VOLUME - 10, ISSUE - 12, DECEMBER - 2021 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper Engineering STUDY OF AC/DC CONDUCTIVITY OF POLY VINYL CHLORIDE PVC AND EC, EC/PVC CONDUCTION MECHANISMS RESPONSIBLE FOR THE CONDUCTIVITY Ph.D. Scholar, Vidyabharati Mahavidyalaya, SGBAU Amravati, **R.S. Bhuyar** Maharashtra, India. Assistant Professor, Department of first year Engineering, Sipna College of S.D. Kharbade\* Engineering and Technology Amravati, Maharashtra, India. \*Corresponding Author Assistant Professor, Shri Shivaji Science College Amravati, Maharashtra, N.R. Welekar India. The current work investigates the AC and DC conductivity constant of PVC and EC samples (3:1) at many ABSTRACT constant temperatures in the frequency range (323K to 363K). The findings were presented in graph form.

The dielectric constant increases with temperature increase at constant frequencies, Dielectric constant decreases with frequency increases, and AC conductivity increases with frequencies at different constant temperatures. The frequencies reach almost saturation values as the ultimate 1MHz value reaches. The AC conductivity increases with the increase in frequency has been observed.

**KEYWORDS :** Solution cast method'; percentage of amorphousness/crystallinity; 3:1 (PVC+EC); AC conductivity; dielectric constants; etc.

# INTRODUCTION

When two or more polymers are mixed, poly-blends or polymer alloys are obtained. This physical mixing or blending of two polymers produces alloys with quite different properties, which can be potentially useful. Two polymers are generally incompatible as they have very low combination entropy of mixing for the components. This is insufficient to overcome the positive heat of mixing of polymers to make the Gibb's free energy of mixing negative. Only when two polymers are interacted directly Mixing heat is adverse, which allows independence of mixing energy to become a negative quantity, and then random mixture (e.g., hydrogen bonding, acid-base type interaction etc).

In comparison to combining small molecules, the dictum is not good for merging macro molecules like likes. However, industrially important materials are both compatible and incompatible blends. The compatible blend, that exists in one step, can form two polymers. On the other hand, the incompatible mixtures occur in two steps. Since most blends combine immiscible materials, the resulting material includes minute particles of one polymer in the other matrix. Regulated mixing and refraction of the mix allows for the optimal concentration and sizes of particles to be formed. Blending allows the positive characteristics of many polymers to be blended. Mixing two-part polymers in the molten state is the most direct way to obtain a polymer (melt mixing). The magnitude of the mixing in this case depends on how far the molecules are spreading. Because such a combination takes high temperatures, the polymer can decompose and change chemicals.

# **Experimental Technique**

# PVC-EC undoped process of preparing the film mixes:

The choice of materials in any research project is governed by several theoretical as well as practical considerations such as their physical and chemical properties, cost and availability, the range of applications, their suitability and compatibility under the laboratory conditions. PVC and EC are among the extensively studied polymers owing to their unique insulation and other important characteristics such as transparency, low cost, easy availability and wide range of applications.

The present work aimed at study of AC/DC conductivity of poly vinyl chloride (PVC), EC., EC/PVC Conduction mechanisms responsible for the conductivity will also be studied.

### • Preparation of thin film using pool of mercury

In the present work, Isothermal evaporation technique (Sangawar and Adgaonkar 1995) has been used. The two polymers PVC and EC were taken in the ratio 1:1 was dissolve in a common solvent Tetrahydrofuran (THF). The solution was kept for 3-4 days to allow polymers to dissolve completely to yield uniform solution.

A glass plate (15X15 cm) thoroughly cleaned with water and later with acetone was used as substrate. To achieve perfect leveling and uniformity in thickness of films, a pool of mercury was used finger given below in a plastic tray. The solution was poured on glass plate and allowed to spread uniformly in all direction on substrate. The whole assembly was placed in a dust free chamber at room temperature. The solvent in the solution was thus allowed to evaporate completely and get air-dried. The film on the glass substrate was then removed and cut in to small pieces suitable sizes. In this way the films were prepared by isothermal evaporation technique. Further it was dried for three days to remove any traces of solvent.



