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Dielectric behaviour study analysis on Indian wood species: *Tectona grandis L, Terminalia arjuna, Tamarindus indica, Shorea robusta, Annona squamosa, Pouteria sapota*

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ABSTRACT

In this paper, dielectric constant (ε′), dielectric loss (ε″), electrical conductivity (σ) and relaxation time(τ) behaviour were measured for six Indian wood species in the frequency range 100Hz–1MHz at room temperature. The significant variations in dielectric properties are observed from one species to other, dielectric constant (ε′) decreases for hard wood species with increase of frequency. Soft wood species dielectric constant (ε′) decreases with frequency up to 200 KHz and then increased with increase of frequency to1Mz .Relaxation times have been calculated for the six species at308K, which show that hard wood species exhibits three and soft wood exhibits two relaxations discussed critically with their structure.

Keywords: Indian wood species, Dielectric constant (ε′), Dielectric loss (ε″), Electrical conductivity (σ), and Relaxation time (τ)

INTRODUCTION

The measurement of dielectric properties of materials is critical to understanding the electromagnetic field distribution in the materials. Apart from those, wood is a complex biomaterial has basic properties and significantly different even in the same tree (Ze-Xin Fanet al., 2009). Therefore it would be affected the function in its use. Wood has great variation in their structure and cells for each species of wood or even in the same species has conspicuously. Therefore it gives well establish its function as well as appropriation in further used. Wood utilization closely intertwined by its properties as well as has to be cautiously considered due to it's possess hygroscopic characteristic which of relate closely to the surrounding environmental (Antony Finto et al., 2009).

Dielectric properties of wood have both theoretical and industrial applications. They also provide a better understanding of the molecular structure of wood and wood-water interactions (Resch Helmuth., 2006). The behaviour of water with the constituents of wood such as cellulose and lignin can be understood more clearly by studying dielectric properties. Dielectric properties of material are influence frequency, temperature, water content, density, composition and material structure. Wood has dielectric properties and non ideal polarization conduct dissipation phenomena, energy adsorption, and damages that influence dielectric constant (James, W.L et. Al, 1965; Kabir F.,2001).

The dielectric properties of material are intrinsic properties expressed by the relative complex permittivity $\varepsilon^*=\varepsilon'- j\varepsilon''$, where ε' is the dielectric constant and represents the ability of a material to store electrical energy and ε'' is the loss factor and represents the loss of electric energy in the material. Amount of loss is described by a parameter loss tangent (tanδ). The dielectric parameters are generally dependent on frequency, temperature, density and other factors such as material structure and composition (Bansal et al., 2001; Nelson, 1992).

This present Investigation is concern to the dielectric properties such as dielectric constant (ε′), dielectric loss (ε″), electrical conductivity (σ) and relaxation time (τ) of several Indian wood species at room temperature in sundried condition.

MATERIALS AND METHODS

For the study of dielectric properties, six different wood logs (Table.1) are collected belonging to different botanical families from different places at normal dried condition for present investigation. The test samples were obtained from the sapwood region in the form of pellets; Dielectric constant and dielectric loss factor and electrical conductivity were measured at low frequencies from 100Hz to 1MHz by the computer using the low frequency impedance analyzer Hioki 3532-50 LCR-Hi tester Koizum, Japan

Table.1. Data of wood species for the present investigation

Name of Wood species	Type of wood	Botanical Family
Tectona grandis L.	Hard wood	Lamiaceae
Terminalia arjuna	Hard wood	Combretaceae
Tamarindus indica	Hard wood	Fabaceae
Shorea robusta	Hard wood	Dipterocarpaceae
Annona squamosa	Soft wood	Annonaceae
Pouteria sapota	Hard wood	Sapotaceae

RESULTS AND DISCUSSION

a) Dielectric Properties

Dielectric data for frequencies from 100Hz to 1M Hz at room temperature 308K are presented in Fig.1-3 by taking 5 samples each. The variations in dielectric properties are observed from one wood species to other and they depend on type of wood species (Hard and Soft wood) .The dielectric constant (ε') decreases for all the six wood species nearly up to 200 KHz at room temperature 308K, also it was observed that by varying the frequencies in hard wood species dielectric constant (ε') decreases to 1MHz. In soft wood species such as in *Annona squamosa* after 200 KHz dielectric constant (ε') increases abruptly with frequency. In hard woods Decrease of dielectric constant (ε') shows that the contribution of interfacial polarization becomes insignificant, and the predominant polarization is molecular; that is, energy is absorbed in the form of induced dipole moment of the molecule, and in the form of alignment of molecules having fixed dipole moment. The increase in dielectric constant (ε') at low frequency for soft wood, can be explained by the fact that the dipolar groups are bound in the solid structures so that the dipole is a structural element of the solid lattice and rigidity of the lattice hinders the orientation of the dipoles .It is assumed that the fixed dipole moment of the cellulose molecules and the interfacial polarization at lower frequencies are both activated by thermal energy. This concludes that dielectric constant (ε') affect the amount of power that is dissipated in soft wood in the form of heat (Kabir, F.M et.al 2001). Fig.2 shows that a decrease and increase in the dielectric loss at low frequency range from 100Hz to 1MHz. An elevated dielectric loss in hard and soft wood results in higher power absorption by wood in the form of heat. Conversely a lower dielectric constant favors higher heat absorption in wood. Inhomogenity likes defects, space charge formation and lattice distortions etc. in the interfacial layers together produce an absorption current resulting in dielectric loss (Vasubabu et al 2016).

