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DIELECTRIC PROPERTIES OF AMLA POD POWDER AND ITS POLYMER COMPOSITES OF POLY VINYL ALCOHOL

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ABSTRACT

Polymer composites of PVA with APP for different weight percents have been used for measurement of dielectric constant, dielectric loss and ac conductivity as a function of frequency at 1 KHz as well as function of temperature. The Dielectric constant as well as the dielectric loss values of the polymer composites increases as weight percent of APP increase with decrease of Poly Vinyl Alcohol substance. In case of different weight percent, it has been observed that the ac conductivity value increases exponentially and that studied fixed frequency for 1 KHz at independent temperatures. Further the measurement of XRD spectrum in XRD peak showing high value of intensity for pure then PVA with APP.

Keywords: Dielectric permittivity, Polymer composite, dielectric loss, ac conductivity.

I. INTRODUCTION

Polymeric materials are generally insulating or nonconductive materials in nature and normally used in electric and electronic applications as insulators, but likely to accumulate the electronic discharge. The composites are the wonder materials which are an essential part of today's materials due to the advantages such as low weight, corrosion resistance, high fatigue strength, and faster assembly. They are extensively used as materials in making aircraft structures, electronic packaging to medical equipment, and space vehicle to home building [1]. The composites offer unusual combinations of materials properties such as weight, strength, stiffness, permeability, electrical, biodegradability and optical properties that is difficult to attain separately by individual components [2]. Polymer composites are physical mixtures of two or more structurally different polymers or copolymers which interact through secondary forces with no covalent bonding that are miscible at molecular level. The basis of polymer-polymer miscibility may arise from any specific interaction, such as hydrogen bonding, dipole-dipole forces and charge-transfer complexes for homopolymer mixtures [3,4].

Polyvinyl alcohol was first prepared by Hermann and Haehnel in 1924 by hydrolyzing polyvinyl acetate in ethanol with potassium hydroxide. Polyvinyl alcohol is produced commercially from polyvinyl acetate, usually by a continuous process. Polyvinyl alcohol is an odorless and tasteless, translucent, white or cream colored granular powder. It is soluble in water, slightly soluble in ethanol, but insoluble in other organic solvents [5].

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The dielectric behavior of PVA is incorporated that acts as host material in the semi conducting composite polymer containing PVA. The development of dielectric materials for applications in communication systems such as substrates, cellular phone, etc. has been rapidly progressing in the past few years [Wolfram and Gobel Mater 1981]. The PVA composites materials with improved electrical properties may offer a viable alternative for the applications to than conventionally nano filler filled PVA materials. [Archana Nigraval *et al* 2011]. There is no paper in the literature on electrical properties of Amala pod powder-PVA composites. In this study of characterized for their electrical properties.

Amla (Emblica officinals) is a native of India, Ceylon and China. The fruit of amla is used in several Ayurvedic medicines such as Chyavanprash and Rasayana which promotes health and longevity [6]. Amla is one of the most important foods in Ayurvedic medicine with an incredible list of health benefits. The benefits of amla are also believed to include improving liver function. Amla is even said to be good for your appearance, improving skin tone, protecting the eyes, preventing hair loss and gray hairs and aiding in weight loss. Amla juice is a natural rich source of energy, very Rich with Vitamins "C", and minerals. Amla juice increases red blood cell count and hemoglobin percentages, and patients started their anabolic phase (metabolic processes involved in protein synthesis) sooner. It is especially valuable in seasonal cough and cold. Amla is also useful in recurrent respiratory infections such as tonsillitis, sinusitis and sore throat [7].

The dielectric constant is associated with the ability of a material to store electrical energy in the presence of an external electric field while the loss factor is the dissipation of energy in the form of losses [8]. The mechanisms that contribute to the dielectric loss in heterogeneous mixtures include polar, electronic, and atomic Maxwell-Wagner responses [9]. The first data on the dielectric constant and dielectric loss of grain are reported by Nelson *et al,* [1953]. Many researchers also have been reported the dielectric properties of agro-products, such as grain seeds or grain flours [Nelson 1983]. The moisture-dependent dielectric properties in specific frequency ranges can be used to develop online moisture meters [10].

