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The Effect of Modulated Millimeter Electromagnetic Waves of Non-Thermal Intensity on the Physical Properties of Aqueous Solutions

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Abstract. The surface tension and density of bi-distilled water, water salt solution and salt solutions of the DNA, irradiated by non-thermal millimeter electromagnetic waves with the frequencies 64.5 GHz, 50.3 GHz and 48.3 GHz with modulation 1 Hz and 16 Hz are investigated. The measurements of test samples show that due to irradiation the surface tension does not change. The densities of water salt solution and the salt solutions of the DNA increase under irradiation at the frequencies 64.5 GHz and 50.3 GHz with modulation 1 Hz. When modulated with a frequency of 16 Hz, the density increases at a carrier frequency of 64.5 GHz and decreases at a carrier frequency of 50.3 GHz which coincides with the resonant frequencies of oscillations of water hexagonal structures.

Keywords: non-thermal millimeter electromagnetic waves, modulation, water structure, density

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1. Introduction

The physical parameters of electromagnetic waves (EMW) play an important role in the process of their interaction with living matter. It is interesting that living organisms contain an average of 65 to 95% water by weight. A special range of frequencies and powers of electromagnetic oscillations, in which EMW play an important role in the process of life activity at the molecular level, are non-thermal waves of the millimeter range (waves of low intensity,10 mW/cm^2 and below). An analysis of the experimental data available in the literature indicates that in living organisms, the primary target of millimeter electromagnetic waves (MEMW) is water, which plays a unique role in the functioning of living organs, as well as in the organization and stabilization of various biomolecules [1-3]. It is known [4, 5] that irradiation of aqueous solutions with frequencies resonant for vibrations of aqueous molecular structures can change the state of water, which in turn can affect the physicochemical properties of salts and macromolecules dissolved in it. The properties of water and aqueous solutions are largely determined by the cluster structure of water, and any changes in the hexagonal structure of water would lead to a change in the physical characteristics of the system.

We have recently shown that MEMW of non-thermal intensity are not absorbed by the surface layer of aqueous solutions, but penetrate into deeper layers of aqueous solutions and lead to dehydration of ions present in the solution, resulting in an increase in the density of aqueous-salt solutions [4].

Relatively recently [6, 7], the effect of modulated MEMS on neutrophils has been investigated. It is shown that under the action of MEMW with a carrier frequency of 41.95 GHz and a modulation frequency of 1 Hz, the effect changes direction, i.e., if the action of MEMW with a frequency of 41.95 GHz caused the inhibition of the synergistic reaction by about 25%, then under the action of modulated MEMW with these frequencies, activation of about 10% is observed. If another carrier frequency of 41.85 GHz is fixed, then irradiation of neutrophils with modulated MEMW at a frequency of 1 Hz causes inhibition of the synergistic reaction, and at a modulation frequency of 16 Hz, activation of the synergistic reaction is observed. Thus, the direction and magnitude of the effect strongly depends on the combination of carrier and modulating frequency. Therefore, the purpose of this work was to study the density of water-salt solutions and water-salt solutions of biopolymers when irradiating samples with non-thermal resonant millimeter electromagnetic waves modulated at frequencies of 1 Hz and 16 Hz.

2. Materials and Methods

The densities of bi-distilled water, water-salt solution, and the DNA were determined on a densitometer DNA 4500 Anton Paar with the sensitivity 10^{-5}g/cm^3. The coefficient of surface tension is determined by the Tensiometer SITA. The irradiation of solutions was carried out in a special glass container. Solutions were top covered by thin film of vinyl chloride which in transparent to radiation. As a source of MM- wave radiation, the generators of coherent extremely high frequency oscillations G4-141 and G4-142 (Russian made) were used. Frequencies regions for G4-141 is 37.5÷53.37 GHz (flux density at the sample location is 0.6 mW/cm^2), and for G-142- 53.3÷78.33 GHz (flux-density of 50 μW/cm^2). The stability of frequency of the generator signal was equal to ±0.05%. The conical radiating antenna is placed at the output of the generator. The samples were irradiated at the room temperature in the amplitude modulation mode with the frequency of 1 Hz and 16 Hz. We used calf thymus DNA from Sigma. DNA solutions were prepared in 0.9%NaCl -water solution Preparation and exposure of the solutions described in detail in [4, 5]. The concentration of the DNA in water-salt solutions of the DNA remains constant and equal to $6 \bullet 10^{-8}$g/cm^3. In tables shows the arithmetic mean values from six independent measurements. For the irradiation used frequencies of 50.3 GHz and 64.5 GHz (with coincide with the resonant frequencies of oscillations of the water molecular structures-hexagons and triads) and at a frequency 48.3 GHz, which does not coincide with resonant frequencies [3].

