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RESEARCH ARTICLE

DIELECTRIC MEASUREMENT OF *AZADIRACHTA INDICA* (BARK) AT 9.85 GHz FREQUENCY

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ABSTRACT

The effect of packing density, moisture content and temperature on dielectric parameters such as dielectric constant (ε'), dielectric loss (ε"), loss tangent (tanδ), relaxation time (τ_p), conductivity (σ_p) for *Azaditrachta Indica* (bark) in powder form was assessed. The results show that there was a systematic increase in dielectric constant (ε') and loss factor (ε") with increasing values of relative packing fraction (δ_r) and decrease in dielectric constant and loss factor with increasing temperature. The moisture percentage measured by Thermo-gravimetric method. The water jacket was provided with fittings for connection with flexible rubber tubing to constant temperature circulator. The digital thermometer connected to water jacket to read temperature directly. Experimental results of different relative packing fractions were further used to obtain transformation to 100% solid bulk using correlation equations of Landau-Lifshitz- Looyenga and Bottcher. Result shows that, there is a fair agreement between experimental values and theoretical values of different dielectric parameters.

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INTRODUCTION

Medicinal plants have great importance used in manufacturing drugs in both Ayurvedic and Allopathic treatments. India has an old tradition of uses of herbal medicines. In fact, our traditional Ayurvedic system of medicine, which includes most of the entries of plant origin, is still popular amongst rural India. Most of these drugs are obtained from plants collected in nature. Neem is one of the best known bitter tonics that helps detoxification and improves immune system. It has anti-viral and anti-bacterial properties and work excellently in skin disorders and liver problems. It is useful in arthritis, blood-purifies and bronchitis, cough, diabetes, drowsiness, eczema, fever, jaundice, leucorrhea, malaria, obesity, parasites, rheumatism, skin diseases, syphilis, thirst, tumors, vomiting and febrile, diseases (Dastur, 1962 and Kirtikar, Basu 1935). Dielectric properties have been discussed in detail from an electric viewpoint (Kraszewski and Nelson, 1994) and in terms of electromagnetic field concepts (Nelson, 1992). To obtain useful information of various kinds of medicinal products, the study of dielectric behavior from microwave absorption is of great value. The dielectric properties of medicinal products describe interaction (Bansal *et al*., 2001; Gandhi *et al*., 1996; Kraszewski and Nelson, 1993) with microwave energy and depend on frequency of electromagnetic field as well as on bulk particle properties of the materials such as moisture content, density, temperature, packing fraction and composition. The dielectric heating effect on germination early growth of medicinal, agricultural products, improvement in nutritional quality, stored-grain insect control, drying of grains etc., is of great importance to know the actual process at molecular level. To get some information, dielectric properties of *Azaditrachta Indica* -bark were determined at various packing fractions and temperature.

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MATERIALS AND METHODS

Dielectric constant (ε') and dielectric loss (ε") were measured by using reflectometric technique (Chelkowski, 1980; Gandhi *et al*., 1996; Sisodia and and Raghuvanshi, 1990). Measuring the reflection co-efficient from air dielectric boundary of sample in the microwave X – band at 9.85 GHz frequency at 20, 35 and 50 ºC temperature. The following relations were used to determine the dielectric parameters.

$$\in' = \left(\frac{\lambda_0}{\lambda_c}\right)^2 + \left(\frac{\lambda_0}{\lambda_d}\right)^2 \qquad \text{.......... (1)}$$

$$\in'' = \frac{1}{\pi}\left(\frac{\lambda_0}{\lambda_d}\right)^2 \alpha_d \beta_d \qquad \text{.......... (2)}$$

Where,
λ_0 = the wavelength in free space.

$\lambda_c = 2a$ is cut-off wavelength of the wave guide.
a – is broader dimension of the rectangular wave guide.
αd = is the attenuation introduced by the unit length of the dielectric materials.
$\beta d = 2\pi\lambda_d$ is phase shift introduced by the unit length of the dielectric materials.
λ_d = wavelength in the dielectric powder.