II. EXPERIMENTAL MEASUREMENTS

This chapter deals with the experimental measurements of Capacitance, Dissipation and $\tan\delta$ to study the dielectric properties and AC conductivity as a function of frequency as well as function of temperature for the polymeric materials of Polyvinyl Alcohol (PVA), and also for the samples of Amla pod powder (APP) at different thicknesses.

2.1 Preparation of Sample

2.1.1 Amla powder

The Amla Pod Powder (APP) is obtained from the pods of a Phyllanthus emblica plant a tree species that belongs to the native of India, Ceylon and China. [11,12]. The APP molecular formula is $C_4H_8O_2$ .The Amla pods collect Bhalki surrounding from , Karnataka which are shown in Fig 2.1.


Fig. 2.1 The pods of Phyllanthus emblica tree (Amla) and different pieces for samples of dried Amla Pod.

The dried Pods are gently opened and a brown colour powder is poured into a petri dish and has been grinded properly. The different quantity of substance such as 100 mg, 200 mg, 300 mg, 400 mg, 500 mg, 600 mgs 800 mg 900 mg and 1000 mgs of grinded Amla Pod powder (APP) is weighed using a single pan balance with an accuracy ± 0.0001 gm. The pellets of the APP substances have been prepared by applying 2-3 tons of pressure using a hydraulic pellet making machine (model : 4 RDL 02 HPTGD -03 Polyhedron 05708)

2.2 Preparation of polymer and their of composites for dielectric measurement

We have selected polymeric materials such as Polyvinyl Alcohol (PVA) is semi-crystalline, water soluble, with low electrical conductivity polymer are obtained from the Sd Fine Chemicals, Mumbai. It has certain physical properties resulting from crystal–amorphous interfacial effects. It is a potential material having a good charge storage capacity and dopant-dependent electrical properties. The structural formula for the PVA is given in Fig. 2.2.

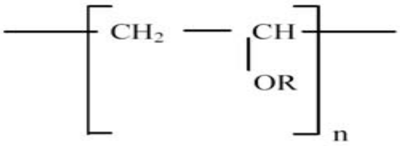

Fig. 2.2 The chemical structure of PVA

2.2.1 Preparation of Polymer composites of PVA with APP

A 1 gm substance of the APP have been weighed using the single pan balance and a pellet of thickness 6.5 mm have been prepared using Pellet making machine at a pressure of 2-3 tons. The PVA was mixed with the APP at different weight percentages such as 50 and 90 to prepare the polymer composites of PVA with APP. The polymer substance of 500 mg of PVA was dissolved in distilled water to get the supersaturated solution, then physically mixed with 500 mg substance of the APP after grinding for a period of 4 hours in a crucible for proper mixing of these substances, to make a polymer composites of 50:50 weight percent in total substance of 1 gm The substance was mixed with distilled water by continuous stirring with magnetic stirrer for 4 hours. The freely suspended particles of APP were settled at the bottom of the container or glass beaker after 1 hr. The

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substance was filtered using filter paper and dried by keeping in a woven for 1 hr at temperature of 40 ^{0}C. The dried 50:50 weight percent of PVP with APP substance was used for preparation of pellet of thickness 3.14 mm by using pellet making machine. Similarly the other pellets of polymer composites of PVA with APP at 90 weight percent of APP for corresponding thickness of 6.35 mm have been prepared. Thicknesses of the pellets of above samples have been measured using screw gauge. A silver paste was coated on either side of surface of the pellets for Ohmic contacts to provide an electrical connection.

III. RESULT AND DISSCUSION

In this chapter the experimental measured results have been discussed and analyzed for the dielectric properties such as dielectric constant, dielectric loss, ac conductivity for the sample for PVA and amla pod powder (APP) together with as function of frequency, for various thicknesses at different temperatures. The measured data of capacitance and dissipation given in previous chapter have been used for determination of dielectric constant, dielectric loss, A C conductivities, for the above mentioned samples and their composites as function of frequency as well as temperature at various thicknesses. The prepared samples have been characterized using XRD for analyzing the crystalline/ amorphous nature and the functional groups of the polymer composites respectively. The detailed discussions and analysis for characterization and physical properties of the above samples have been given as follows.

