New Experimental Method for Measuring the Dynamic Behavior of the Average Density of Human Cell Membrane

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Abstract
In this paper, we present experimental results measuring of dynamic behavior of the average density of human cell membrane (ADHCM). The above results were obtained considering the application of a mathematical model as the density nonlinear function of parameters such as temperature, relative electric permittivity, and voltage resonance frequency, measured with an electronic device in the Central University designed by the research group ESSOPTO and membranes using as dielectric material between the plates of a flat plate capacitor. The nondestructive capacitive electronic circuit compares the frequency behavior of the density, with a reference capacitor sampling as electronic element.

Keywords: Density, membranes, dielectric material, electrical permittivity

Exposition of the Problem
In the experimental processes reported in (Moncada, M. E. et al, 2010; Volkov A.G. et al., 2014), the determination of the average density of human cell membrane (ADHCM), there are in use destructive technologies that they carry to establishing values of the ADHCM of a local way, without it could include the characterization of the properties electro mechanical, and inclusive electromagnetic of the cell membrane as dielectric material. Though it is true that the ADHCM reflects in it the behavior of the mechanical resistance and the properties of transfer of frequencies, also it reflects the thermal expansion and the molecular structure of this class of materials. At present the experimental technology most used and accepted by the majority of the laboratories and producing companies of medical equipment for the determination of the ADHCM, is the dual technology energy X-ray absorptiometry. This technology apart from being highly harmful according to the time of radiation exposure, does not offer any other information on the electromagnetic properties of the above mentioned compounds as: electrical and thermal conductivity \( \sigma_e \), \( \sigma_T \) impedance \( Z \), magnetic susceptibility \( \chi \), between others.

Theoretical Model
Departing from the theoretical developments presented by (Nadya, U. 2004) and (Hakulinen, M. A. et al. 2003) for the calculation of the electrical permittivity of dielectric material, the behavior of the ADHCM as a function of multiple variables, between them: OC-organic component, V-voltage generated by the samples under the action of an electrical uniform field, \( \varepsilon \)-electrical permittivity, w-resonance frequency, between others; it has been one of the principal aims of study of the group of investigation ESSOPTO in the Central University in last two years.

To be able to determine the value of the ADHCM for samples of cell membranes material, so much theoretical as experimentally, a model proposes of capacitors in series, constituted by the material to analyzing, the plates or arms of the capacitor and the air that one could present between them.

The value of the ADHCM to calculating would be:

\[
\text{ADHCM} = \frac{k_p k_1 d_p d_1 (C_L - A q_1)}{C_L (\varepsilon_p (k_p d_p - k_1 d_1) + k_1 k_p (d_1 - d_p)) - k_p d_p (\varepsilon_1 - k_1)} \tag{1}
\]

Where: \( \varepsilon_p \)-electrical permittivity of the air; \( k_H \)-electrical relative permittivity of the solid one; \( C_L \)-total distance between plates of the capacitor; \( A \)-area of one of the plates of the capacitor.

For the previous thing, the value of the ADHCM like distribution function will have the form:

\[
\text{ADHCM} = f(OC, w, V, \varepsilon, d,...) \tag{2}
\]

Where: \( d \)-thickness of the sample.

In this model, it is necessary bear in mind that the material is a phase configuration (air / solid, solid / solid, water/air) and that the physical properties previously mentioned change in every direction of movement in the material. For the previous reason, the vector of polarization will depend of: OC-organic component, degree of porosity, degree of transfer of frequency of the cell membrane with the periphery, the ADHCM, electrical permittivity and temperature.

Experimental Procedure
The previous theoretical model for the experimental development of the present work, initially took as values of reference of the ADHCM information of (Rodriguez, O, 2012;...
(Rodríguez, O. 2012, et al 2014), which later were compared by the obtained ones by the method proposed in the formless present for different samples of human cell membranes. (5 groups of people aged 19 years, were selected first group, and 36 years latter group, each of 20 members). The experimental data obtained for groups, (values of voltage, frequency, and calculating ADHCM) they were made at different times and at different time of day to eliminate influences of the laboratory conditions. With the values obtained by the method of simulation, one found a diversion of the curves in 1.18 % which the mathematical model led to correct in terms of the ADHCM of the samples.

**Analyses of Results**

In the sequence graphs of Figure 1, the behavior shown ADHCM, depending on the variables involved in the development experimental (phase of the incident wave in the sample, wave frequency, voltage generated samples), and theoretical model (1) proposed for calculation. Given these results it is clear that the greatest impact on behavior ADHCM It gives the phase of the wave, it describes the absorption peak of the function and behavior of the structure of the membrane. This because dipoles generated molecular structure having a specific resonance frequency network. This approach rules out reradiation of waves near the resonance peak, because the dipoles fail to acquire energy in the range of the incident wave to the membrane.

The dynamic behavior of the material in the range from 30 to 130 KHz, gives like proved initially, the activation of normal manners of oscillation of the dipoles of the structure of the H2O near to 50.4 KHz, and later for effect of collision, the activation in the measure the increase of the frequency of the dipoles of the net in strict sense. Experimental comparison. One of the electrical properties found in the cell membrane, was the presence of electrical hysteresis in several volunteer patients for testing. In Figure 2, the shift is seen in curve ADHCM in the measurement process of raising and lowering frequency levels.

**Figure 1**: Sequence showing the behavior of the ADHCM address the variables taken into account in the proposed in this paper theoretical model

**Figure 2**: ADHCM experimental behavior against the variables considered in the proposed in this paper theoretical model.

**Discussion of Results**

Having in counts the hypothesis raised in the theoretical frame on the anisotropic behavior of the samples, object of study, the figures 1 demonstrate the behavior of the ADHCM without the adjustment to the theoretical raised model, the curves follow the same path and trend, applying the model, this is achieved fitting the value of the resonance frequency for every sample.

**Conclusions**

By his anisotropic structure, to think a specific form of distribution of the cell structure is not adapted, for what the process of polarization that is generated to the interior of the samples, does that the electromagnetic sign gets depressed in such a way that this makes change the resonance frequency.
with the distance of tour of the electrical field in the sample, which in other words, comes closer the thickness of the same one. The previous thing generates a not homogeneous distribution of the energy in the volume of the samples, driving to make change this way the ADHCM of the same ones.

References