Microwave X- band set up for dielectric measurements

In the present investigation, small quantity of bark powder was introduced in the cell and the plunger was brought over the powder column. A pressure was allowed to exert by plunger on powder in the dielectric cell. The height of the powder column and the corresponding reflection co-efficient was measured by means of a crystal pick-up in the directional coupler. This process was repeated at every addition of powder in the cell. The relationship between reflected power and height of the powder column was approximately given by a damped sinusoidal wave. The distance between two adjacent minima's of the curve gave half the dielectric wavelength (λ_d =2L). For the determination of dielectric parameters of *Azaditrachta Indica* bark, three samples of various particle sizes were prepared by using sieves of different size. For the comparison of correlation formulae between powder and bulk, the packing fraction (δ_r) were taken as the ratio of density of powder and the density of the finest crushed closely packed particle assembly of the sample. The conductivity (σ_p) and relaxation time (τ_p) were obtained by using following relations.

$$\sigma_p = \omega \in_0 \in'' \quad \text{........ (3)}$$

$$\tau_p = \frac{\in''}{\omega \in'} \quad \text{......... (4)}$$

Where,
ω - is angular frequency of measurement (9.85 GHz).
ε_o - is permittivity of free space.
For low loss materials, dielectric constant (ε') and loss factor (ε'') for bulk materials can be correlated with their powder form by the relations derived independently by Landau-Lifshitz and Looyenga, (1960).

$$\in'_S = \frac{\left[\left(3\delta + 2\in'_p - 2\right)\in'_p\right]}{\left(3\delta - 1\right)\in'_p + 1} \quad \text{………. (5)}$$

$$\in''_S = \left(\frac{\in''_P}{\delta}\right)\left(\frac{\in'_S}{\in'_P}\right)^{2/3} \quad \text{for} \quad \frac{\in''}{\in} << 1 \quad \text{………. (6)}$$

Where,

ε'_s – is the dielectric constant for the material in bulk,
ε'_p – is the dielectric constant of powder sample at relative packing fraction (δr).
ε''_s and ε''_p – are the dielectric losses for solid and powder respectively.
The results obtained have been verified with values obtained from Bottcher's equation (Bottcher, 1952).

$$\in'_S = \frac{\left(2\in'_P + 3\delta - 2\right)\left\{\left(3\delta - 1\right)\left(\in'^2_P + \in''^2_P\right) + \in'_P - 2\in''^2_P\right\}}{\left(3\delta - 1\right)^2\left(\in'^2_P + \in''^2_P\right) + 2\in'_P\left(3\delta - 1\right) + 1} \quad \text{……. (7)}$$

$$\in''_S = \frac{2\left(3\delta - 1\right)\left(\in''^3_P + \in'^2_P \in''_P\right) + \in''_P\left(3\delta - 2\right) + 4\in'_P \in''_P}{\left(3\delta - 1\right)^2\left(\in'^2_P + \in''^2_P\right) + 2\in'_P\left(3\delta - 1\right) + 1} \quad \text{…... (8)}$$

RESULTS AND DISCUSSION

Dielectric constant (ε') and dielectric loss (ε'') along with the values of relative packing fraction (δr) of *Azardichita Indica* - bark powder are given in Table -1.

Table 1. Values of dielectric constant ($\in'_p$), dielectric loss ($\in''_p$), loss tangent (tanδ), relaxation time (τ_p), conductivity (σ_p) and moisture percentage of Neem bark powder at different temperature and packing fraction (δ_r)

Temp °C	Packing Fraction (δ_r)	$\in'_p$	$\in''_p$	tanδ	5_p (p.s.)	σ_p (10^{-2})	Moisture (%)
	0.7905	2.445	0.364	0.146	2.36	19.90	0.788
20°C	0.8331	2.552	0.403	0.158	2.55	22.06	0.657
	1.00	2.685	0.530	0.197	3.20	29.02	0.394
	0.7905	2.485	0.354	0.143	2.31	19.40	0.548
35°C	0.8331	2.546	0.397	0.156	2.52	21.76	0.445
	1.00	2.681	0.480	0.179	2.89	26.27	0.310
	0.7905	2.454	0.315	0.128	2.08	17.27	0.512
50°C	0.8331	2.475	0.365	0.147	2.39	20.01	0.410
	1.00	2.664	0.436	0.163	2.64	23.86	0.275

Table 2. Measured and calculated values of dielectric constant ($\in'_s$), and dielectric loss ($\in''_s$) for bulk from powder at different temperature and packing fraction (δ_r)

Temp °C	Relative Packing fraction (δr)	Є's For solid bulk			Є"s For solid bulk		
		Measured	Calculated From Bottcher's formula	Calculated From Landu, et al formula	Measured	Calculated From Bottcher's formula	Calculated From Landu, et al formula
	0.7905		3.024	2.964		0.523	0.510
20°C	0.8331		2.963	2.898		0.534	0.523
	1.00	2.686	2.686	2.610	0.530	0.530	0.530
	0.7905		3.010	2.952		0.509	0.497
35°C	0.8331		2.955	2.892		0.527	0.516
	1.00	2.681	2.681	2.620	0.480	0.480	0.480
	0.7905		2.967	2.920		0.453	0.442
50°C	0.8331		2.864	2.809		0.483	0.474
	1.00	2.664	2.664	2.610	0.436	0.436	0.436

