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THE "LIQUID WOOD" BEHAVIOR IN ELECTROMAGNETIC FIELD

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Abstract: Due to the increasing demand for products and materials through some non-toxic, environmentally friendly and biodegradable alternative, society is always in a race to develop new, performant and biodegradable materials for specific applications. It is important to know and make use of the characteristics of these materials and their behavior in certain environments and conditions, so that, by using them in the future, to be improved their behavior in certain environments, and to find available or innovative ways of processing of their, in order to save energy in their processing or recycling. Therefore, we studied the action of the electromagnetic field on arboblend, arbofill and arboform "liquid wood" biocomposite. Characteristic parameters are determined (i.e. breakdown voltage, electrical conductivity, polarization degree) and we are going to establish the class of material to which it belongs from an electromagnetic point of view. Following their behavior in the external electromagnetic field is aimed at eliminating structural defects that may occur during the injection process thereby improving the quality and durability of products obtained by injection. The modification of the physicochemical properties of the three "liquid wood" biocomposite under the action of electromagnetic radiation depending on their frequency and energy are considered. The results will indicate the activity areas in which the use of these materials can have a major impact with significant environmental consequences.

Key words: electromagnetic, liquid wood, biocomposite, electrical conductivity, polarization degree.

1. INTRODUCTION

The Following the continuous development of human society and its daily needs, scientific research reveals, identifies and develops the use of the innovative materials that can be new or can replace materials whose widespread use irreversibly affect the environment. The diversity of the used plastics and their long biodegradability (1000 years, over 100 human generations) requires replacing them with new biodegradable materials and whose characteristics and properties are always researched and modified so as to be used optimally in different branches. One of these materials already used successfully in some industries is "liquid wood", a biocomposite known so far in three main variants: Arboform, Arbofill and Arboblend. Knowledge of the electrical properties of these forms of "liquid wood" is very important to determine the materials behavior during their processing as well as during their use in different conditions and environments.

Similar and yet somewhat different, the composition of the three forms of liquid wood causes different or similar behaviors in miscellaneous conditions sometimes. Thus, Arboblend V2® is practically difficult to differentiate from the classical polymer (polyethylene-PE or polyamide-PA), because its surface is smooth, with a compact appearance and pure white. It is almost exclusively composed of lignin (99%) and some natural additives. Arboform LV3® consists of a matrix of lignin (30%-60%) improved with a significant percentage of flax or hemp (40%). In this case, the cellulose imprints to the material a brown color and a slightly rough surface aspect. Natural fiber reinforcement improves the mechanical properties, giving the material rigidity. Arbofill is made up of a matrix of lignin (60%) improved with petrochemical polymers like polyethilene or polypropylene, mixed with natural fibres such as hemp, flax or even wood. The modification of the polymers components leads to obtain the miscellaneous types of Arbofill, depending on the needs and purpose of use. Arbofill is fully recyclable, too and looks like light colored wood, [1].

There is already a relatively extensive use of various forms of liquid wood: handles, accessories, panels, chairs in the furniture industry, floors and various junction elements in construction, the toys industry, the car industry, computers, telephones etc., [2]. Through this research we aim at deeper knowledge of these innovative materials and extending the use of different forms of liquid wood in various applications in order to improve the quality of life. Using of these new types of biodegradable materials such as liquid wood, will diminish the utilization of harmful, polluting plastic materials, always present, resulting a decreased rate of environmental pollution by limiting their presence.

Through previous research [2] it was determined that liquid wood is an electrically insulating material, but without accurately proving its properties. Electrical insulators are substances with large but not infinite rezistivity, with permitivity and other electrical properties which vary depending on various factors: temperature, external electric field, internal structure etc. In the external electric field, dielectrics suffer a polarization phenomenon, too, which may take various forms. Numerical values of electrical parameters experimentally measured and the polarization mode are factors that directly influence the dielectrics classification into five categories. Depending on the category to which it belongs, it is determined the use of a dielectric under certain conditions, [3]. The specific electrical parameters are relative permitivity ε_r, conductivity σ, breakdown voltage U_S, loss factor tgδ, and polarizability α.

2. TECHNOLOGY AND EXPERIMENTAL RESEARCH PLAN

In this research were studied three types of liquid wood: (1) Arboblend V2, (2) Arboform LV3 Nature, (3) Arbofill Fichte. In order to perform electrical investigations, on both sides of the samples were deposited silver electrodes, [2]. To eliminate the errors, we performed two sets of measurements using two different devices. The results were comparatively similar.

Dielectric constant and conductivity. The dielectric measurements were performed at room temperature with a Novoncontrol setup (Broadband dielectric spectrometer Concept 40, GmbH Germany), in the frequency range of 1÷106 Hz, placing the samples with uniform thickness between two copper plated round electrodes biased at 1.0 V, [4].