Fig.3 represents variation electrical conductivity of different for different woods species, when measured 100Hz to 1MHz frequency range , reveals that the significant variations which may be attributed to the extent of hydration, molecular architecture, nature and composition of woods. In spite of the fact that each constuient of the wood has its own physiological individuality, definite relations between wood parameters

b) Relaxation Time

Dielectric parameters of materials are function of many exponential controlled parameters, the main issue is the temperature dependency of characteristics of relaxation times, it represents rate of chemical reaction rates. The Cole – Cole plot is a simple, elegant and highly useful tool to determine dielectric relaxation of a material in a particular range of frequency. Dielectric relaxation exhibits in wood due to the frequency and temperature dependence of dielectric parameters, different dielectric relaxations observed in different woods with different characteristic frequencies (Table 2).The number of relaxations from Cole-Cole plots, which show proportionality to the concentration of dipoles contributing to the orientation polarization, increasing with increase accessibility of dipoles in wood samples. In the present investigation, the results of dielectric parameters of different type of woods, reveals that hard woods shows three dielectric relaxations where as soft woods shows two dielectric relaxations. This concludes that in soft wood the power is dissipated in the form of heat with frequency variation which diminishes the relaxation of water content present in wood ie, the orientation polarization of hydroxyl group.

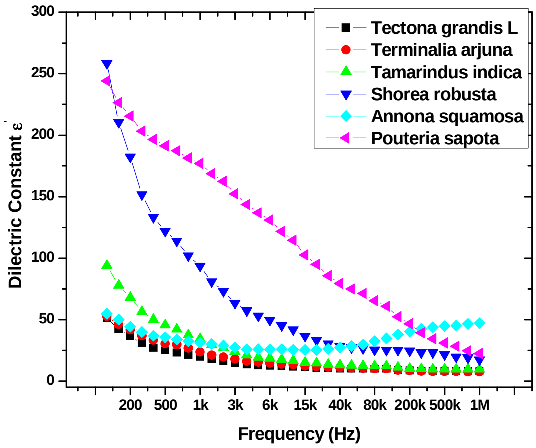

Fig.1 .Variation of Diectric constant (ε′) of different wood species as a function of frequency from 100Hz to 1MHz

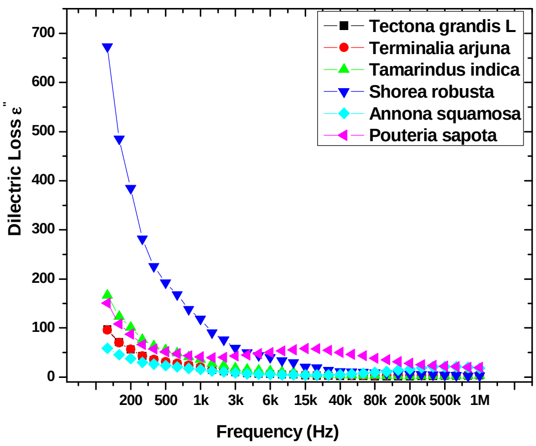

Fig.2 .Variation of Diectric loss (ε′′) of different wood species as a function of frequency from 100Hz to 1MHz

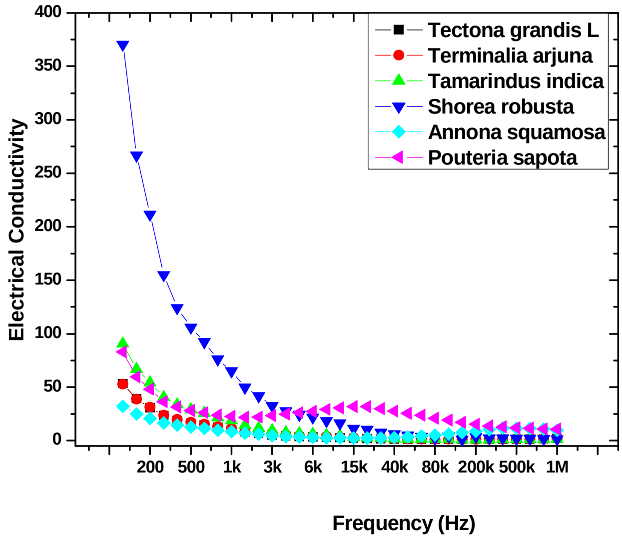

Fig.3 .Variation of Electrical conductivity (σ) of different wood species as a function of frequency from 100Hz to 1MHz

Table.2. Data on Cole-Cole parameters

Name of wood species	Type	Characteristic frequency(Hz)	U	V	θ	Relaxation time(sec)
Tectona grandis L. (TL)	Hard wood	2K 6K 800K	8.4 4.4 6.1	22.3 7.1 2.3	14.5 22.5 27	0.03 µ 0.5 µ 0.49n
Terminalia arjuna (TA)	Hard wood	1.5K 6K 800K	12.3 5.8 3.6	37.1 7.7 2.4	35 18.5 28	0.07 µ 0.4 µ 0.04n
Tamarindus indica (TI)	Hard wood	3k 15K 800K	4.9 8.9 3.5	1.4 26.8 6.9	21.5 35.5 22	0.102 µ 0.65 µ 0.05n
Shorea robusta (SR)	Hard wood	1K 5K 40K	13.8 6.8 2.3	24.6 13.7 3.4	20 21 39.5	0.034 µ 0.8 µ 8.2 µ
Annona squamosa (AS)	Soft wood	2K 5K	12.3 11.2	21 16.4	31.5 15	0.02 µ 0.03 µ
Pouteria sapota (PS)	Hard wood	10K 20K 100K	18.5 13.1 18.2	34.3 21 33.5	12 21 13.5	0.16µ 0.2 µ 0.035n

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