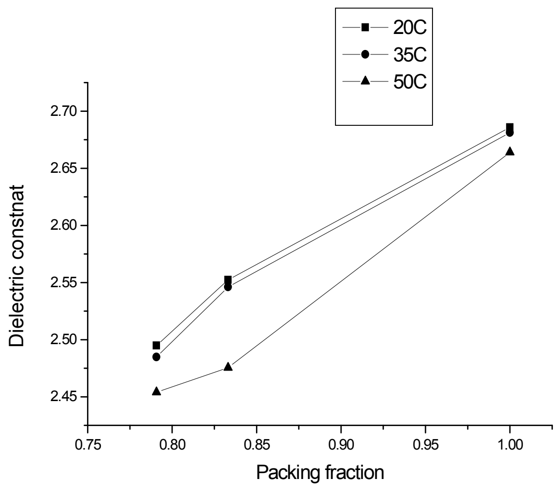

Fig.1.Packing fraction Vs Dielectric constant

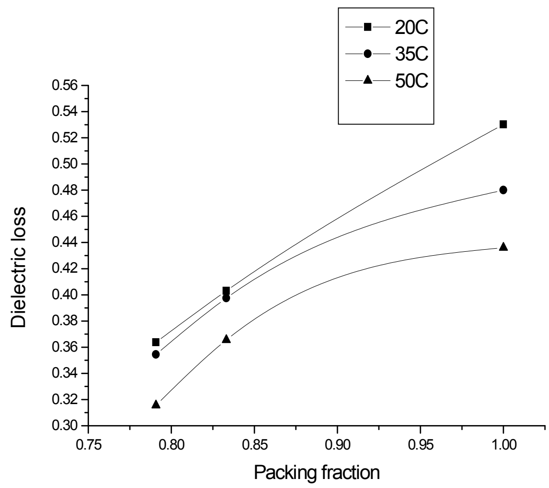

Fig.2. Packing fraction Vs Dielectric loss

The values of (ε'_p) and (ε''_p) obtained experimentally for different grain sizes and temperature showed that, there is simultaneous increase in dielectric constant (ε') and loss factor (ε") with increasing temperature. This was expected, because with higher values of relative packing fraction (δr) the inter particle hindrance offered to the dipolar motion for a compact medium will be much higher than for less bounded particles. Such observations have been already made by other workers (Bhatnagar *et al.*, 1996; Nelson, 1992; Yadav and Gandhi, 1992) for higher values of packing fraction. Values of relaxation time (τ_p) loss tangent (tanδ) conductivity (σ_p) and values of moisture content with relative packing fraction and different temperature revealed that there was increase in σ_p, τ_p and tanδ with the increasing values of packing fraction (δr). There was systematic decrease in σ_p, τ_p and tanδ, moisture percentage with increasing values of temperature. Such behavior is expected because when polar molecules are very large, the rotatory motion of the molecules is not sufficiently rapid for the attainment of equilibrium with the field. The increase in conductivity therefore suggests that, at higher compactions, no micro cracks are developed in the sample due to high mechanical pressure.