3.1 Xrd Spectra

The XRD patterns of intensity verses angle of 2Θ for PVA and 50 wt% APP doped. The spectra of X-ray diffraction pattern for the prepared samples have been recorded individually by the X-ray diffractometer. The X-ray radiation source used was Cu K_α (λ= 1.542 A^o) with 2θ values at the rate of 2^o/min. The particle size *(D)* could be easily estimated using the Debye Scherrer formula given by

$$D = \frac{K\lambda}{\beta \cos\theta} \qquad (3.1)$$

Where K (= 0.9) is constant, λ is wavelength of X-ray source, β is FWHM and θ is the diffraction angle.

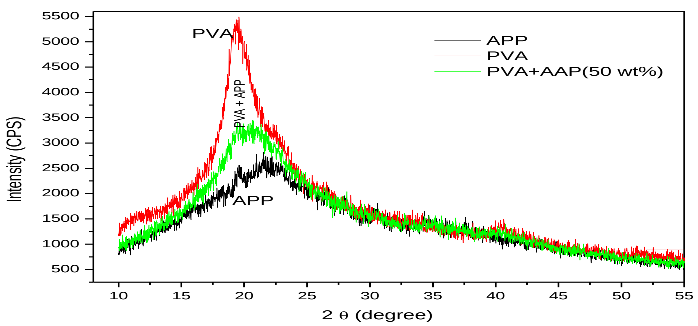

Fig. 3.1 XRD spectrum for the sample of Pure PVA, APP and PVA with 50 wt % of APP.

The XRD spectrum of PVA, APP and PVA with APP sample is given in Fig 3.1. It is seen that high intensity sharp peak for PVA (Corresponds to 5434.8 cps) is observed at a Bragg angle (2Θ) of 19.5^0 and the high intensity sharp peak for APP (corresponds to 2796.9 cps) is observed at an angle of 21.5^0 and the high intensity sharp peak for PVA with APP (corresponds to 3298.98 cps) is observed at an angle of 20.6^0 The particle size *(D)* could be easily estimated using the Debye Scherrer formula in equation (3.1).

The XRD spectrum of PVA sample is given in Fig 3.1. The appearance of broader and diffused peak indicates that sample of PVA has crystalline in nature. The PVA particle size is 3.908 nm, 0.587 nm APP and the size of particle 1.3267 nm PVA with APP which is obtained with the help of equation (3.1). Which are comparable to our measurements and confirms that PVA has semi crystalline nature. The XRD pattern of pure PVA shows a characteristic peak for an orthorhombic lattice cantered at 20° indicating its semi crystalline nature [13,14]. The peaks have resulted from the part of crystallinity in PVA polymer molecules. This crystallinity is the result of strong intermolecular and intra molecular hydrogen bonding between the PVA molecular chain [15, 16].

3.2 Dielectric Properties

In this section the dielectric permittivity as function of frequency for the samples of APP and their composites such as PVA with APP, for various weight percentages as well as at different temperatures have been studied and analyzed. The values of dielectric permittivity are obtained with the help of the experimentally measured data of capacitance given in previous chapter and using the Equation given by

$$\varepsilon' = \frac{c\,d}{\varepsilon_o A} \tag{3.2}$$

Where *C* is the capacitance (pF), *d* is the thickness of the sample, *A* is the surface area of the sample and ε_0 is the absolute permittivity of free space (8.854 x 10^{-12} *F/m*). Using the above expression, the dielectric constant (ε') of the polymer sample was calculated. The details for analysis of Dielectric properties of individual samples are discussed below.

3.2.1 Dielectric properties of APP and polymer composites of PVA with APP sample

The dielectric permittivity as function of frequency over a range of 50 Hz -1 KHz at different temperatures for the samples of Amla Pod Powder (APP). The plots of dielectric constant versus different temperatures at function of frequency for sample of APP for thickness of 6.5 mm are given in Fig. 3.2. In case of dielectric constant as temperature dependent, it is observed from Fig 3.2 that at temperature 313K for fixed frequency the dielectric constant of the APP decreased at frequency range of 1 K Hz, afterwards it decreased gradually and remains constant at higher temperature. The same behavior has been observed in variation of values of dielectric constant at other temperatures for APP of 300 K, 320 K, 340 K and 340. Further it is observed that as temperature of the sample of APP increased the values of dielectric constant are also increased at lower frequencies in the range of 1 K Hz for all the temperatures, but at higher temperature the values of dielectric constants remains constant.

