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Dielectric Studies of Some Bio-Materials at Microwave Frequencies and Correlation Between Dielectric Parameters, Minerals and Vitamins Nutrient

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***Abstract*— An attempt is made to improve the Robert von Hipple measuring method and the Present work is concern with measurement of complex dielectric permittivity, conductivity, loss tangent and penetration depth of some bio-material. The measurement makes use of Robert Von Hipple technique or short circuited waveguide method. All the measurements were made in the microwave frequency range (Experiment is carried out at 9.9 G.HZ). In the present investigation it is interesting to note that the high dielectric constant is coupled with high dielectric loss in case of biological samples which contain large quantity of water but this is not the feature of a non biological materials. The influence of vitamins and minerals on the dielectric parameter is made using a correlation calculation is made between dielectric parameters, vitamins and nutrients.**

***Index Terms*— Dielectric constant, dielectric loss factor, penetration depth, conductivity, microwave frequency and vegetables.**

INTRODUCTION

Biological effects of microwave radiation have been focus of various research efforts in the last decade. Key to this is the determination of complex permittivity (ε' and ε'') of biological tissues. Dielectric properties of materials are important in determining how electromagnetic energy in the radio-frequency and microwave range interacts with materials [1-2]. There are many ways in which dielectric measurements may be made [3]. In this paper the short circuited waveguide method is used originally reported by Roberts and von Hippel[4].

More literature on dielectrics is available at radio wave frequency range, data available on dielectric at microwave frequency range are not adequate. So an effort is made to bridge this gap, a detailed survey has been undertaken on some bio materials which includes the measurement of dielectric properties.

II. THEORETICAL BACKGROUND OF VON HIPPLE METHOD

V Von Hipple method for determining the complex dielectric permittivity, the sample of unknown permittivity is placed against a short-circuited termination at the end of waveguide where electromagnetic standing waves with fixed wavelength λ are established. Position of the minima (nodes) is measured in both cases (i.e without sample (air) and with dielectric sample), the shift in the minima (nodes) was observed. The shift of the minima(nodes) position is due to the presence of the sample depends mainly upon the relative dielectric constant (ε_r') and the change in the standing wave ratio (VSWR) depends mainly upon the relative dielectric loss factor(ε_r'')[6].

Relating the sample impedance as calculated from its intrinsic parameters to that calculated from the characteristics of the standing wave, which can be measured, yields the transcendental equation on the complex plane [7]

$$\frac{-j\lambda_g}{2\pi d}\,\frac{1-jS\tan\left(\dfrac{2\pi D_m}{\lambda_g}\right)}{S-j\tan\left(\dfrac{2\pi D_m}{\lambda_g}\right)}=\frac{\tanh(\gamma d)}{\gamma d} \qquad (1)$$

The complex propagation coefficient for electromagnetic waves inside a nonmagnetic sample can be written as $\gamma = \alpha + j\beta$ where α is attenuation constant and β is phase constant. Complex propagation coefficient γ, is a function of the complex relative permittivity $\boldsymbol{\varepsilon^* = \varepsilon' - j\varepsilon''}$.

Propagation coefficient is expressed as

$$\gamma = j2\Pi\sqrt{\varepsilon^*}/\lambda_0 \qquad (2)$$

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where λ0 is the wavelength in vacuum.
where λ_0 is the wavelength in vacuum.
Writing T / τ for the polar form of γd, (1) becomes

$$c\angle -\xi = \frac{\tanh(T/\tau)}{T/\tau} \qquad (3)$$

Knowing C and ξ , values of T and τ are seen from the standard Von Hipple charts (fig1).The admittance is expressed as[6]

$$Y_\varepsilon = \left(\frac{T}{\beta l_\varepsilon}\right)^2 \angle 2\left(\tau - 90^0\right) = G_\varepsilon + jS_\varepsilon \quad \text{(say)}$$

Gε and S_ε are related to ε' and ε'' or

$$\varepsilon' = \frac{G_\varepsilon + (\lambda_g/2a)^2}{1+(\lambda_g/2a)^2} \qquad (4)$$

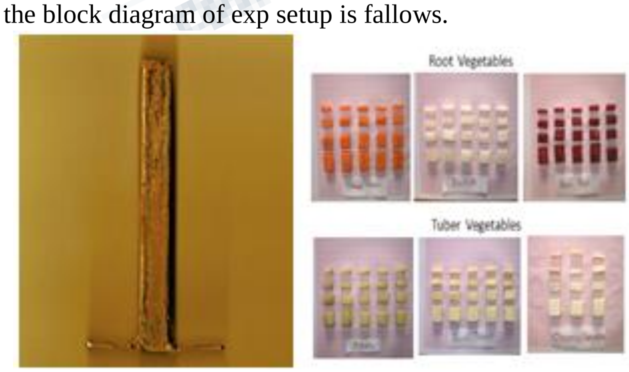
$$\varepsilon'' = \frac{-S_\varepsilon}{1+(\lambda_g/2a)^2} \qquad (5)$$

$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} = \frac{\sigma}{\omega\varepsilon_0} \qquad (6)$$

ac conductivity is expressed as
$\sigma = \omega\, \varepsilon_0\, \varepsilon'' = 2\Pi f\, \varepsilon_0\, \varepsilon''$ (7)
Penetration depth , d_p is computed as
$d_p = (\lambda_0 \sqrt{\varepsilon'}) / 2\Pi \varepsilon''$ (8)
and hence propagation constant (γ = α + jβ) is determined.

