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DIELECTRIC PROPERTIES OF PARKIA POWDER AGAR

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ABSTRACT

The dielectric properties, a. c. and d. c. conductivities of Parkia Powder Agar (PPA) for different sample thicknesses have been studied as a function of frequency over the range 50 Hz – 5 MHz at room temperature. The characterizations for crystallinity of Parkia powder have studied using XRD. The morphological studies have been made using the SEM. The value of dielectric constant of PPA decreases gradually as thickness of the sample decreases. But as thickness of the sample increases the dielectric constant decreases exponentially over the frequency range 50 Hz to 10 KHz and afterwards it remains constant as frequency increases. This leads to the occurrence of changes in the properties of dielectrics of PPA as thickness of the sample increases. The a c conductivity of PPA remains constant over the frequency range 50 Hz to 300 KHz and afterwards the conductivity increases exponentially as frequency increases. Further it is observed that a c conductivity of PPA increases as thickness of the sample increases in the frequency range of 300 KHz to 5 MHz. The dielectric loss of PPA increases as thickness of the sample increases.

Key Words- Dielectric constant, Dielectric loss, XRD-characterization, Activation energy, D C conductivity

INTRODUCTION

The dielectric properties of polymer and its composites are dependent upon several factors, including of method of preparation, chemical composition, doping concentration and grain structure or size. Polymer composites have steadily gained importance during past one/two decades, because of the need for electrostatic charges, dissipation,
electromagnetic shielding etc. The electrical conduction in polymer film has much importance due to the discovery of the memory phenomenon[1] and currently has wide applications in thin film devices[2]. Electrical properties constitute one of the most convenient and sensitive methods for studying the polymer structure[3, 4]. The electrical properties of regenerated cellulose (cello phone) film were studied by others[5]. The current-voltage characteristics of malachite green doped cellulose acetate films[6], for the measurement of electrical conductivity, as function of temperature, field, thickness and dopant concentration have been studied. The present work evolved the ac and dc measurements of naturally occurring Parkia Powder Agar (PPA) material. The Parkia powder taken from the pods of a plant belongs to the subfamily Mimosoideae and family Leguminosae[7] is a tree species. In India, it is found in parks and as avenue trees. Pods attain maturity during March to May and hang from the peduncle in clusters. The Pods produce a creamy-white powder with flour-like texture. The PPA is a good source of ascorbic acid, fat, proteins and minerals. The pod contains minerals such as Ca (97.47mg/100g), K (2400), Cu (2.3), Zn (2.77), Fe (57.1) and Mn (35.0 mg/100g) reported by some other else[8]. The new substance named as Parkia Powder Agar (PPA) is used for the dielectric a c and d c measurements[9]. The conductivity has been explained usually in terms of electron from cathode i.e. Schottky-Richardson mechanism[10] or the electron libration from traps in the bulk of the material i.e. Poole-Frenkel mechanism[11].Frequency dependence of the dielectric behaviour of sample of PPA.[12] In most of their industrial applications, elastomers are used as Chemical materials.[13-14]

In present study of electrical properties of PPA is reported.[15-16] The change in dielectric relaxation intensity with t is therefore a function of the change in the dielectric constant at lower frequencies.[17-18] These material properties with desirable mechanical and physical characteristics.[19] The variety of technological applications such as solar cells, electromagnetic shielding, electrodes for rechargeable batteries, sensors, etc.[20] The broad peak is due to the scattering from PPA chains at the interplannar spacing.[21] Preparing PPA materials in which organic materials of H_2SO_4 for the Elemental anlysis.[22] A.C. electrical properties of high-frequency behaviour.[23-25]

EXPERIMENTAL MEASUREMENTS

The Parkia Powder Agar (PPA) is obtained from the pods of a leguminous plant. The dried pods collected from Gulbarga University campus. The Pods were gently opened and powder was poured into a Petri plate. The different weights such as 250, 300, 350, 400, 450 and 500 mgs of PPA substance was taken to make the pellets of different thickness in circular shape. The pellets of 10 mm diameter have been made by applying 2-3 tons of pressure using the pellet making machine with 10 mm diameter. Thicknesses of the pellets have been measured using screw gauge. The silver paste is coated on either side of the pellets for an Ohmic contact to provide the electrical connections for the measurements. The prepared samples of PPA are used to measure the capacitance, impedance, phase angle and dissipation to determine the dielectric constant (ε'), dielectric loss factor (ε") and a. c. conductivity as a function of frequency over the range from 50 Hz - 5 MHz at room temperature using PC based LCR meter (Model: HIOKI 3552-50-LCR Hitester). The dielectric permittivity has been calculated from the measured values of capacitance using the relation given below.

$$\varepsilon' = \frac{C\,d}{\varepsilon_0 A} \tag{1}$$

Where C is capacitance of the dielectric material, d is thickness of the sample, A is area of the sample and ε_o is the permittivity of free space. Further, from the measured values of dielectric constants, dielectric loss and a. c. conductivities (σ_{ac}) are calculated using the equations (2) & (3) respectively, which are given below.