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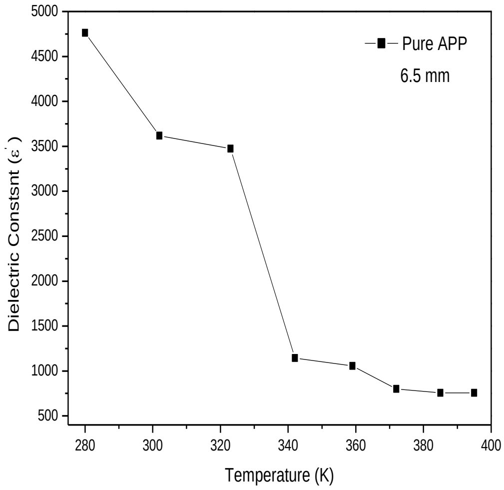

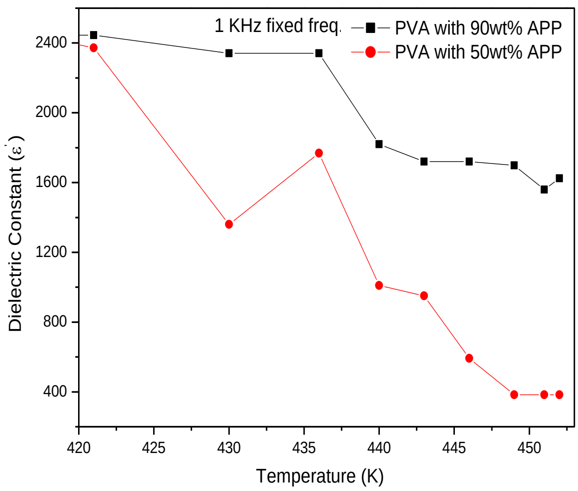

Fig. 3.2 The APP of Dielectric Constant Versus Different Temperature. Fig. 3.2.1 The Plots of Dielectric Constant Versus Function of at fixed frequency. Temperature for composites of PVA with APP.

The low frequency region, the dielectric constant is high for temperature at 280 K and less for temperature at 372 K. At lower frequencies, the dipoles could be easily switched for alignment as the field changes. But as temperature increases, the dipoles are less able to rotate and maintain phase with the applied field, thus they reduce their contribution to the polarization hence the dielectric constant decreased [17].

It is observed from Fig 3.2.1 that as frequency increased the dielectric constant of the polymer composites of PVA with APP decreased at lower frequency range 1 K Hz, afterwards it decreased gradually and remains constant at higher temperature. The temperature of 437 K shows a small peak or hike in dielectric constant at 90 wt% of APP with PVA. The same behavior has been observed for the other polymer composites as temperature increased for the polymer composites of other weight percentages. Further it is observed that lower frequency as well as weight percentage of PVA with APP increased the values of dielectric constant are increased for PVA with APP at 90 wt% comparing to other wt. percentages.

It is evident from this figure that dielectric constant decreased with increasing the temperature at function of frequency. This is due to dielectric relaxation which is the cause of anomalous dispersion. From a structural point of view, the dielectric relaxation involves the orientation polarization which in turn depends upon the molecular arrangement of dielectric to be material [Smyth *et al* 1995].

3.3 Measurement of dielectric loss

In this section the dielectric loss as function of frequency for the samples of APP and their composites such as PVA with APP for various weight percentages at different temperatures have been studied and analyzed. The values of dielectric loss (ε'') are obtained with the help of the experimentally measured data of dissipation factor given in previous chapter and the values of dielectric permittivity using equation given by

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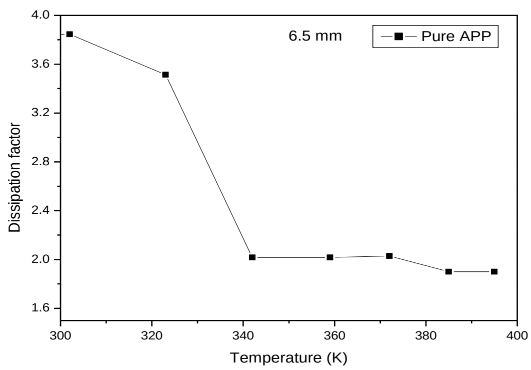
$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} \qquad (3.3)$$

Where ε'' is the imaginary part of the permittivity and ε' real part of the permittivity and $\tan\delta$ is the loss factor. The details of analysis for properties of dielectric loss of the above samples are given as follows.