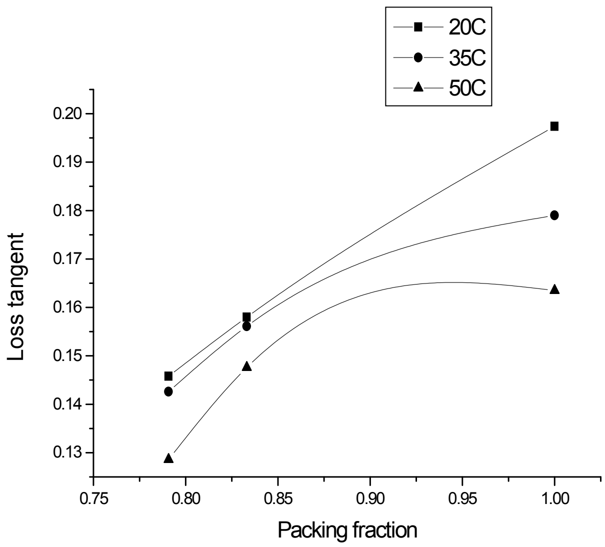

Fig.3. Packing fraction Vs Loss tangent

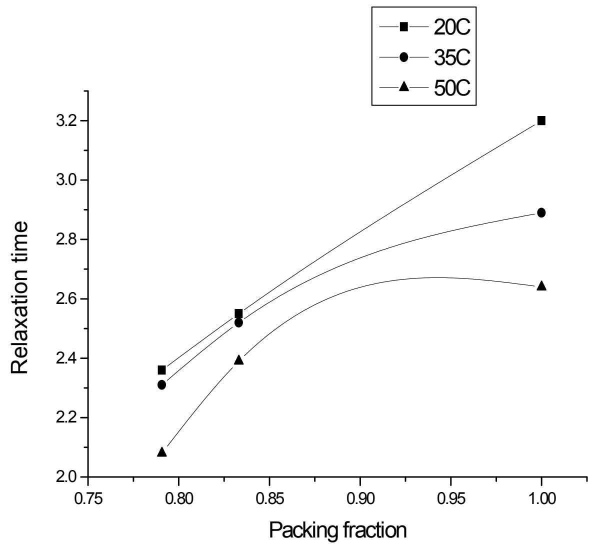

Fig.4. Packing fraction Vs Relaxation time

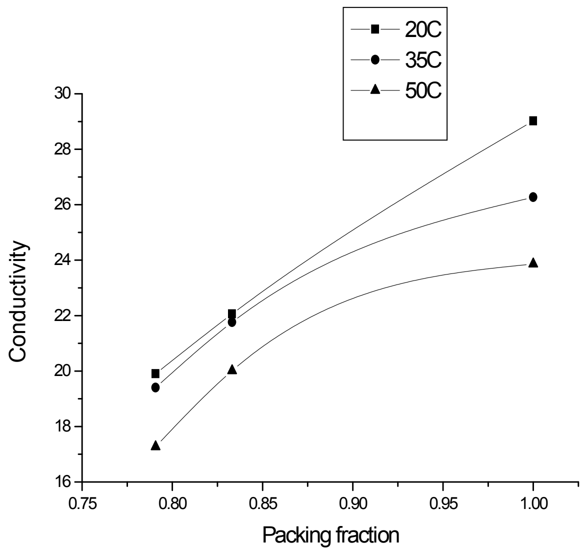

Fig.5. Packing fraction Vs Conductivity

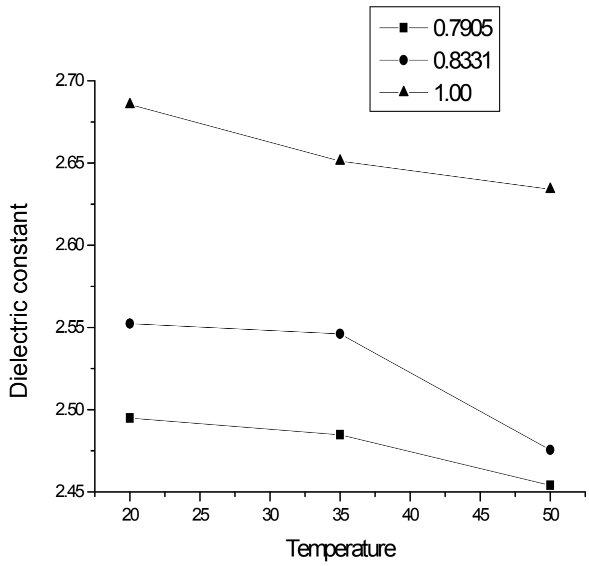

Fig.6. Temperature Vs Dielectric constant

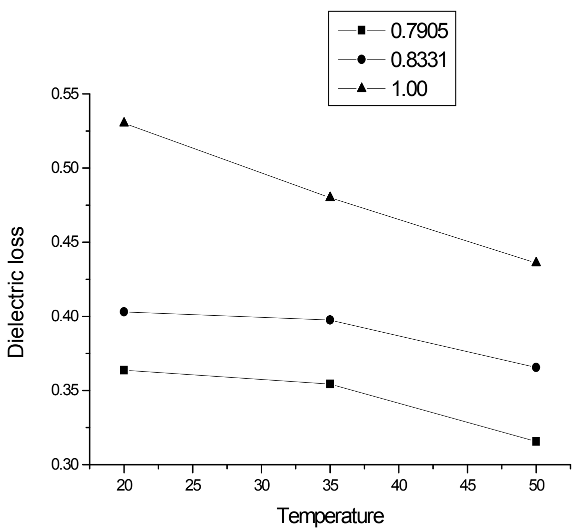

Fig.7. Temperature Vs Dielectric loss

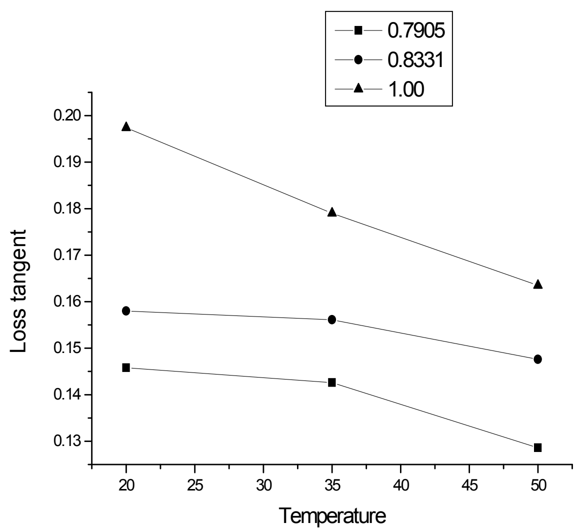

Fig.8. Temperature Vs Loss tangent

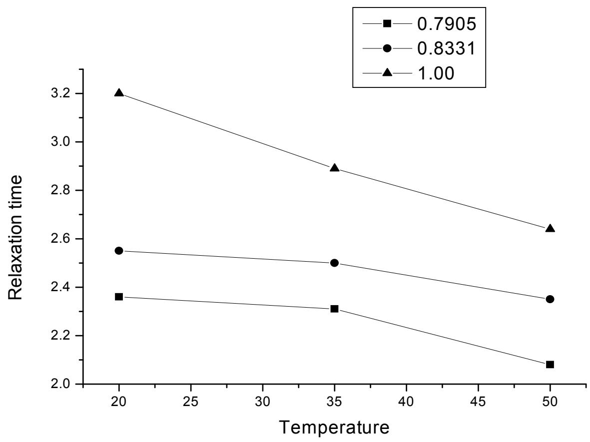

Fig.9. Temperature Vs Relaxation time for different relative packing fractions

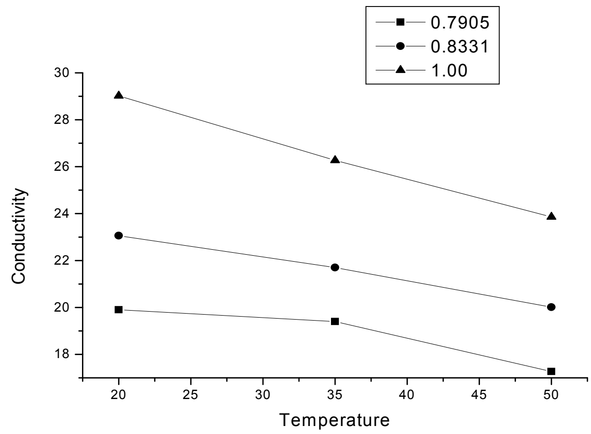

Fig.10. Temperature Vs Conductivity for different packing fractions

The decrease in relaxation time (τ_p) with increasing temperature may be due to increase in the effective length of dipole. In addition, due to increasing temperature, number of collision increases because increase in energy loss and thereby decreasing relaxation time. Table -2 shows measured and computed value of dielectric parameters for bulk from bark powder measurement. The results reported at $\delta r = 1$ are those measured on the finest crushed powder sample packed very closely in a wave-guide cell pressing it under a fixed pressure, so as to obtain minimum voids between the particles. Out of the three powder sample of different packing fractions, the sample having minimum particle size is defined as finest which is about 0.70μm. In this case, we assumed it as solid bulk for getting correlation between powder and solid bulk. The correlation formulae were used to find other value for ($\delta r > 1$). The bulk values obtained for (ε') and (ε'') are same to the measured values and those calculated from (Landau and Lifshitz, 1960), are closer to the values calculated from (Bottcher, 1952) formulae. The values of packing density increase linearly with the values of dielectric constant, dielectric loss and conductivity increases (Fig.1-5). There was a simultaneous decrease of dielectric constant, dielectric loss and conductivity with increase in the temperature.

Conclusion

It was found that, experimentally measured values of (ε') and (ε'') at ($\delta r = 1$) are similar to those calculated from Landau-Lifshitz-Looyenga formulae. There was fair agreement between the values obtained experimentally and calculated theoretically by using Bottcher's formulae. The correlation formulae of Landau-Lifshitz-Looyenga and Bottcher can be used to provide accurate estimate of (ε') and (ε'') of powder materials at known bulk densities. It may be predicted that, *Azardichita Indica*- bark powder is having cohesion in its particles and serve as a continuous medium.

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