$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} \ \ or\ \ \varepsilon'' = \varepsilon' \tan\delta \tag{2}$$

$$\sigma_{ac} = \varepsilon' \varepsilon_0 \omega \tan\delta \tag{3}$$

Further, we have also observed the presence of some of the minerals in the PPA sample using the Atomic Absorption Spectrometer.

RESULTS AND DISCUSSIONS

Characterization using XRD

The crystallinity of PPA have been studied using powder X-ray diffractometer (XRD) (Philips Analytical) and observed the strong intensive peak of pure PPA indicate its crystalline nature. In the PPA sample sharp and diffuse peaks observed at 2θ angles 19^0 and 22^0 with peak heights 133 and 211 respectively as shown in Fig. 1. The values of lattice parameter *(d)* at angles 19^0 and 22^0 are respectively 4.6559 A^0, 4.0226 A^0 which were calculated using the Bragg's Law.

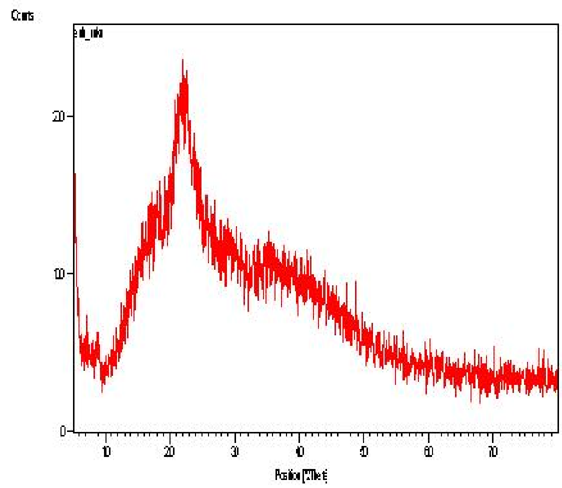

FIGURE 1 - The XRD spectrum of the sample of PPA.

Scanning Electron Microscopy (SEM)

The morphological studies of PPA sample has been made using SEM. The micrographs of PPA in scales of 100 µm and 10 µm .are given in Fig. 4 (a) & (b) respectively. The morphological studies of the pure PPA show the microcrystalline particles. The surface of these particles in a magnified scale is appeared to be glared and it seems to be in reflecting nature.

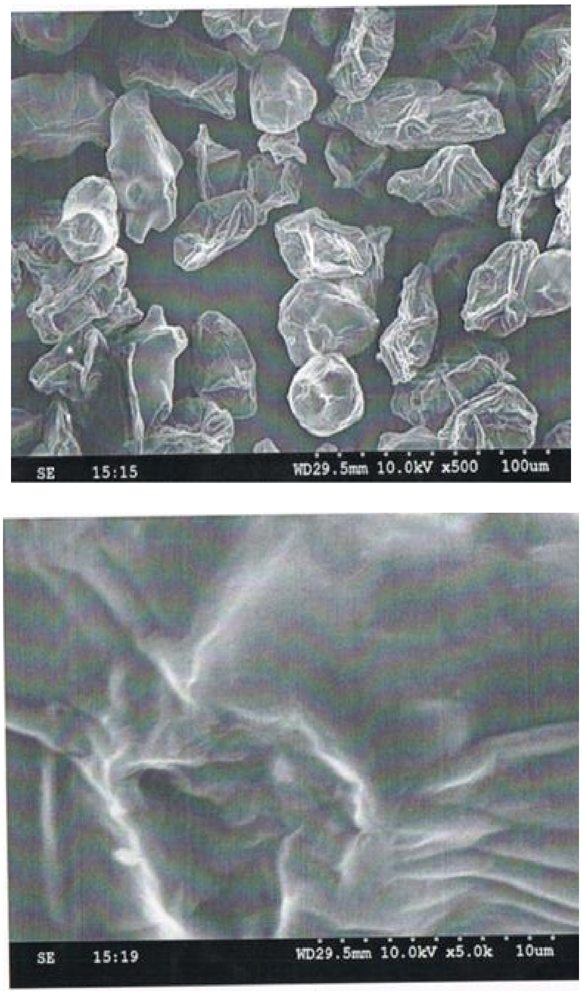

FIGURE 4 - SEM micrographs of PPA in a) scale of 100 µm and b) in magnified scale of 10 µm.

