant (ε_r) decreases with the increase of frequency as shown in fig.1(a-b). This is the expected behaviour in most dielectric material. This is due to the dielectric relaxation. From a structural point of view the dielectric relaxation involves the orientation polarization, which in turn depends upon the molecular arrangement in to the dielectric. So, at higher frequencies the rotational motion of polar molecules of dielectric is not sufficiently rapid for the attainment of equilibrium with the field. As a result, dielectric constant decreases with frequency [8].

Also, there is the increase of dielectric constant with increase in temperature as shown in fig. 2 (a-b). Thus, the increase in dielectric constant is due to the greater freedom of moment of dipole molecular chains within the polymer blends.

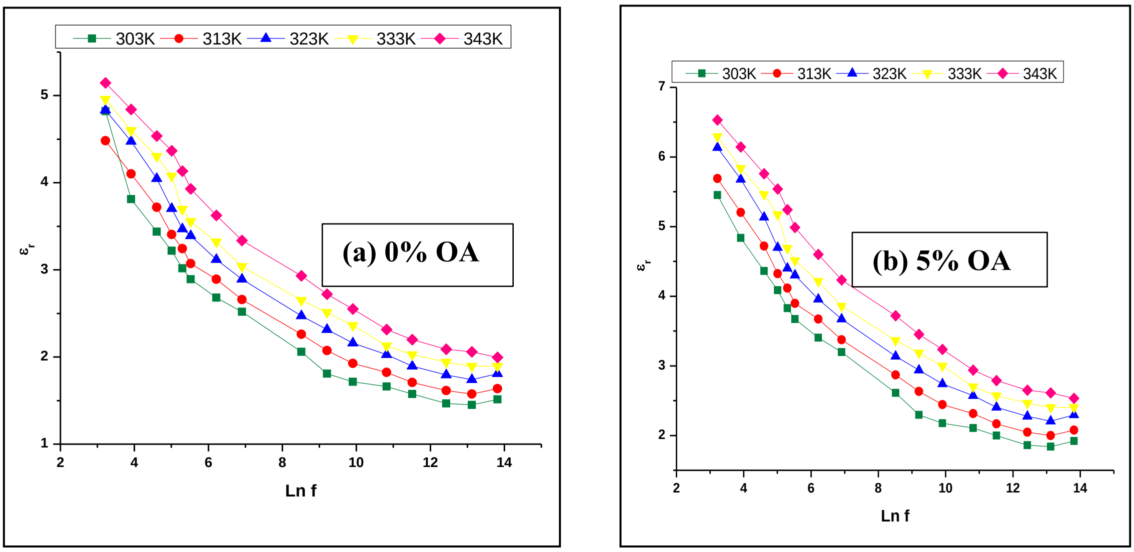

Figure 1 (a-b): Variation of ε_r with Ln f at different temperatures for 1:1 EC-PMMA System

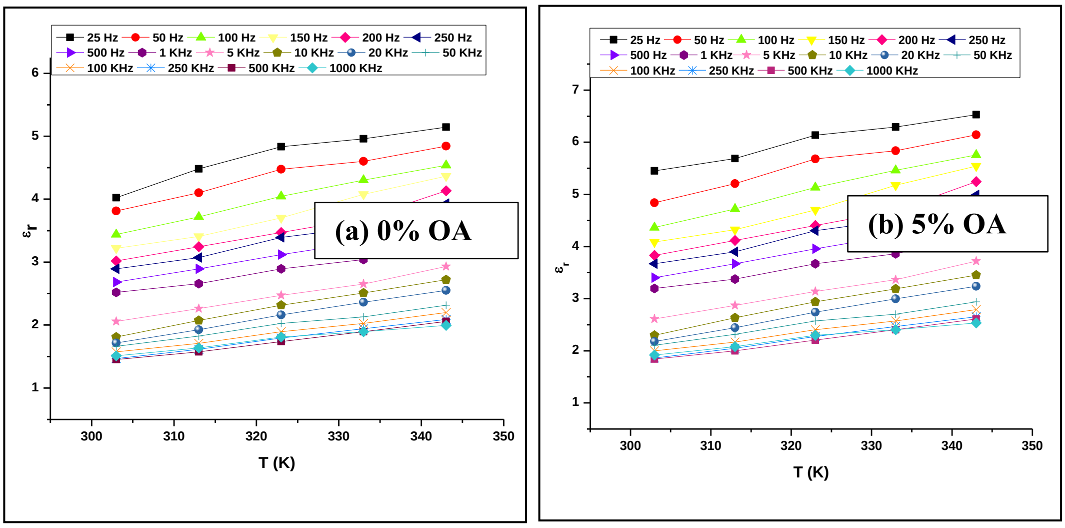

Figure 2 (a-b): Variation of ε_r with T(K) at different frequencies for 1:1 EC-PMMA System