#### Thickness Measurement

Direct Measurement (Screw gauge)

This method (Mehendru et.al 1981) is particularly important for measuring the thickness of the films which have been prepared using two or more components and may be conveniently used with minor approximation for the films having thickness above  $50 \mu m$ .

The micrometer screw gauge having the least count 0.001 cm= 10  $\mu$ m is readily available. For the material such as polyblends whose dielectric constant ( $\epsilon$ r) or density ([]) are not reported in the standard literature, this method assumes special significance.

In present research, the thickness of each sample film was measured at the four different places by using the digital micrometer. The average of four reading was taken as sample thickness.

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### Fig.2 Digital Micrometer Electrode Coating

For coating the silver electrodes, the method employed by Bahri and Sood (1983), Zakaria (1991), Rangaswami et. *al* (1993) and Sangawar (1995) has been employed. In this method, a highly conductive, quick drying silver paint is applied on both sides of the sample by using a fine brush, The same method is use here, the sample films were coated on both sides by a quick drying silver paint and allow to dry for 3-4 hours at room temperature. To achieve uniformity of area, a mask of circular aperture 2.5 cm was used while applying silver paste with fine brush.

#### Equipment used:

### 1. Sample Holder for DC conductivity Measurement:

A sample holder was fabricated in the laboratory as shown in fig. no. It has brass electrode of equal diameter 2.4 cm. The lower electrode remains fixed with assembly, while the upper on can be move vertically up or down. The electrode surface were perfectly smooth and cooled established perfect electrical contact with the silver electrode paints on the sample films.



Fig.3 Sample Holder for DC conductivity Measurement

# 2. Sample Holder for AC conductivity and dielectric constant measurement

The sample holder was supplied with the furnace as shown in the figure. It has two gold electrodes, the lower electrode remain fix with assembly, while the upper one can be move vertically up or down. The electrode surface with perfectly smooth and could established perfect electrical contact with silver electrode paints on the sample films.



Fig.4 Sample Holder for AC conductivity and dielectric constant measurement

# Power Supply

Electronically Regulated Power Supply (EHT-11 supplied by Scientific Instruments and Services, Roorkee) has been used as  $\alpha$  voltage source. It consists of a stable power oscillator whose output is controlled by an input signal and this output is boosted with the help of a step-up transformer and then rectified and filtered. There is a built-in protection against accidental overloading. The instrument has output 0-1500V continuously adjustable with polarities as required, stabilization  $\pm$  0.02% for  $\pm$ 10% main variation and a digital display. The output can be connected to the circuit through Amphenol connector on the front panel. Its power requirement is 220 V  $\pm$ 10%, 50 Hz.

# KEITHLEY (Model 6487)

The model 6487 is high resolution bus programmable (RS-232 and IEEE-488) pico-ammeter. The model 6487 has the following current measurement ranges from 20 meter down to

the 2nA range. This model also includes  $a_{-}$  + 500V DC voltage source and an ohm's function that includes an alternating voltages mode to improve accuracy and repeatability of very high resistance measurement.



# Fig. 5 Keithley (Model 6487)

#### LCR Meter:

The AC conductivity and Dielectric constant were measured using 4284A Precision LCR meter (20 Hz-1MHz) supplied by Agilent technology Singapore.

![](_page_1_Picture_22.jpeg)

#### Fig.6 LCR Meter

In conjunction with a Precision LCR (20 Hz-1MHz) of 4284 A supplied by Agilant Technology, Singapore was used to test AC electrical conductivity and dielectric constant in the form of a thermal operated electrical oven supplied by Pushpa Scientific, Hyderabad.