Atomic absorption spectra

The presence of minerals in PPA is studied by using Atomic absorption spectra. To identify concentration of minerals we prepared standard solution of PPA sample by dissolving 1 gm of PPA powder in concentrated H_2SO_4 and double distilled water each of 25 ml in 1:1 ratio. The solution is stirred well for complete dissolution and further added 950 ml of double distilled water, to make 1000 ml solution, to examine the presence of minerals in Parts Per Million (PPM). The 10 ml of standard solution was used for analysis of the minerals present in the PPA using an

Atomic Absorption Spectrometer (Thermo Scientific, iCE 3000 series). The results of the spectrometer reveals that the solution contains 0.1061 mg/litre of copper, 0.1995 mg/l of zinc, 0.7569 mg/l iron, 0.0417 mg/l of lead and 2.3126 mg/l of magnesium.

Capacitance Measurements

The capacitance of PPA sample has been studied as a function of frequency at different thicknesses. The plots of these samples as a function of frequency at ambient temperature for different thicknesses are given in Fig. 5. It is observed from Figure 5 that as frequency increases the capacitance of the PPA decreases exponentially at lower frequency range from 100 Hz to 10 K Hz, afterwards it decreases gradually and remains constant at higher frequencies. The same trend shows for all the different thicknesses of PPA as frequency increases, Further it is observed that as thickness of the PPA increases the capacitance of the sample decreases.

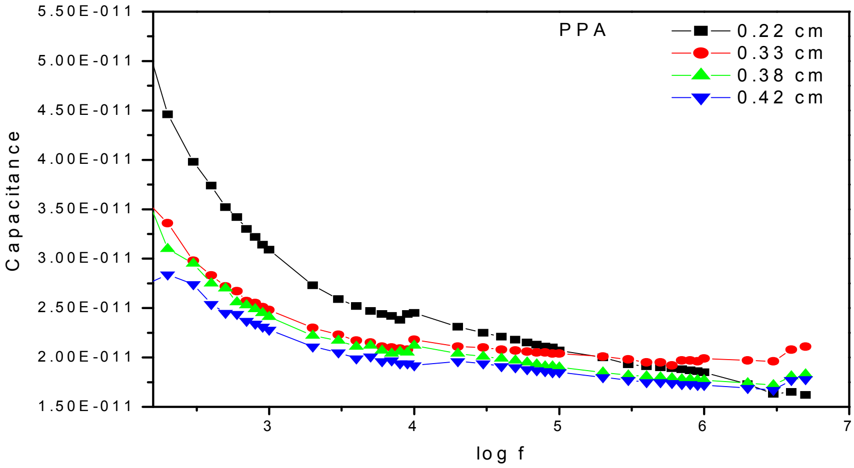

FIGURE 5 - Capacitance of PPA at different thickness as function of frequency.

Dielectric Properties

The values of dielectric permittivity of PPA are obtained from the measured values of capacitance as function of frequency and are shown in Fig. 6. The dielectric Constant of PPA decreases exponentially as the frequency increases up to 3 KHz and gradually decreases up to 10 KHz. But where as at higher frequencies the dielectric permittivity remains same and is independent of the higher frequencies. The same trend has been observed for all the thicknesses. Further we observed that as thickness of the PPA sample increases the values of dielectric permittivity also increases appreciably with in the frequency range 100Hz-10 KHz. But where as at higher frequency range that is above 10 KHz a noticeable increase in the values of dielectric permittivity have been observed. We plotted the dielectric permittivity as function of thickness at frequency 3 KHz is given in Fig 7. It is observed that as thickness of PPA increases the dielectric permittivity increases linearly.

