Study of Ac conductivity and Electrical properties of Shorea robusta wood species as a function of Chemical Treatment

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Abstract:The aim of present investigation is to study the behavior of electrical properties and ac conductivity of Shorea robusta wood species as a function of chemical treatment (NaOH) at different concentrations 3%, 6%, 9%, 12% and 15%.Frequency dependence of dielectric parameters like dielectric constant, dielectric loss and ac conductivity of the composites were investigated in the frequency range from 100Hz to 1MHz at different concentrations. The results showed that the chemical treatment effect on Shorea robusta wood species lowers its dielectric constant and dielectric loss with concentration compared to untreated wood. It was also found that dielectric constant and dielectric loss factor values decreased with increase in frequency of the applied field. However, the ac conductivity of all wood samples is found to increase with increase in frequency.

Keywords: Chemical treatment, dielectric constant, dielectric loss and Ac conductivity, Shorea robusta wood species.

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 [4-10]. The dielectric properties of a hardwood are significantly varies by chemical treatment [13-16]. To our knowledge, despite its important effects, chemical treatment has not been extensively studied.

Shorea robusta (Sal tree) is a species of tree belonging to the *Dipterocarpaceae* family is native to southern Asia It is often the dominant tree in the forests where it occurs. Sal tree is one of the most important sources of hardwood timber in India, with hard, coarse-grained wood that is light in colour when freshly cut, and becoming dark brown with exposure. The wood is resinous and durable, and is sought after for construction, although not well suited to planning and polishing. Sal resin of the sal tree is known as ṛla in Sanskrit and is used as an astringent in Ayurvedic medicine. It is also burned as incense in Hindu ceremonies, and sal seeds and fruit are a source of lamp oil and vegetable fat [11-12].

This work studies electrical properties such as dielectric constant, dielectric loss and ac conductivity is measured at different concentrations (3%, 6%, 9%, 12% and 15%) with caustic soda (NaOH) for 1hr at 110^{0}C on *Shorea robusta* (Sal tree) wood species

II EXPERIMENTAL PROCEDURE:

2.1 Materials

Shorea robusta (Sal tree) wood logs were obtained from Alankar Tubular Furniture Manufacturing Company, Vijayawada; Andhra Pradesh, India Sodium Hydroxide pellets of 99% purity were obtained Suvarna Scientifics, Vijayawada, Andhra Pradesh, India.

2.2 Chemical treatment:

Shorea robusta (Sal tree) wood logs were washed to remove dust and dirt and then normal dried for present investigation. Chemical treatment involved a procedure of immersing wood logs in NaOH solution with concentration of 3,6 9,12 and 15% at ambient temperature of 110^{0}C for one hour, then test samples are washed with distilled water, dried for one week under sun radiation.

2.3 Electrical properties:

For the study of dielectric properties, 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, for untreated and chemical treated wood samples with different concentrations.

III RESULTS AND DISCUSSION

Dielectric properties such as dielectric constant, dielectric loss and Electrical conductivity property measurements at different frequencies ranging from 100Hz to 1MHz were conducted at room temperature for *Shorea robusta* (Sal tree) wood, Both untreated and alkali-treated wood materials at different concentrations (3,6 9,12 and 15%) were used in experimentation presented from Figure 1-3.

From Figure 1 it can be observed that dielectric constant values of both untreated and alkali-treated wood materials decreased with increase in frequency, and when compared with untreated wood, alkali-treated wood recorded lower dielectric constant at all frequencies. This is due to the fact that during the alkali treatment, breaking of cross links of amorphous hemicelluloses and lignin with cellulose takes place, and their constituents like hemicelluloses and xylene are removed. This would lead to increased crystalline and reduced moisture absorption capacity of the wood fiber. Also, alkali treatment, by breaking the hydrogen bonds, makes the hydroxyl groups of the cellulose unit more reactive in addition to contributing to the fibrillation process (breaking down of fibers into smaller ones), which provides a large surface area leading to better mechanical interlocking between the fibers and matrix. All these factors result in lower absorption of water and orientation polarization. Consequently, dielectric constant of the alkali-treated wood fiber decreases [20-21].

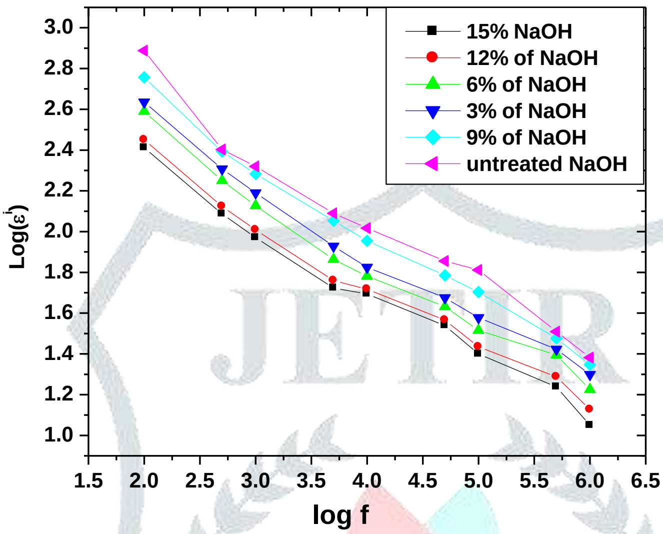

Fig. 1. Variation of Dielectric constant of *Shorea robusta* wood at low frequencies at different concentrations of chemical treatment.