Fig.3 LCR meter and sample holder for the measurement of AC conductivity

The film sample was loaded into the sample holder in an oven. The entire experimental set up is as shown in fig 6. The AC frequencies were applied (in the range 1 KHz -1 MHz) across the sample by using the 4284 A precision LCR meter (20 Hz -1 Mhz). The corresponding dielectric constants were measured by using LCR meter. From the dielectric data, the AC conductivity of the samples was calculated by using the relation [Rao, 2000],

$$\sigma_{ac} = \frac{f \cdot \varepsilon_r \cdot tan(\delta)}{1.8 \times 10^{10}}$$

Where,

$$\begin{split} f &= Frequency applied in Hz \\ r &= Dielectric Constant at frequency f \\ tan(\delta) &= Dielectric loss tangent. \end{split}$$

#### **RESULTS AND DISCUSSION**

Several investigators have researched electrical conduction / dielectric properties of different polymers composites [Shukla and Gupta 1987, Aziz and Aggour 1999, Khaled et al. 2003, Raghvendra et al. 2003, Muhammad Akram 2005.] The present work investigates a constant and reliable dielectric conductance of 1:3 EC-PVC blend sample at different constant temperatures (323K to 363K) and in the frequency interval (1KHz to 1MHz). The findings were shown. The following criteria have been discussed.

1) Dielectric constant (Er)

2) AC electrical conductivity (oac)

#### 1) The Dielectric Constant (Er)

- I) Increases with temperature increases
- ii) Decreases when the frequency is increased.

#### 2) The AC conductivity (σαc)

- increases at different constant temperatures almost linearly with frequency over 1KH and almost constantly saturates the frequency when the maximum value is 1MH.
- ii) The changes in temp between 323K and 363K tend to be almost continuous at a constant frequency.

Graphs Related To Ac Conductivity Study For 1:3 Ec/pvc For Blend System

Variation of Temperature with dielectric constant of EC/PVC The film of polyblend Ethyl Cellulose and Poly Vinyl Chloride (PVC) at the ratio of 1:3 has been prepared, DC conductivity has been measured on Kathley device. Dielectric constant against the frequency at different temperature has been studied. The results shows that (Fig.7.1), the dielectric constant is varies at different temperature in same proportion i.e. as temperature increase the dielectric constant also decreases. It is markedly affected by various temperature ranges , dielectric constant is inversely proportional to temperature i.e. as the temperature increases the dielectric constant decreases. The highest dielectric constant is recorded at lowest frequency of 7 KHz. It start decreasing from 7KHz to 8.5 KHz after it was stable upto the frequency level of 14 Khz

![](_page_2_Figure_3.jpeg)

#### Fig.7.1

Variation of conductivity with frequency at different temperature of EC/PVC

The conductivity of pure EC/PVC studied at different temperature against the different frequency range. The result shows that (Fig.7.2) the conductivity is Mark-ley increases as the frequency increases up to 12 KHz however it remains more or less stable up to 14 Khz.

![](_page_2_Figure_7.jpeg)

#### Fig.7.2

# Variation of conductivity with temperature at different frequency of EC/PVC

The film of polyblend EC/ PVC at the ratio of 1:3 has been prepared; AC conductivity has been measured on LCR Meter. Conductivity against the temperature at different frequency has been studied. The results show that (Fig.7.3), the conductivity increases as frequency increases. It is not significantly affected by various temperature ranges.

![](_page_2_Figure_11.jpeg)

# Fig.7.3

Variation conductivity with frequency at different temperatures of EC/PVC

The Dielectric Constant of pure EC/PVC studied at different frequency against the different temperature range. The result shows that (Fig.7.4) the Dielectric Constant is affected by frequency. The Dielectric Constant is increases as the temperature increases, up-to 335 K, however it decrease and shows stable pattern up-to 355 K. But there is make-able difference in the frequency range of 1 KHz and other higher frequency level.

![](_page_2_Figure_15.jpeg)

### Fig.7.4

Fig.7.5

Several investigators have researched electrical conduction / dielectric properties of different polymers composites [Shukla and Gupta 1987, Aziz and Aggour 1999, Khaled et al. 2003, Raghvendra et al. 2003, Muhammad Akram 2005.] The present work investigates a constant and reliable dielectric conductance of 4:1 PVC-PMMA blend sample at different constant temperatures (323K to 363K) and in the frequency interval (1KHz to 1MHz). The findings were shown. The following criteria have been discussed.

