2. URL: https://www.unian.ua/science/2108641-stvoreno-nanodrili-dlya-sverdlinnya-rakovih-klitin-foto.html (Date of appeal: 01/13/2019)

3. Sylakov K.I., Sylakova T.T. Proceedings of the National Technical University of Ukraine (Kyiv Polytechnic Institute). Radioaparatobuduvannya. – 2012. – 215 pp.

4. Voytovych Y.D. etc. Basic principles of modeling, designing and manufacturing medical nanorobotov. Part 1. Mathematical mashyns and Systems. – 2009. – №4. – 147 pp.

RESONANT METHOD FOR MEASUREMENT OF COMPLEX PERMITTIVITY OF MEDICINES AND BIOLOGICAL OBJECTS ON MICROWAVES

Strizhachenko A.V., Reshetnyak Yu.B., Dyagileva F.G.

Department of Biophysics and Information Technology

National University of Pharmacy, Kharkiv, Ukraine

a.strizhachenko@gmail.com

Introduction. The majority of substances existing in the nature are heterogeneous, i.e. consisting of several components which are divided by distinctly expressed limit of the section. When smashing one of phases and her uniform distribution in other phase disperse heterogeneous system is formed. Examples of such systems are powdery medicines, porous bodies, emulsions, suspensions, composite materials, and also almost all substances of a biological origin: blood and cellular suspensions, muscular and bone tissues, etc.

Aim. The aim of investigation is the measurement of a complex permittivity of medicines and biological objects on microwaves.

Materials and methods. One of research methods of heterogeneous disperse systems is the resonant method for measurement of complex permittivity that has been developed. It is based on consideration of the proceeding processes in substance under

the influence of electric field in connection with structure and a structure of substance. The questions that studied by such method closely adjoin to molecular physics in general and are connected with physical chemistry, physics of polymers, etc. Resonant method for measurement of complex permittivity [1,2] allows to obtain very valuable information about features of a substance structure of a biological origin, about the nature of intermolecular and intramolecular forces, about the structural violations and changes caused by various factors, etc. Objects of molecular biophysics, such as blood, serums, extracts, macromolecular and cellular suspensions, etc. represent liquid disperse systems with big dielectric losses.

Results and discussion. The way of calculation of permittivity of heterogeneous dispersive systems is the following. Some volume V is entered into consideration, which sizes are small in comparison with the sizes of all system, but are great in comparison with the local heterogeneities. Making averaging of electric field on the chosen volume $\vec{E}$ and electric induction $\vec{D}$ we will receive effective values, $\vec{E}$ and $\vec{D}$, in relation to which the considered heterogeneous environment is uniform and isotropic and as that, it can be characterized by a certain effective value of permittivity ε_{eff}.

For effective entered thus $\vec{E}$, $\vec{D}$ and ε_{mix} (ε_{eff}) ratios take place:

$$\overline{\vec{D}} = \varepsilon^{\text{см}} \overline{\vec{E}}, \tag{1}$$

$$\overline{\vec{E}} = \delta_1 \overline{\vec{E}}_1 + \delta_2 \overline{\vec{E}}_2, \tag{2}$$

$$\overline{\vec{D}} = \delta_1 \overline{\vec{D}}_1 + \delta_2 \overline{\vec{D}}_2, \tag{3}$$

where δ_i – a volume fraction for i components. From the equations (2), (3) follows

$$\varepsilon_{mix} = \varepsilon_2 + (\varepsilon_1 - \varepsilon_2)\delta_2 f_2, \tag{4}$$

or

$$(\varepsilon_{mix} - \varepsilon_1)\delta_1 f_1 + (\varepsilon_{mix} - \varepsilon_2)\delta_2 f_2, \tag{5}$$

where $f_i = \overline{\vec{E}_i} \Big/ \overline{\vec{E}}$.

For example, for particles of the spherical form:

$$f_i = \frac{1}{3}(2 + \frac{\varepsilon_{mix}}{\varepsilon_1}). \tag{6}$$

Ratios (4), (5) are the basis majority of the methods for calculation of permittivity of two-component heterogeneous disperse systems that have been described in literature. Various options of formulas correspond to various ways for calculation of coefficients f_1 and f_2, the particles considering a form, their orientation, interaction, etc. It is easy to see also, that ratios (4), (5) are easily generalized on a case of any number component. Knowing values δ_i, find permittivity for mix component may be to find. For this purpose, it's necessary to measure resonant frequencies of electromagnetic oscillations in the resonator for two close volumes of mix (to minimize dispersion of permittivity for disperse environments). And then to solve system of the equations are made for equation (4) or (5). It is also possible to solve the return problem: on known to permittivity mix component to find volume concentration the substances mix.

Conclusions. In work the resonant method for measurement of complex permittivity double objects on microwaves is offered. The offered method for measurement is less expensive, than the spectral methods of the analysis of heterogeneous systems existing now and it's easily generalized on a case of any number components in mix.

References:

1. Strizhachenko A.V. Measurement of anisotropic dielectrics on microwaves. Theoretical analysis, devices, methods/ A.V. Strizhachenko - Monograph. - Lambert Academic Publishing. - Germany. - 2011. - 282 P., ISBN 978-3-8454-4040-8.

(*https://www.lap-publishing.com/catalog/details/store/gb/book/978-3-8454-4040-8/*)

2. Strizhachenko A.V. The Measurement of Permittivity Tensor of Uniaxial Crystals with Tetragonal and Hexagonal Symmetry at Microwaves/ A.V. Strizhachenko // Electrical and Power Engineering Frontier. - 2013.-Vol. 2, № 1.- P.17-21. (*http://www.academicpub.org/EPEF/*)