III. METHODS AND MATERIALS

Sample Preparation and Measurment.
A metallic die is designed and fabricated for the sample preparation of bio material. The dimension of metallic die is same as the dimension of X band waveguide as in Fig.1. The measurements are carried at a frequency of 9.9 GHz. the block diagram of exp setup is fallows.



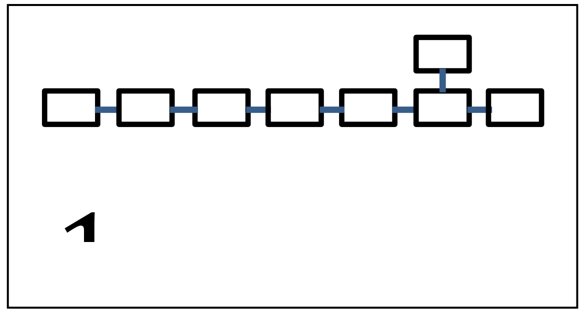


Fig. 1. Metallic die, Vegetables sample and von-Hippel Technique block diagram

Prepared Sample of different length was kept at sample holder (7) in the wave guide. Guide wavelength before and after inserting sample was noted using slotted section (6) i.e. λg= 2nd minima-1st minima , VSWR & length of sample, dielectric parameters were computed using MATLAB.

IV. RESULTS AND DISCUSSION

The following parameters tabulated are computed using a MAT LAB software developed instead of von Hippel graphs.

Vegi tables	ε'	ε''	Tanδ	σ	d_p (cm)
Carrot	10.12	2.16	0.21	1.19	0.89
Radish	7.35	1.64	0.22	0.90	1.00
Beetroot	2.81	0.29	0.1	0.16	3.5
Potato	31.89	8.31	0.26	4.57	0.41
Sweet potato	12.27	1.20	0.09	0.66	1.77
Culkesia	9.82	2.15	0.21	1.18	0.88

TABLE 1. dielectric parameters for the different vegetable tissues.

A Plot is drawn for the computed dielectric Parameters of all the bio samples is in fig 2.

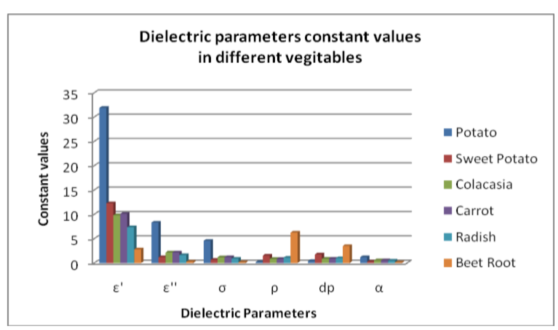


Fig. 2. Dielectric parameters of bio samples.

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Correlations:
Nutrient Present in Vegetables, Vitamins & Minerals Contained affect on properties.

Dielectric constant / loss	Correlation	VitaminB6	Niacin
ε'	Pearson Correlation	.938**	.843*
	Sig. (2-tailed)	0.006	0.035
	N	6	6
ε''	Pearson Correlation	.836*	0.739
	Sig. (2-tailed)	0.038	0.093
	N	6	6

Dielectric constant / loss	Correlation	K	P	Zn
ε'	Pearson Correlation	.827*	.925**	.885*
	Sig. (2-tailed)	0.042	0.008	0.019
	N	6	6	6
ε''	Pearson Correlation	0.789	.880*	.856*
	Sig. (2-tailed)	0.062	0.021	0.03
	N	6	6	6

** Correlation is significant at the 0.01 level (2-taile
* Correlation is significant at the 0.05 level (2-tailed).

TABLE 2. Correlations between dielectric parameters and nutrient present in vegetable.

V. CONCLUSIONS

The results obtained shows that a simple experimental setup i.e. The Von Hipple method can be very use full for measuring the complex dielectric permittivity of biological tissues. The Program developed to evaluate the above parameter is relatively exact method for the determination of dielectric parameters of biological tissues.
It is interesting to note that the high dielectric constant is coupled with high dielectric loss in case of biological samples which contain large quantity of water but this is not the feature of non biological materials. The influence of vitamins and minerals on the dielectric parameter is made using a correlation calculation & is significant on dielectric parameters, the vegetables contains minerals (K, P & Zn), vitamins B6, and Niacin. As per the Pearson Correlation computation.

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