3.3.1 Dielectric loss in APP and PVA with APP sample

The dielectric loss as function of frequency over a range of 50 Hz – 1 KHz at function of temperature for the samples of APP at different thicknesses are obtained using the experimental measured data of dissipation factor and values of dielectric constant with the help of equation (5.3). Further, the plots of dielectric loss versus temperatures for APP of thickness 6.5 mm are given in Fig. (3.3).

It is observed from Fig. (3.3) that, the sample of APP at thickness of 6.5 mm, as frequency increased the dielectric loss gradually decreased exponentially at frequency range from 1 K Hz, afterwards it drastically decreased and remains constant at higher temperature. Further it is observed that at lower frequencies up to 1 K Hz, the dielectric loss of the APP is decreased and afterwards the dielectric loss remains constant. When an electric field is applied to the materials, due to the long range drift of ions and barrier layer formation on the electrode surface results the large value of dielectric loss [Sengwa and Sonu 2008]. The dielectric loss, in case of temperature dependent, it is observed from Fig. (3.3) that as frequency increased the dielectric loss of the APP decreased gradually at lower frequency range from 100 Hz to 1 K Hz. However, at frequency of 1 KHz the dissipation factor decreased suddenly, afterwards it decreased gradually and remains constant at higher temperature. In lower frequency region more energy is received for electron exchange during any oxidation, thus the energy loss is high. In the high frequency region, a small energy is needed for electron transfer during the oxidation hence the energy loss is small [18].



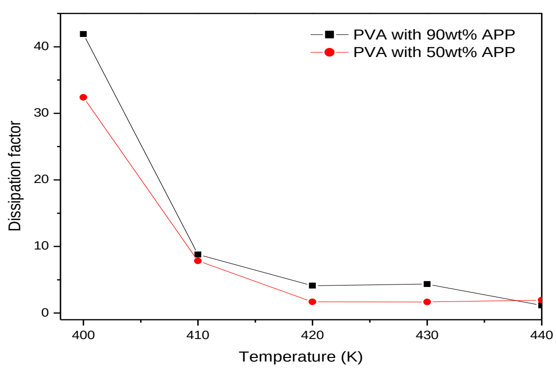


Fig 3.3 The APP Of Dielectric Loss For Different Fig. 3.3.1 The Plot Of Dielectric Loss Of PVA And Its Polymer Composites With Temperatures As Function Of Frequency. APP for Different Wt% at 6. 35 M m and 3.21 Mm.

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The dielectric loss for the polymer composites of PVA with APP at 50 and 90 weight percentages are studied as function of frequency at 1 KHz at different temperatures for the polymer composites of PVA with APP are obtained using the experimental measured data of the dissipation and dielectric constant with the help of equation (3.3). The Plots of dielectric loss versus function of temperatures for the polymer composites of PVA with APP at different weight percentages are given in Fig 5.4. It is observed from Fig. 5.4 that as frequency increased the dielectric loss of the polymer composites of PVA with APP decreased abruptly at lower frequency range 1 KHz, afterwards it decreased gradually and remains constant at higher temperatures. Further it is observed that the frequency 1 KHz, as weight percentage of PVA with APP increased at 10 weight percentages of PVA the dielectric loss is decreased and then increased, hence it showed oscillatory behavior. While the decreased of dielectric loss value with increasing applied frequency is attributed to the insufficient time for dipoles to align before the field changes direction [Chandrakala *et al* 2012].

