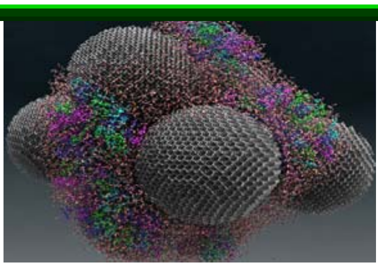

DIELECTRIC PROPERTIES OF BLOOD CELLS AS BIOMARKERS FOR CANER DIAGNOSTICS: EXPERIMENTAL DATA AND MATHEMATICAL MODELING

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Introduction

Molecular and cellular components of human blood exchibit dielectric properties that can be described by complex dielectric permittivity $\varepsilon^* = \varepsilon' - i\varepsilon''$, where ε' is the relative permittivity, ε'' is the loss factor. It was shown, the both ε' and ε'' values of the red blood cells (RBCs) and their ghosts at different frequences differ significantly in healthy blood of donors and in the cancer and stroke patients [1], that can be used in medical diagnostics and estimation of the individual treatment success including the use of nanodiamonds [2].

Materials and methods

In this study a comprehensive review of recent literature published on dielectric properties of RBCs and their membranes is presented. The measurement data are systematized by electric parameters, frequency limits, and diseases. Mathematical models of RBCs as fluid-filles multilayer viscoelastic shells are discussed. A generalized model of RBC accounted for bond water layer of different structure and density depending on the disease type/stage is proposed. The blood is considered as a concentrated suspension of aggregating microparticles suspended in the complex fluid containing the nanoparticles with additional degrees of freedom is developed. Complex dielectric properties of the single RBC model and blood suspension of different concentrations are computed.

Results and discussions

The obtained dependences of ε' and $\varepsilon^{//}$ on the temperature of the sounded suspensions of nanodiamonds at a concentration of 0.055% are characterized by a nonmonotonic change in the dielectric parameters at different ultrasound frequencies at one exposure time (5 min). This behavior is characteristic of processes in which the ratio between free and bound water in the solution changes alternately. For non-sounded nanodiamonds, several sites with increased hydration at 10, 23, 31°C are observed and in the interval 38-45 ° C and at 50 ° C. This can be explained by the fact that structural formations of nanodiamonds have several forms in aqueous suspensions [2] and at these temperatures a change in their conformation is observed. In general, the entire curve can be divided into three sections with increased hydration at: 10-15, 20-35 and 38-50°C.

The multidirectional nature of the change in ε' in the sounded and non- sounded suspensions of nanodiamonds is probably due to the influence of intermolecular interactions, namely, when the contribution of intermolecular interactions is insignificant, changes in the dielectric properties of suspensions occur only due to changes in the structure of particle conglomerates. The decrease of $\varepsilon^{//}$(22 kHz) can be caused by loosening the surface of the particle conglomerates under the influence of ultrasound, can lead to an increase in the amount of water bound by nanodiamonds. At low ultrasonic frequencies (15 kHz), due to intermolecular interactions, the probability of formation of crosslinks between conglomerates of nanodiamond particles increases in samples. In the solution, oligomers and aggregates appear, leading to a decrease in the hydration of nanodiamonds.

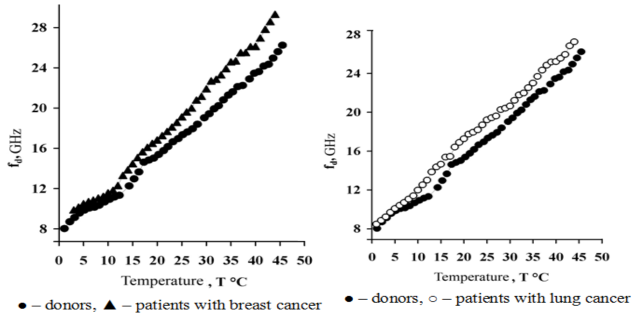

Fig.1.Temperature dependence of dielectric relaxation frequency f_d of H_2O in RBC suspensions.

Conclusions:

It is shown, the dielectric properties of RBCs, their membranes (water-filled shells) and blood with different RBC concentrations can be considered as biomarkers that are unique for the breast and lung cancer, different disease stage and treatment applied (chemoitherapy or X-ray therapy).

References:

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