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Investigations of dielectric behaviour and relaxation time effect on Indian wood species: *Mangifera indica L, Azadirachta indica, Ficus religiosa, Casuarinaceae, Murraya koenigii, Haldina cordifolia.*

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ABSTRACT

In this paper, dielectric constant (ε′), dielectric loss (ε′′), electrical conductivity (σ) and relaxation time(τ) were measured for six Indian wood species in the frequency range, 100Hz–1MHz at room temperature. The 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 relaxations and soft wood species shows two relaxation times.

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

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INTRODUCTION

Wood is complex bio material; it's clear with its structure and composition, the components, gives great contribution to the particular functions and services [1]. Each species of wood or even in the same species shows different of cells and its structures. Based on their structure, wood is used for engineering applications. Wood utilization is considered due to its hygroscopic characteristic that relate closely to the surrounding environment [2]. For practical purposes, the influences of the anisotropy of wood, the fiber orientation in respect to the electric field, must be considered also [3].The optimum field orientation in an application of electric field is noted from the dielectric properties for the field orientation parallel to the grain, which is characteristic of wood and paper products [4].

One of the basic properties, which explain structure of materials as dielectric property of solid possesses ability to storage electrical energy. Although wood is a combustible material, there are several ways in which it outperforms fireproof metal in fire [5]. When wood is placed in an electric field, the current-carrying properties of the wood are governed by certain properties, such as moisture content, density, grain direction, temperature; and by certain components such as cellulose, hemicelluloses, and the lignin of wood. They also vary in an extremely complicated [6].

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 ($\tan\delta$). The dielectric parameters are generally dependent on frequency, temperature, density and other factors such as material structure and composition [7-9].

Complex dielectric spectroscopy technique will be used to study the dielectric properties/parameters of the compounds using a computer controlled LCR meter/impedance analyzer at an ac signal over a wide range of frequency and temperature. Dielectric properties analysis basically involves the display of the dielectric data in different formalism and provides us the maximum possible information about the materials. The display of dielectric properties data in the complex plane plot appears in the form of a succession of semicircles attributed to relaxation phenomena with different time constants due to the contribution of grain (bulk), grain boundary and interface/polarization in a polycrystalline material. Hence, the contributions to the overall electrical property by various components in the material are separated out easily.

This Investigation aimed to reveal 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 sun dried condition.

MATERIAL 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	Botanical Family
Mangifera indica L	Hard wood	Anacardiaceae
Azadirachta indica	Hard wood	Meliaceae
Ficus religiosa	Hard wood	Moraceae
Casuarinaceae	Hard wood	Casuarinaceae
Murraya koenigii	Soft wood	Rutaceae
Haldina cordifolia	Hard wood	Rubiaceae

RESULTS AND DISCUSSION

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 *Murraya koenigii* 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 [6]. 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.

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

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

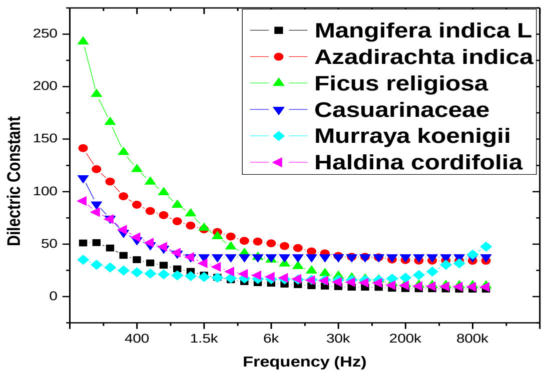


Fig 2: Variation of Diectric loss (ε′') of different wood species as a function of frequency from 100Hz to 1MHz.

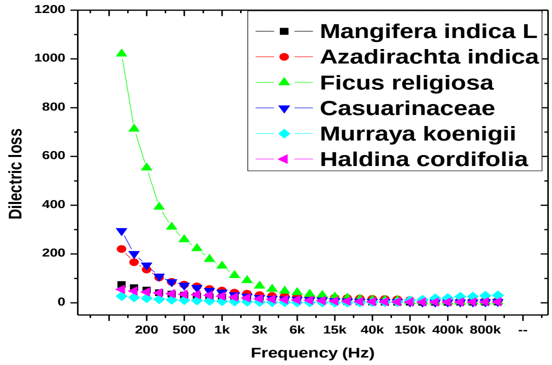
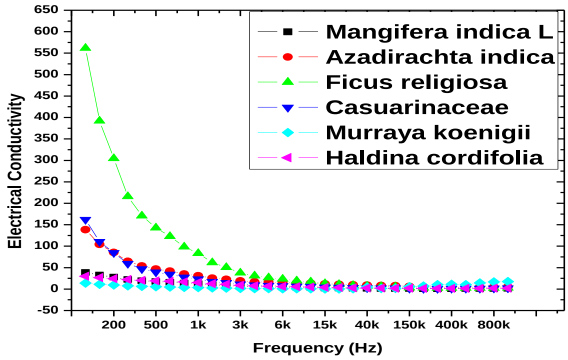


Fig 3: Variation of Electrical conductivity (σ) of different wood species as a function of frequency from 100Hz to 1MHz



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.

Table 2: Data on Cole-Cole parameters

Name of the wood species	Type	Characteristic frequency(Hz)	U	V	θ	Relaxation time(sec)
Mangifera indica L	Hard wood	2K 4k 150k	9.6 8.1 1.5	14.1 47.2 3	12 43 35	0.012µ 0.07 µ 0.023µ
Azadirachta indica	Hard wood	1.5K 30K 400k	12.4 5 2.3	31 11.5 6.2	24.5 18 27	0.04 µ 0.15 µ 2.95n
Ficus religiosa	Hard wood	2K 8K 60K	17.1 4.2 1.9	24.5 9.7 3	39 11 27.5	0.02 µ 0.5 µ 5.12 µ
Casuarinaceae	Hard wood	1.5K 4K 200K	22 11.2 1.2	34.3 14.3 3.7	41 30 23.5	0.02 µ 0.6 µ 3.65 µ
Murraya koenigii	Soft wood	1K 4K	14.9 5.3	42.2 21.6	9 12	0.05 µ 0.02 µ
Haldina cordifolia	Hard wood	2K 8K 100K	13.2 5.3 2.9	29.9 9.9 3.1	19 11 20.5	0.02 µ 0.4 µ 1.72 µ

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