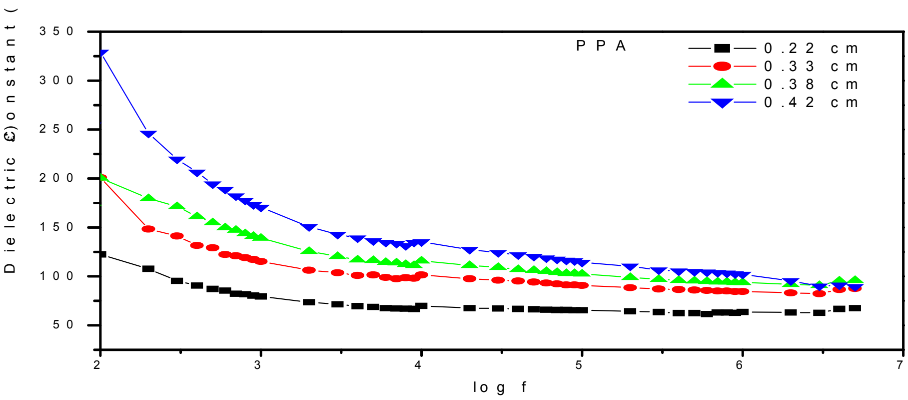

FIGURE 6- Dielectric permittivity of PPA as function of frequency at different thickness.

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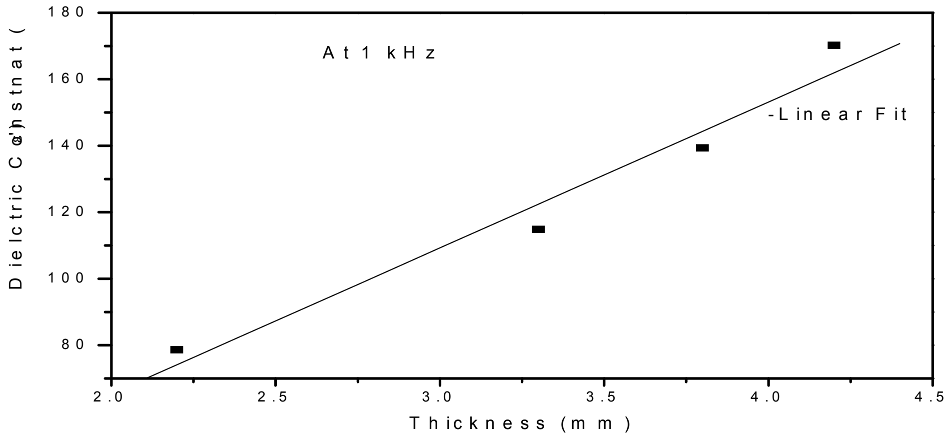

FIGURE 7- Dielectric constant of PPA at 1 KHz for different thickness.

Dielectric Loss

The dielectric loss of PPA for different frequency is shown in Fig 8. The dielectric loss of PPA decreases exponentially as the frequency increases up to 1 KHz and gradually decreases up to 3 KHz but at higher frequencies the loss remains constant. Further we observed that as thickness of the PPA increases the dielectric loss also increases with in the low frequency range 50 Hz to 3 KHz, where as at higher frequency range it remains again constant.

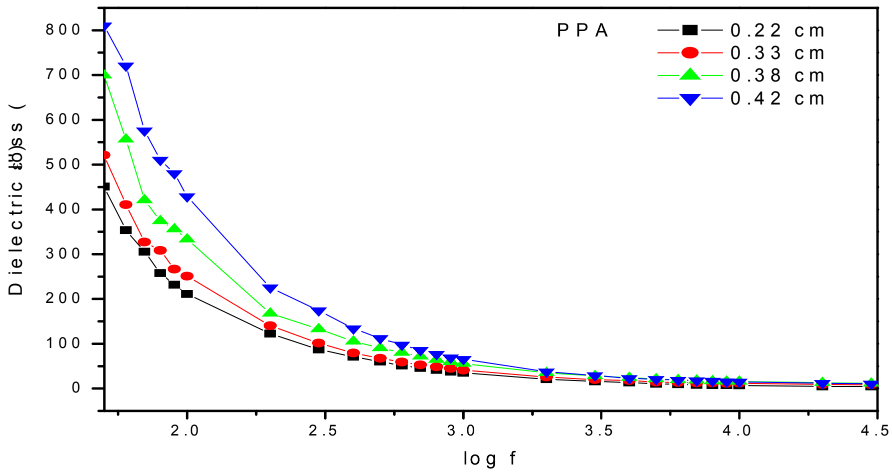

FIGURE 8- Dielectric loss of PPA as function of frequency at different thickness

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A C Conductivity

The a. c. conductivity of PPA as function of frequency for different thickness is given in Fig. 9. The a. c. conductivity of PPA remains constant up to 10 KHz and afterwards it increases exponentially as frequency increases. Here we also noticed that as thickness of the PPA increases the a c conductivity also increases at frequency 300 KHz onwards. We observed from Fig. 9 that the a. c. conductivity shows a peak at frequency of around 3 MHz and again it increased at frequency 4 MHz for thickness 2.2, 3.3 and 3.8 mm, where as in case of thickness at 4.2 mm no peak is observed but it is increased as compared to other thicknesses.