### GRAPHS RELATED TO DC CONDUCTIVITY STUDY FOR 1:3 EC/PVC FOR BLEND SYSTEM

# Variation of conductivity with temperature (Arrhenius Plots) at different voltages for EC/PVC

The film of polyblend Ethyl Cellulose and Poly Vinyl Chloride (PVC) at the ratio of 1:3 has been prepared; DC conductivity has been measured on Kathley device. Conductivity against the temperature at different voltages has been studied. The results show that (Fig.7.5), the conductivity is varying at different temperature in same proportion i.e., as voltages increase the conductivity also decreases. It is markedly affected by various temperature ranges, conductivity is inversely proportional to temperature i.e., as the temperature increases the conductivity decreases. The highest conductivity is recorded at lowest temperature of 27 K at the voltage range of 700 V and 800 V. and decreases at 31 K at same voltage range. However, there is significant difference in the decrease conductivity at voltage range of 100-600V as compared to 700-800 V.

![](_page_2_Figure_21.jpeg)

Variation of Current with Voltage at different temperature of blend of EC+PVC DC conductivity has been measured on Kathley device. Current against the voltage at different temperature has been studied. The results show that, Fig.7.6 the current directly proportional to temperature i.e., as temperature increases the current increases against the voltage. The graph shows linear pattern. It reaches its peak level at 7 (V) where the current reaches its maximum at -12 (Amp) at the temperature of 373 K.

![](_page_3_Figure_2.jpeg)

#### Fig.7.6

Variation of Current Density with Electric field at different temperature for EC+PVC Current density against the increasing electric field has been studied at different temperature (Fig.7.7). The result shows that current density (J) increases as the electric field increases, however higher current density has been observed at highest temperature, as the temperature increases the current density increases. Current density reaches its highest peak at highest electric field i. above 3000 (V/m).

![](_page_3_Figure_5.jpeg)

Fig.7.7 Variation of Current density with Temperature at different voltage for EC/PVC

Current density against the temperature has been studied at different voltages (Fig.7.8). The result shows that current density (J) varies as the voltage increases against the temperature. The graph indicates that the current density increases at lower temperature i.e., 323 K, however it starts increasing as the temperature increases reaches its highest peak at 363 K and then again start decreasing at highest temperature i.e., 373 K.

![](_page_3_Figure_8.jpeg)

# Fig.7.8

# METHODS OF CHARACTERIZATION:

There are many techniques commercially available for the analysis of polymer opening up new possibilities for fundamental material research. In this section, I will encounter some methods for characterizing polymers and not discuss their capabilities and limitations that have been described in the literature. The following are the basic working principle of the experimental techniques used in this work for characterization.

#### X-ray Diffraction Study:

![](_page_3_Picture_14.jpeg)

X-ray diffraction technique is an unambiguous tool in the scientific and industrial work for checking and identifying the materials. Debye and Scherer in 1916 and Hull in 1917 first developed this method independently [1-3]. Peiser et al (1960) and Kaelble (1967) described in detail about the principle of X-ray diffraction method, which is described below.

In this method the material to be examined, is taken in a powder form, and it is kept at the center of the experimental arrangement. A fine beam of monochromatic X-ray is allowed to fall on the specimen. The specimen in a powder form is equivalent to crystallites oriented randomly in all possible directions with respect to the direction of incident X-ray beam. It is possible that some of the particles, oriented with their (h k l) planes, satisfying the Bragg's condition of reflection i.e. 2d  $\sin = n$ , reflect X-rays in the direction of with respect to the incident direction. Every particle of powder is equivalent to a single crystal. Thus for the powdered sample, all the possible orientations with respect to axis are present. If a particular plane is rotated about the axis taken in the direction of incident beam, such that is kept constant, then that reflected plane forms a cone as shown in Fig. 3.1a. The rotation of plane does not occur in the powder method, but the presence of large number of crystals, particularly having all possible orientations, is equivalent to rotation.

![](_page_3_Figure_17.jpeg)

Formation of diffraction cone of radiation in the power method

### XRD of pure EC/PVC blend system

![](_page_3_Figure_20.jpeg)

# CONCLUSIONS

- With temperature growth at constant frequencies, the dielectric constant increases
- 2) The dielectric constant decreases with constant frequency

decreases in temperatures

- The AC conductivity increases at different constant 3) temperatures with frequencies
- The frequency exceeds its highest value and hits almost 4) saturation values.
- The dielectric constant in the temperature range does not 5) differ greatly.

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