For the second measuring method, the determinations were performed by keeping the same conditions of temperature and the frequency, but we used a deck HF LCR Meters Wayne Kerr 6500P, [5].

A first set of measurements was performed to determine the variation of conductivity σ according to the frequency variation ν. In the second set of experiments we studied the variations of electric permitivity εr and the loss factor tgδ depending on frecvency variations ν for each studied sample. In a third set of measurements we determined the breakdown voltage for each sample.

Measurements allowed us to study the polarizability variation α, depending on frecvency variation ν.

3. RESULTS AND DISCUSSIONS

The figures from the dielectric spectroscopy measurements we used the collected data for plotting graphics for the relation σ = f(υ). In figure 1 are shown the electrical conductivity variations for the three materials studied: arboblend V2 Nature, arbofill Fichte and arboform L, V3 Nature.

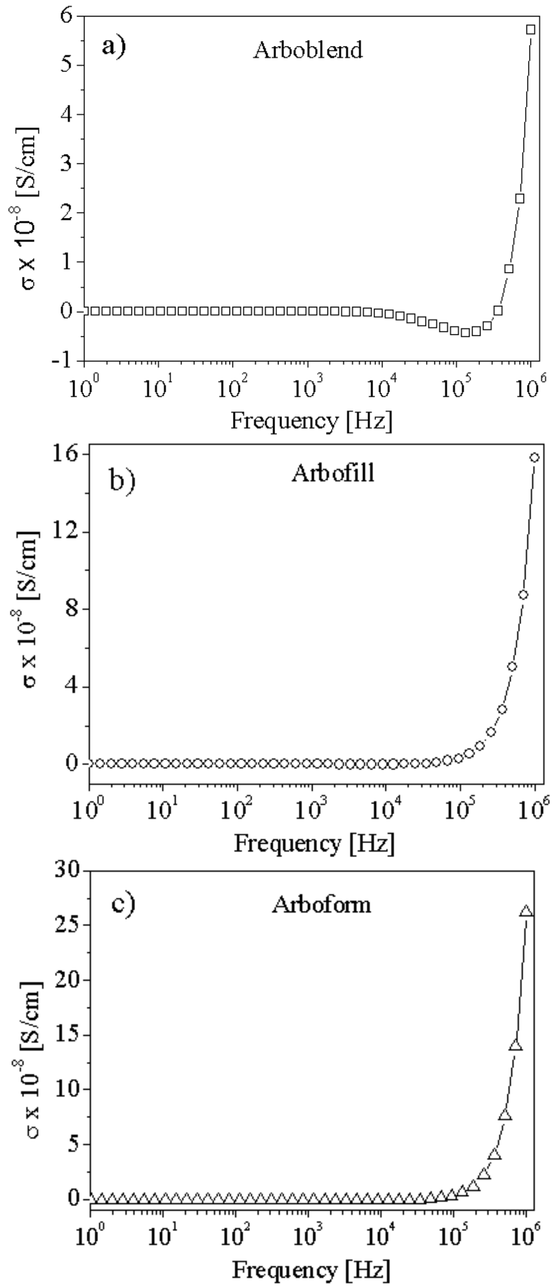

Fig. 1. (vertical)
Variation of electrical conductivity depending on the frecvency of the samples: (a) Arboblend; (b) Arbofill; (c) Aboform.

The next set of measurements was performed to determine the relative permitivity of the studied materials. At the same time there has been determined the loss factor for each material type.

The collected datas allowed us plotting graphics of the relative variation of electrical permitivity and loss factor, [5].

Another specific parameter of insulators is the breakdown voltage whose determination was performed by using films of the three types of material sandwiched between two metal electrodes and applying a ramp signal of 500 V/s. The working method for determining the breakdown voltage of each of the three samples is described below, [6].

