International Journal of Physics and Mathematical Sciences ISSN: 2277-2111 (Online)
An Online International Journal Available at http://www.cibtech.org/jpms.htm
2012Vol. 2(2) April-June, pp.180-186/Karhale and Kalamse

Research Article

DIELECTRIC STUDY OF BAHEDA (*TERMINALIA BELLERICA* ROXB.) AT 9.85 GHz FREQUENCY

G. Karhale[1] and *G. Kalamse[2]
[1]Depart. Of Physics, M. P. College, Palam
[2]Microwave Research Lab.
N. E. S. Science College, Nanded
**Author for Correspondence*

ABSTRACT
The effect of packing density and temperature on dielectric parameters, relaxation time (τ_p), conductivity (σ_p), moisture content of Baheda (*Terminalia bellerica Roxb.*) 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. Moisture content is measured using Thermo-gravimetric method. 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. There is a fair agreement between experimental values and theoretical values of different dielectric parameters. It shows cohesion in the particles of Baheda powder under investigation.

Key Words: *Dielectric constant, Packing fractions, Baheda (Terminalia bellerica Roxb.)*

INTRODUCTION
The dielectric properties or permittivity of a material determine the interaction of the material with electric fields. Dielectric properties have been previously defined and discussed in detail from an electric viewpoint (Gandhi *et al.*, 1996) and in terms of electromagnetic field concepts (Kraszewski and Nelson, 1994). For practical use, the dielectric properties of usual interest are dielectric constant and the dielectric loss factor, the real and imaginary parts, respectively of the relative complex permittivity, ($\varepsilon = \varepsilon' - j\varepsilon''$). Where, δ – is the loss angle of the dielectric. In this paper, "Permittivity" is understood to represent the relative complex permittivity, i.e. the permittivity relative to free space or the absolute permittivity divided by permittivity of free space. $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m. Often the loss tangent $\tan\delta = \varepsilon''/\varepsilon'$, or dissipation factor is also used as an descriptive dielectric parameter and sometimes the power factor (tanδ) is used. The a c conductivity of dielectric in S/m is $\sigma = \omega\varepsilon_0\varepsilon''$. Where, $\omega = 2\pi f$ is the angular frequency, with frequency (f) in Hertz. The dielectric constant of a material is associated with energy storage capability in the electric field in the material and loss factor is associated with energy dissipation, conversion of electric energy to heat energy in the material. Here, ε" - is interpreted to include the energy losses in the dielectric due to all operating dielectric relaxation mechanism and ionic conduction.

Basic Microwave Material Interaction
When microwave are directed towards a material, part of the energy is reflected, part is transmitted through the surface and of this latter quantity part of it is absorbed. The properties of energy, which fall into these three categories, have been defined in terms of dielectric properties. The fundamental electrical property through which the interaction are described is the complex relative permittivity of the material, it is mathematically expressed as,

$$\varepsilon^* = \varepsilon' - j\varepsilon'' \quad .... (1)$$

Where, ε' – is dielectric constant,
ε" – is dielectric loss factor.
The absolute permittivity of a vaccum ε_0 - is determined by,

$$C_0\mu_0\varepsilon_0 = 1 ...... \quad (2)$$

Where,

The value of $\varepsilon_o = 8.85*10^{-12}$ F/m.
In other media (solid, liquid and gaseous), the permittivity has higher values and is usually expressed relative to the value in vacuum (Nyfos and Vainikainen 1989).
To obtain useful information on biophysical properties 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 and Yadav, 1992, Kraszewski, and Nelson, 1993, Landau and Lifshitz, 1960) 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, sterilization of grains, making medicine etc., is of great importance to know the actual process at molecular level. To get some information, dielectric properties of Baheda were determined at various packing fractions and temperature.

Medicinal uses

The fruits of Baheda are widely used in Ayurvedic system of medicine. It is mainly used in triphala churn. It is used in various formulations but it is mainly used externally in paste form for painful conditions, skin diseases, leukoderma, graying of hair and to control bleeding for injuries.
Internally, it is used in formulations for chronic cough, indigestion, flatulence, piles and nausea and worm infestations.