3.4 Measurement of Electrical Conductivity

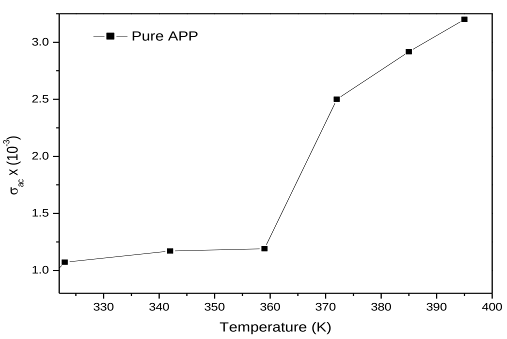
The A C electrical conductivities have been studied and analyzed for the polymers and their composites in this section. The ac conductivity as function of frequency for the samples of APP and their composites such as PVA with APP for various weight percentages at different temperatures have been studied and analyzed. The values of ac conductivity as function of frequency are obtained with the help of the experimentally measured data of dissipation factor and the dielectric constant using the Equation given by

$$\sigma_{ac} = \varepsilon' \varepsilon_o 2\pi f \tan\delta \qquad (3.4)$$

Where ε_o is the permittivity in free space, ε' is dielectric constant, f is the frequency and $\tan\delta$ is the loss factor.

3.4.1 Measurement of A C conductivity for APP and PVA with APP

It is observed from Fig 5.4 that ac conductivity of APP remains constant up to 360 K temperature and afterwards ac conductivity increased exponentially as temperature also increased. The AC conductivity of the APP decreased suddenly at lower frequency range of 100 Hz - 1 KHz, afterwards it decreases gradually and remains constant at 1 KHz frequencies.



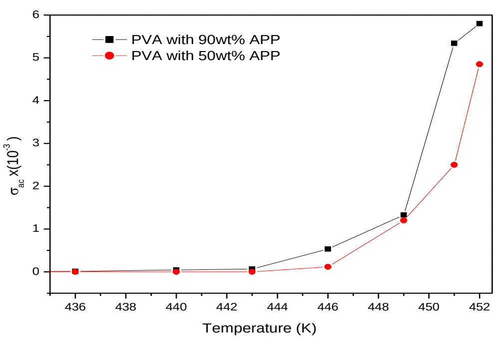


Fig. 3.4 the A C conductivity verses function of temperatures Fig. 3.4.1 The plot of ac conductivity of PVA and its composites with for APP at thickness of 6.5 mm.different weight percent of APP at thickness of 6.35 mm and 3.21 mm.

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It is observed from Fig 3.4.1 that as temperature increased the ac conductivity for the polymer sample of PVA with APP remains constant up to 443 K and afterwards it gradually increased as well as exponentially increased temperature. Here it is also noticed that as 90 wt% of APP increased compare the 50 wt% of APP and ac conductivity also increased at frequency of 1 K Hz onwards. In general, the defect centers and impurities that could contribute to the conductivity are randomly distributed in dielectrics and conduction is basically due to a hopping of electrons in the dielectric materials [19].

IV. CONCLUSION

The present study summarizes and concludes the findings of our investigations observed in the experimental measurements. Which are comparable to our measurements and confirms that PVA has semi crystalline in nature. The XRD pattern of pure PVA shows a characteristic peak for an orthorhombic lattice centered at 20° indicating its semi crystalline nature Sheng-Jian Huang *et al* [2005] and Kurumova *et al* [2000]. It is observed from XRD spectra that the appearance of broader and diffused peaks in the samples of APP indicates non-crystalline nature. The broader and diffused peaks indicate the non-crystalline or amorphous nature for the composites of PVA with APP.

Frequency and temperature dependence of dielectric constant (ε'), dielectric loss (ε'') and in pure APP and polymer composites with various Weight percent of APP has been studied in the frequency range 1 KHz and in the temperature range 280 K – 500 K. The experimental results indicate that ε' and ε'' gradually decreased at higher temperature. The low frequency region, the dielectric constant and dielectric loss is high at lower temperature. The higher values of dielectric constant at lower frequency arises due to the presence of space charge polarization near the grain boundary interfaces and due to the electronic exchange of the number of ions in the sample gives local displacement of electron in the direction of the applied field, which in turn give rise to polarization. In case of ac conductivity (σ_{ac}) of the pure APP and its polymer composites of PVA gradually increased at higher temperature in lower frequency region at 1 KHz. It is observed that the ac conductivity should be low for dielectrics to show a good response.

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