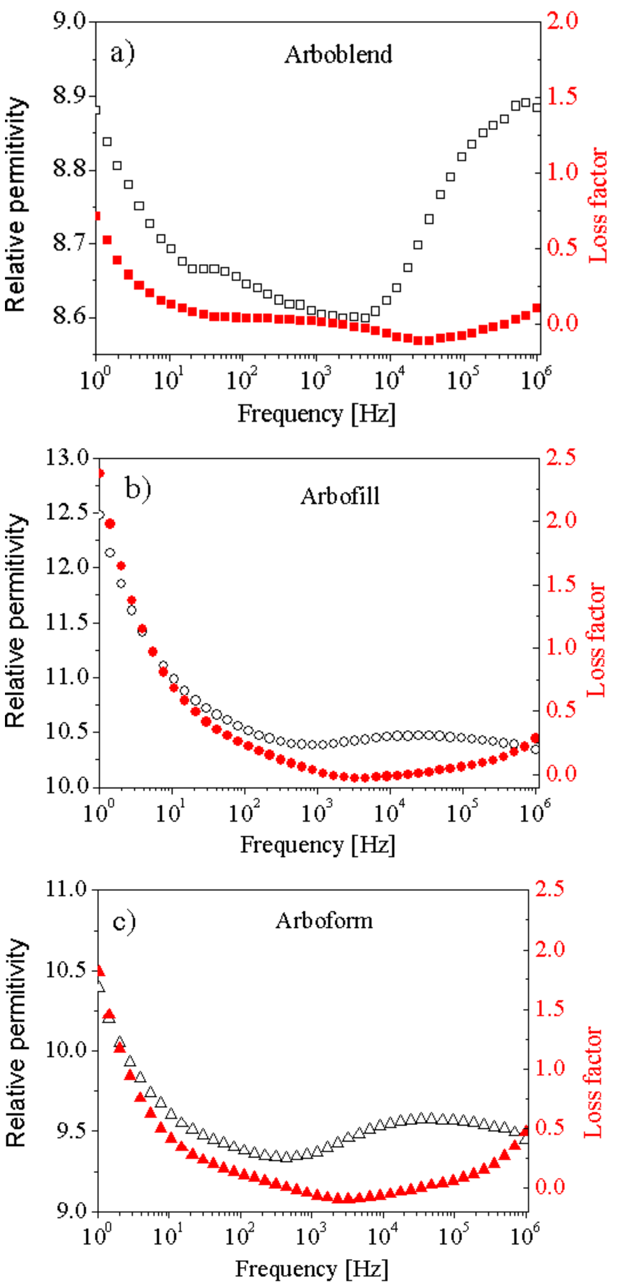

Fig. 2. Relative permitivity and loss factor as a function of frequency for: (a) Arboblend, (b) Arbofill, (c) Arboform.

The sample is placed between two unequal planar circular electrodes arranged coaxially (whose dimensions were 25mm in radius and 25mm high for High Voltage – HV electrode and 150mm in radius and 5mm high for the grounded one, respectively), through a plastic circular isolator for limiting the current leakages in the surrounding air. The uniform distribution of electric lines in contact area is assured by polishing both aluminum electrodes to a roughness of 5nm and rounding the HV electrode to give a radius of 0.5mm. HV amplifier (20/20C-HS, Trek), connected to a function generator (AFG3022C, Tektronix) protrudes the electric potential difference between electrodes and its time variation. The charging voltage of the sample is measured by using a HV probe (P6015A, Tektronix) connected to a digital oscilloscope (200 MHz, 2 G/s, Tektronix).

The breakdown voltage is measured by applying a ramp signal of 500 V/s in the range of (0 ÷ 20)kV and recording the time variation of the electrical voltage on the sample until the breakdown voltage occurs. This corresponds to a maximum value (breakdown voltage) measured by HV probe (Fig. 3) followed by a decreasing region as a leakage current appears.

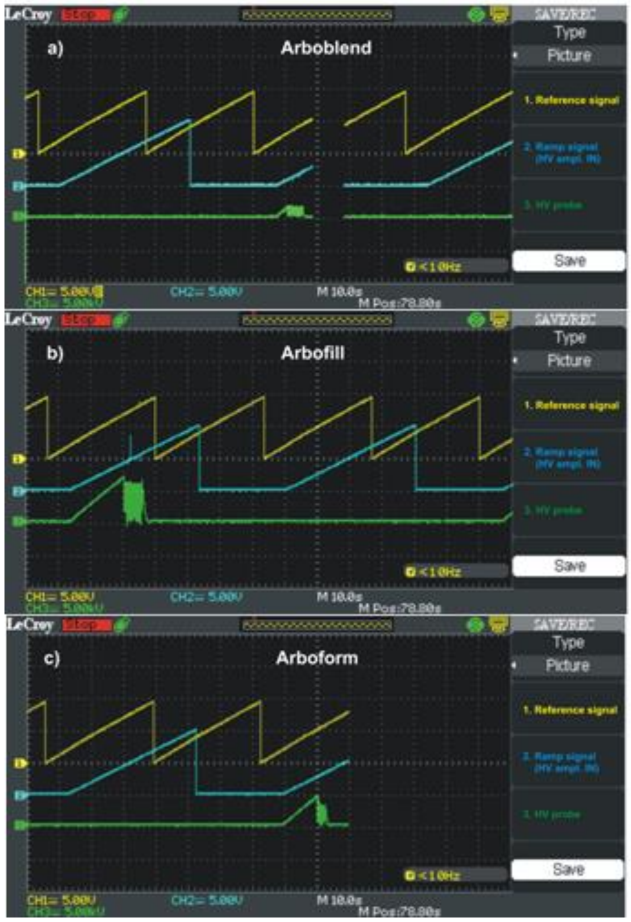

Fig. 3. Screen captures from the oscilloscope registering breakdown voltage (signal noted by 3) for: a) Arboblend, b) Arbofill, c) Arboform.
1-Reference signal, 2.Ramp signal (HV ampl, IN), 3.HV probe

In order to determine the breakdown voltage, the thickness of the obtained films were measured and the derived values are shown in Table 1.