MATERIALS AND METHODS

Dielectric constant (ε') and dielectric loss (ε") were measured by using reflectometric technique (Chelkowski A 1980, Gandhi JM, Jangid RA, and Neeru Bhatnagar D 1996, Sisodia ML and Raghuvanshi GS 1990). Measuring the reflection co-efficient from air dielectric boundary of sample in the microwave X – band at 9.85 GHz frequency at 20º, 35º and 50ºC temperature. The following equations were used to determine the dielectric parameters.

$$\in' = \left(\frac{\lambda_0}{\lambda_c}\right)^2 + \left(\frac{\lambda_0}{\lambda_d}\right)^2 \quad \text{..........} \ (3)$$

$$\in'' = \frac{1}{\pi}\left(\frac{\lambda_0}{\lambda_d}\right)^2 \alpha_d \beta_d \quad \text{..........} \ (4)$$

Where,

$\lambda_0 =$ 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.
βd $= 2\pi\lambda_d$ is phase shift introduced by the unit length of the dielectric materials.
λ_d = wavelength in the dielectric powder.

In order to determine (λ_d) accurately, (Kalamse and Kalamse, 2007) designed and developed a dielectric cell to hold sample powder so as to introduce it in the cell conveniently and exert equal amount of pressure by the plunger on the powder column in the cell. During present investigation, small quantity of 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 Baheda, 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.

$$\sigma_p = \omega \in_0 \in'' \text{........ (5)}$$

$$\tau_p = \frac{\in''}{\omega \in'} \quad \text{......... (6)}$$

Where,

ω - is angular frequency of measurement (9.85 GHz).

ε_o - is permittivity of free space.

RESULTS AND DISCUSSION

Dielectric constant (ε') , and dielectric loss (ε'') along with the values of relative packing fraction (δr) of Baheda powder are given in table -1. 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 (Bansal *et al.*, 2001, Bhatnagar *et al.*, 1996, Nelson, 1992, Gandhi and Yadav, 1992) for higher values of packing fraction.

An examination of values of relaxation time (τ_p) loss tangent ($\tan\delta$) 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 $\tan\delta$ with the increasing values of packing fraction (δr). There was systematic decrease in σ_p, τ_p and $\tan\delta$, moisture percentage with increasing values of temperature. Such behavior is expected because when polar molecules are very large, the rotator 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. 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 increase causes increase in energy loss and thereby decreasing relaxation time.

Table -2 shows measured and computed values of dielectric parameters for bulk from powder measurements. 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 samples of different packing fractions, the samples 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.

It was thus, 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 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 thus, predicted that Baheda powder is having cohesion in its particles and serve as a continuous medium.

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 Baheda powder at different temperature and packing fraction (δ_r).

Temp °C	Relative Packing Fraction (δ_r)	$\in'_p$	$\in''_p$	tanδ	τ_p (p.s.)	σ_p (10^{-2})	Moisture (%)
20°C	0.8934 0.9186 1.00	2.510 2.554 2.806	0.237 0.259 0.313	0.094 0.102 0.112	1.53 1.64 1.80	12.97 14.20 17.13	0.672 0.528 0.335
35°C	0.8934 0.9186 1.00	2.483 2.506 2.723	0.180 0.202 0.247	0.073 0.081 0.091	1.18 1.30 1.47	9.87 11.05 13.54	0.552 0.410 0.329
50°C	0.8934 0.9186 1.00	2.432 2.481 2.515	0.136 0.155 0.188	0.056 0.063 0.078	0.91 1.01 1.19	7.43 8.51 10.30	0.437 0.309 0.285

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)	€'s For solid bulk			€"s For solid bulk		
		Measured	Calculated From Bottcher formula	Calculated From Landu, et al formula	Measured	Calculated From Bottcher' formula	Calculated From Landu, et al formula
20°C	0.8934 0.9186 **1.00**	**2.806**	2.743 2.730 **2.806**	2.723 2.708 **2.780**	**0.313**	0.281 0.295 **0.313**	0.278 0.292 **0.311**
35°C	0.8934 0.9186 **1.00**	**2.723**	2.710 2.677 **2.723**	2.699 2.663 **2.710**	**0.247**	0.214 0.230 **0.247**	0.211 0.227 **0.240**
50°C	0.8934 0.9186 **1.00**	**2.548**	2.651 2.642 **2.548**	2.640 2.638 **2.546**	**0.188**	0.161 0.177 **0.188**	0.159 0.175 **0.189**

International Journal of Physics and Mathematical Sciences ISSN: 2277-2111 (Online)
An Online International Journal Available at http://www.cibtech.org/jpms.htm
2012Vol. 2(2) April-June, pp.180-186/Karhale and Kalamse
Research Article