From Figure 2, it is clear that dielectric loss of the alkali-treated wood fiber composites is lower than that of the untreated wood at all frequencies, and it decreased with increase in frequency. Dielectric Loss measures of the electrical energy that is converted to heat. After alkali treatment with NaOH, hemicelluloses, lignin, and other greasy elements were removed from the fiber, and this leads to a decrease in moisture content of the fiber, which in turn reduces the orientation polarization of the part that is present due to polar water molecules. At higher frequencies, the time available for molecular orientation will be too short. This would also reduce orientation polarization, which results in reduced loss tangent [17-20].

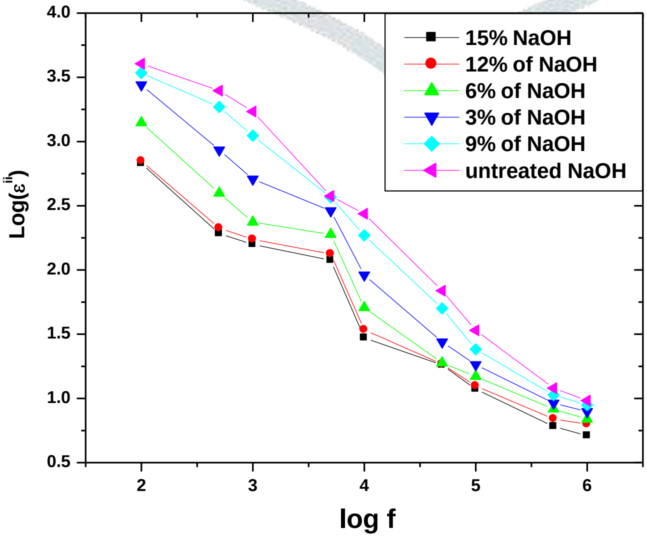

Fig. 2. Variation of Dielectric loss for *Shorea robusta* wood at low frequencies at different concentrations of chemical treatment.

From Figure 3, it is evident that conductivity of alkali-treated wood is lower than that of untreated fiber composites. In natural wood fiber, the conductivity mainly depends on water molecules adsorbed by the fiber surface. It is understood that the presence of water molecules is more important in untreated fiber than alkali-treated fiber as the hemicelluloses and lignin parts are removed. The reduced hydrophilicity of fiber after alkali treatment is the main cause for the lower conductivity of alkali-treated wood fiber composites than untreated wood fiber composites. However, the conductivity of both untreated and alkali-treated fiber composites increased with increase in frequency. This is mainly due to the additional contribution of finite-size clusters formed at higher frequencies. At excited frequencies, finite-size cluster charge carriers perceive an additive concentration due to their fractal nature [20-21]

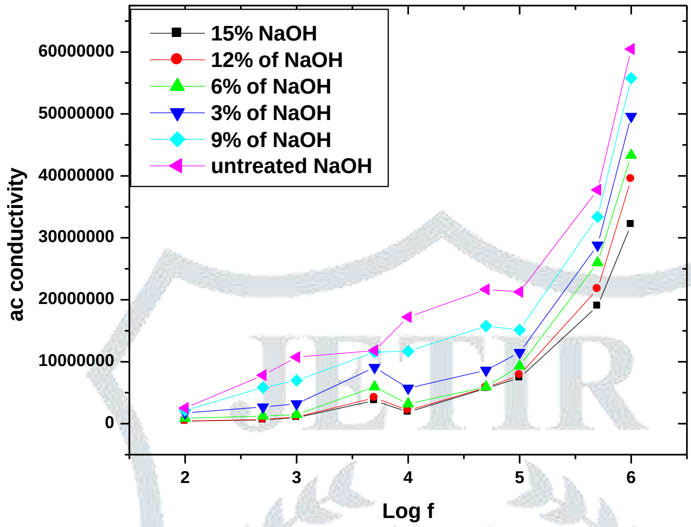

Fig. 3. Variation of ac electrical conductivity for *Shorea robusta* wood at low frequencies at different concentrations of chemical treatment.

IVCONCLUSIONS

Chemical analysis indicated lowering of % hemicelluloses and % lignin with alkali treatment. Conductivity of alkali-treated wood composites is lower than that of untreated wood composites. However, the conductivity of both types of composites increased with increase in frequency. Alkali-treated fiber composites exhibited a lower dielectric loss and lower dielectric constant than untreated wood. However, these values decreased with increase in frequency.

V ACKNOWLEDGEMENT

Authors express their thanks to Department of Physics, Sri Krishnadevaraya University, Anantapuramu, for providing laboratory facilities to carry out the present research work. The financial support rendered by the UGC under SAP[NO.F 530/5/DRS-II/2016(SAP I).and Department of Science and Technology under FIST [SR/FST/PSI-116/2007], New Delhi, are gratefully acknowledged.

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