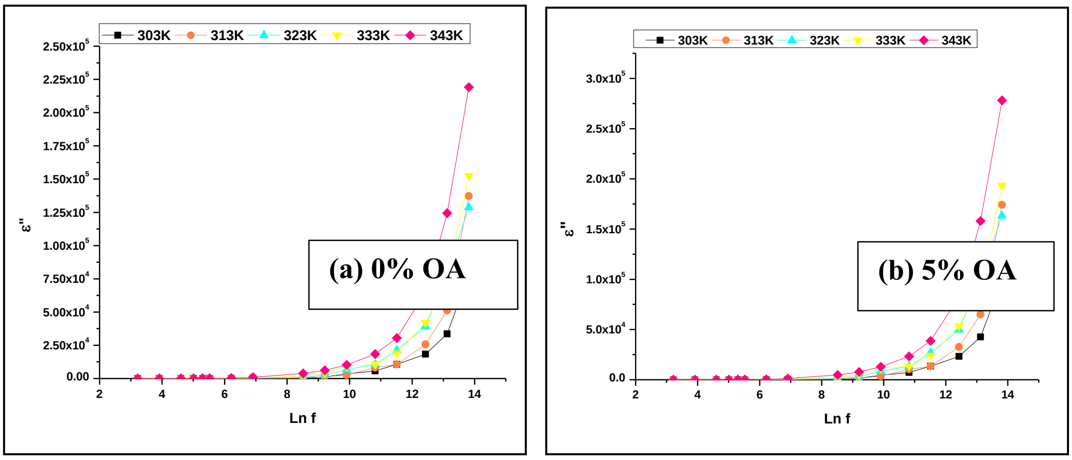

Figure 3 (a-b): Variation of ε" with Ln f at different temperatures for 1:1 EC-PMMA System

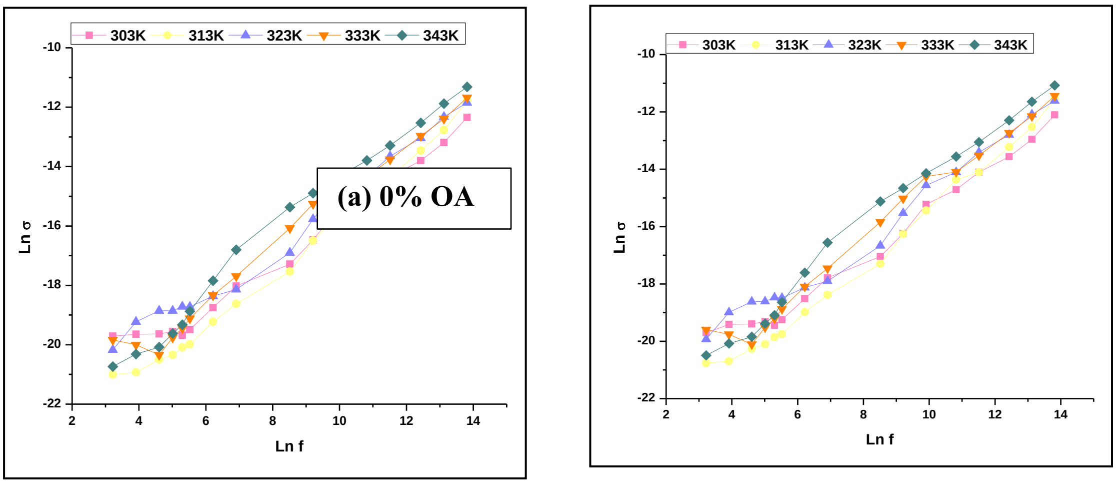

Figure 4 (a-b): Variation of Ln σ with Ln f at different temperatures for 1:1 EC-PMMA System

In the present study, Dielectric loss tangent (tan δ) represents the energy dissipation in the material. From the fig. 3 (a-b), it was observed that the dielectric loss increased with temperature, indicating higher charge carrier movement at elevated temperatures. However, at very high frequencies, the dielectric loss decreased due to a lack of sufficient time for dipole reorientation. Also, AC conductivity of Ethyl Cellulose (EC), Poly Methyl Methacrylate (PMMA) and their blends increase with the increase of frequency as shown in fig. 4 (a-b) [9,10].

4. Conclusion

In the present study, thin films of both samples were prepared by Isothermal Evaporation Technique having different thicknesses.

The dielectric constant of EC-PMMA blends measured at different temperatures are depicted in various figures. It has been seen that there is increase of dielectric permittivity with the percentage of dopant. The dielectric constant and loss measurements on the blends reveals insight into the material. The blends exhibit high dielectric constant at low frequency within the studied temperature range. As frequency increases, permittivity drastically decreases.

The AC electrical conductivity of Ethyl Cellulose (EC), Poly Methyl Methacrylate (PMMA) blend doped with Oxalic Acid (OA) is increasing with increasing frequency of applied electric field. Dielectric constant and AC conductivity of 5% of Oxalic Acid doped in EC-PMMA blend is greater than the 0% of Oxalic Acid doped in EC-PMMA blend.

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