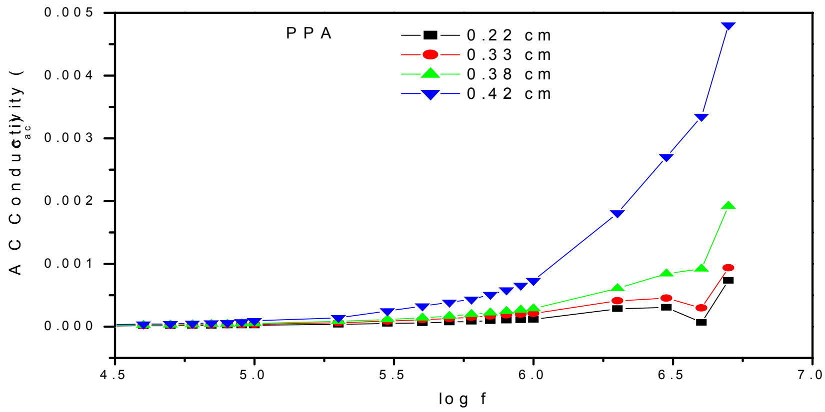

FIGURE 9 - The A C conductivity of PPA as function of frequency at different thickness.

D C Conductivity

The measurement of resistivity of PPA is carried out using Kiethly source meter for different temperatures over the range 45 – 100 ^{0}C. The experimentally measured values of d. c. conductivity and the activation energies of the PPA are calculated using Arrhenius Equation (4).

$$\sigma_{dc} = \sigma_0 \exp - \frac{E}{k}\left[\frac{1}{T} - \frac{1}{T_0}\right] \quad (4)$$

Where σ_{dc} and σ_0 are the conductivities at temperatures T and T_0 respectively, k is the Boltzmann constant and E is the corresponding activation energy. A typical plot of ln(σ_{dc}) versus 1000/T is given in. Fig. 10. The data is fitted for straight line using least square fit. The values of slope of fitting parameters are used to calculate the Activation Energies (E) and are listed in Table–I. We observed that as thickness of the samples increased the activation energy decreased. We have also noticed that the d. c. conductivity is decreased as temperature increased.

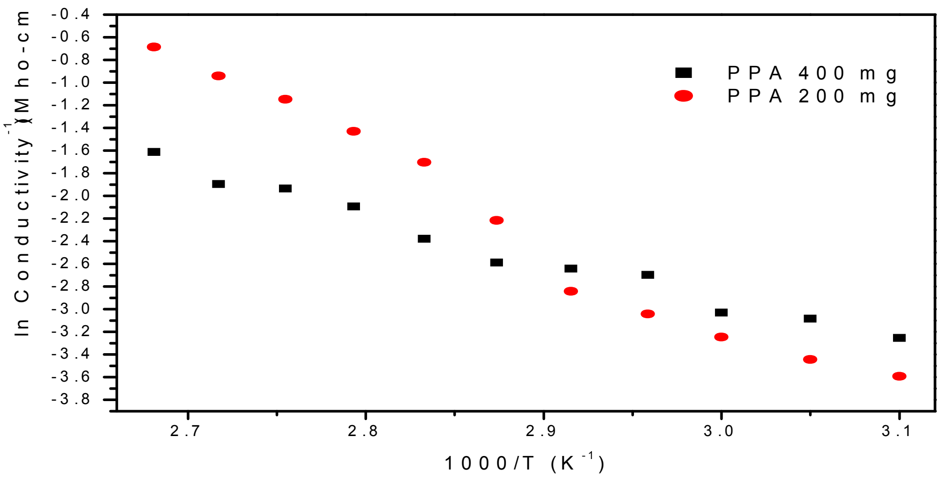

FIGURE 10 - A typical plot of ln(σ_{dc}) versus 1000/T of PPA.

Table-I: Activation Energies of the EC, PPA and its blends.

Sample	Thickness (mm)	Activation Energy (eV).
PPA	**3.8**	**0.659**
	4.2	**0.332**

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