Graphical representation of dielectric parameters

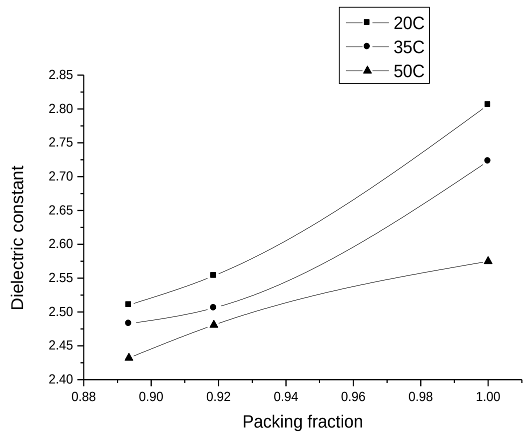

Figure 1: Packing fraction Vs Dielectric constant

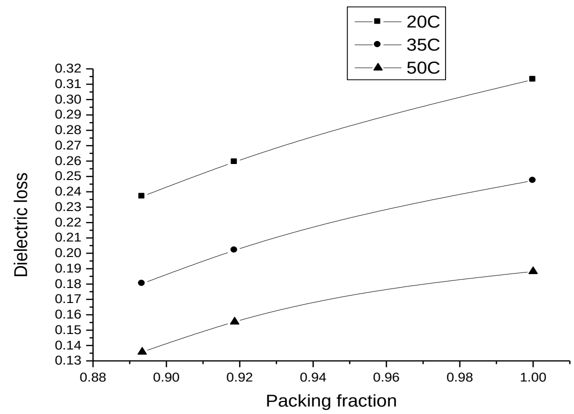

Figure 2: Packing fraction Vs Dielectric loss

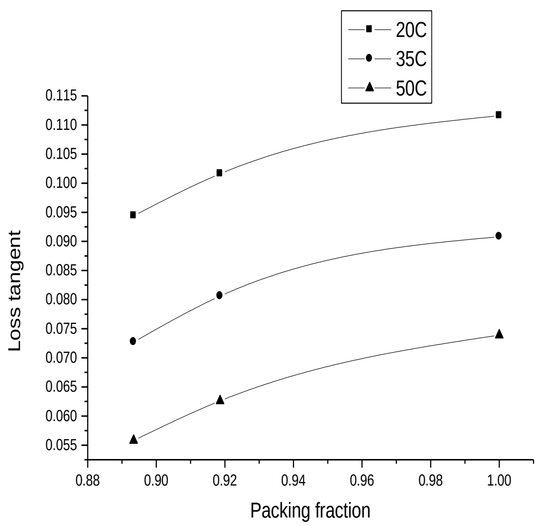

Figure 3: Packing fraction Vs Loss tangent

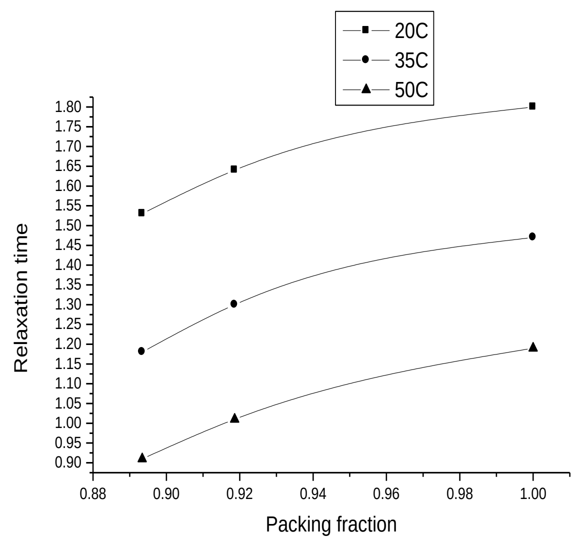

Figure 4: Packing fraction Vs Relaxation time

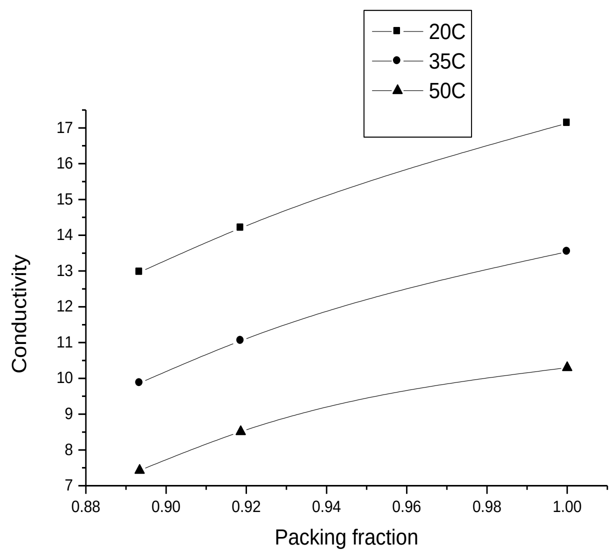

Figure 5: Packing fraction Vs Conductivity

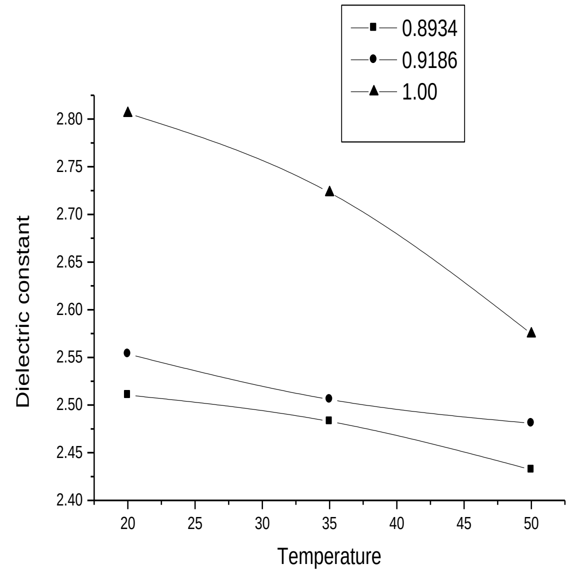

Figure 6: Temperature Vs Dielectric constant

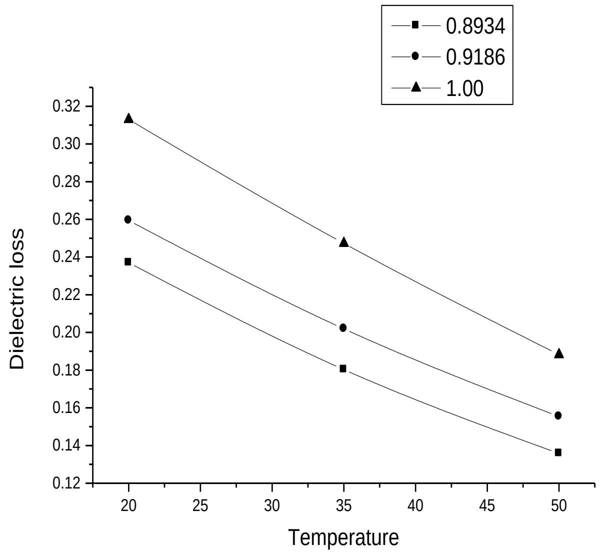

Figure 7: Temperature Vs Dielectric loss

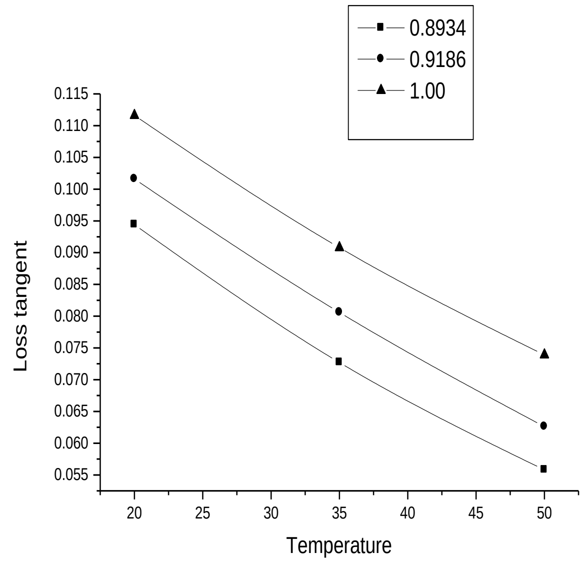

Figure 8: Temperature Vs Loss tangent

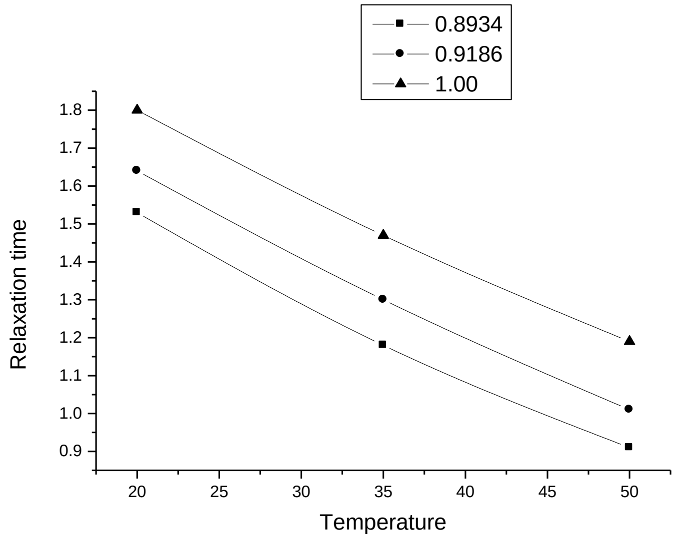