Table 1. Breakdown voltage

Sample	Lignin content [%]	Voltage rate (V/s)	Thickness (μm)	Breakdown voltage (MV/m)
Arboblend V2	99%	500	100	20
Arbofill Fichte	60%	500	570	13
Arboform LV 3 Nature	30÷60%	500	550	9

Measurement of relative permitivity allowed us to determine the polarizability, too. We used the formula:

$$\alpha = \varepsilon_0(\varepsilon_r - 1)/n \quad (1)$$

where $\varepsilon_0 = 8,85*10^{-12}$ F/m, iar $n \sim N_A = 6,023*10^{23}$ part/mol.

The obtained results allowed us to draw graphics of the polarizability variations depending on the frequency for the three samples: (1) Arboblend V2, (2) Arboform LV 3 Nature, (3) Arbofill Fichte. As it can be observed from figure 4, in the case of each material studied, the polarizability reaches a plateau around 100 kHz.

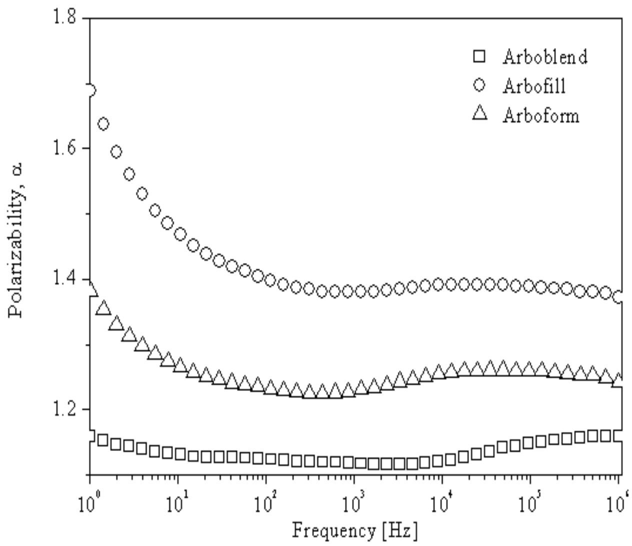

Fig. 4. Polarizability variation depending on the applied voltage frecvency

As it can be seen from figure 1, the conductivity of the materials studied approaches to zero while the frequency decreases below 100kHz. This can be explained by the material polarization due to the variation of the external electric field, [7].

Regarding the breakdown voltage, it can be observed that its value is influenced by the percentage of lignin in the material (Table 1).

The measurements of the relative electrical permittivity show a linear variation as a function of frequency at applying an external electric field. Each sample shows a minimum value of the relative permittivity in the frequency range of $(10^2 \div 10^4)$Hz (figure 2). This is in accordance with the statements effect above regarding the posteffect phenomenon between polarization and the electric field variation. These observations imply that, in the near future, we will study the electrical hysteresis for all three forms of "liquid wood". The loss factor graphs are in accordance with the obtained results for the relative permittivity.

4. CONCLUSIONS

The electrical properties of the three forms of "liquid wood", Arboblend, Arbofill and Arboform were studied. The electrical conductivity, relative permitivity, polarizability and breakdown voltage were determined. Analyses of the obtained results suggest that the "liquid wood" is a dielectric that can be used in the manufacture of electrical equipment: doses, switches, sockets etc. This is supported by the fact that it is also a fireproof material, [1]. Also, the results suggest that the liquid wood may have diverse applications for any pieces which request a dielectric and/or a fireproof material.

In our future researches we will focus on the study of the "liquid wood" polarization to see how polarization it is affected by the temperature, knowing that for the inlet temperature range of $(28 \div 60)^oC$ some types of this material present a microcrystalline structure, [8]. Also, we will investigate the behavior of the "liquid wood" at high frequency for different temperature ranges.

Considering this aspect, in our future studies we will examine if orientation of microcrystals occurs in electromagnetic field within the specified temperature range and if certain forms of presentation of the "liquid wood" have other specific properties when the material is doped with the atoms of the various metals, [9].

This research direction is induced including by the result of the research carried out on a composite with a biopolymeric lignin matrix which was processed to standard tests by doping with Pt atoms. The electrical resistance of this material has been substantially reduced in the described configuration from about 104 MΩ to 101 MΩ, [4]. These are target values for the areas used in electronic circuits without the risk of damaging the semiconductor components.

The results suggest that we could have more various practical applications for the three forms of the material generically called "liquid wood", knowing that today there is a very limited number of its applications.

5. REFERENCES

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