Figure 9: Temperature Vs Relaxation time.

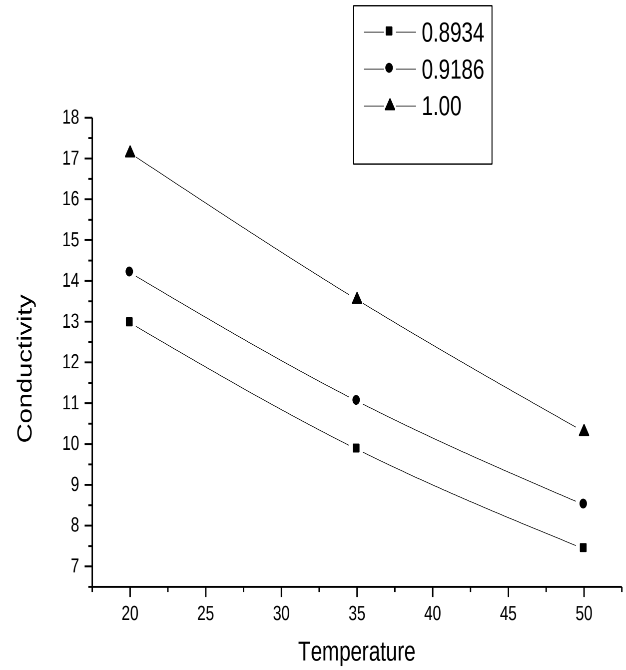

Figure 10: Temperature Vs conductivity.

REFERENCES

Bansal AK, Singh PJ and Sharma KS (2001). *Indian Journal of Pure and Applied Physics* **39** 799-803.
Bhatnagar D, Gandhi JM and Yadav JS (1996). *Indian Journal of Physics* ***70A***(4) 539-542.
Bottcher CJF, (1952). Theory of dielectric polarization. *Elsevier publication, Amsterdam.*
Chelkowski A (1980) Dielectric Physics. *Elsevier, Amsterdam, Oxford, New York.*
Gandhi JM and Yadav JS (1992). *Indian Journal of Pure and Applied Physics* **(30)** 427.
Gandhi JM, Jangid RA, and Neeru Bhatnagar D (1996). *Indian Journal of Pure and Applied Physics* (**34)** 316.
Kraszewski A, and Nelson SO (1993). *Journal of Microwave Power and Electromagnetic Energy* **28(3)** 165.
Kraszewski A, and Nelson SO (1994). *Journal of Agricultural Engineering Research* **(58)** 37-46.
Kalamse VG and Kalamse GM (2007). Microwave dielectric cell for the measurement of dielectric parameters of pulverized materials. *Lab Experiments.* **7(1)** 30-38.
Landau LD and Lifshitz EM (1995). Electrodynamics of continuous media. *Pergamon press, London. **(31)** 46**.*
Nelson SO and Kraszewski (1998). *IEEE Transaction on Instrumentation and Measurement.* **47(5*)***.
Nyfos E and Vainikainen P (1989). *IndustrialMicrowave Sensors*, Nor well,MA:Artech House.
Peter H (1997). Dielectric spectroscopy of polymers. *Adam Hilger Ltd, Bristol.*
Sisodia ML and Raghuvanshi GS (1990). *Basic microwave techniques and Laboratory Manual* Willey Eastern Ltd, New Delhi.