3. Results and Discussion

In [4], we showed that when aqueous-salt solutions and biopolymer solutions were irradiated with non-thermal intensity MEMW resonant (64.5 GHz and 50.3 GHz) and non-resonant (48.3 GHz) frequencies of vibrations of aqueous molecular structures, the surface tension coefficient within the experimental error does not change regardless of the irradiation time. Experiments show that irradiation of samples with carriers of the specified resonant and non-resonant frequencies at a modulation frequency of 1 Hz and 16 Hz does not lead to noticeable changes in the surface tension coefficient. Consequently, non-thermal, weak modulated MEMW are also not absorbed by the surface layer of aqueous solutions and penetrate into deeper layers of aqueous solutions. It is quite possible that as a result, some volumetric characteristics of aqueous solutions may change. To determine the effect of amplitude modulation on the nature of the effect of non-thermal MEMW with resonant and non-resonant frequencies of vibrations of aqueous molecular structures on the volumetric properties of aqueous solutions, samples were irradiated for 30, 40, 60, 90 and 120 minutes, after which the sample densities were determined. In the table 1 and 2 are data on the density of the studied samples with modulation of the carrier frequency of 1 Hz and 16 Hz.

Table1. Densities of bi-distilled water, water-salt and water-salt DNA solutions, non-irradiated and irradiated by the resonant and non-resonant MEMW for frequency modulation 1Hz at 20 ºC.

Duration of irradiation, min	Bi-distilled water	Water-salt solution	solution of DNA
Frequency of irradiation, 64.5 GHz			
0	0,99820±0,00002	0,99921±0,00002	0,99923±0,00002
30	0,99822±0,00002	0,99924±0,00002	0,99926±0,00002
40	0,99824±0,00003	0,99928±0,00002	0,99928±0,00002
60	0,99827±0,00002	0,99932±0,00002	0,99930±0,00003
90	0,99826±0,00003	0,99936±0,00002	0,99937±0,00002
120	0,99826±0,00002	0,99938±0,00002	0,99937±0,00002
Frequency of irradiation, 50.3 GHz			
30	0,99822±0,00002	0,99923±0,00002	0,99926±0,00003
40	0,99823±0,00002	0,99926±0,00002	0,99927±0,00002
60	0,99823±0,00002	0,99928±0,00002	0,99929±0,00002
90	0,99824±0,00003	0,99930±0,00002	0,99930±0,00002
120	0,99824±0,00002	0,99931±0,00002	0,99931±0,00002
Frequency of irradiation, 48.3 GHz			
30	0,99820±0,00002	0,99922±0,00002	0,99923±0,00002
40	0,99819±0,00003	0,99924±0,00002	0,99924±0,00002
60	0,99821±0,00002	0,99924±0,00002	0,99926±0,00003
90	0,99823±0,00003	0,99926±0,00003	0,99925±0,00002
120	0,99822±0,00002	0,99925±0,00002	0,99926±0,00002

Table2. Densities of bi-distilled water, water-salt and water-salt DNA solutions, non-irradiated and irradiated by the resonant and non-resonant MEMW for frequency modulation 16Hz at 20 ºC.

Duration of irradiation, min	Bi-distilled water	Water-salt solution	solution of DNA
Frequency of irradiation, 64.5 GHz			
0	0,99820±0,00002	0,99921±0,00002	0,99923±0,00002
30	0,99819±0,00003	0,99922±0,00002	0,99925±0,00002
40	0,99823±0,00002	0,99924±0,00002	0,99927±0,00002
60	0,99824±0,00002	0,99927±0,00002	0,99929±0,00002
90	0,99824±0,00002	0,99932±0,00002	0,99931±0,00003
120	0,99824±0,00003	0,99933±0,00002	0,99932±0,00002
Frequency of irradiation, 50.3 GHz			
30	0,99820±0,00002	0,99920±0,00002	0,99922±0,00002
40	0,99820±0,00003	0,99919±0,00002	0,99918±0,00003
60	0,99818±0,00002	0,99916±0,00002	0,99916±0,00002
90	0,99818±0,00002	0,99912±0,00002	0,99911±0,00002
120	0,99819±0,00003	0,99912±0,00002	0,99912±0,00002
Frequency of irradiation, 48.3 GHz			
30	0,99820±0,00002	0,99921±0,00002	0,99923±0,00002
40	0,99818±0,00003	0,99924±0,00003	0,99924±0,00002
60	0,99819±0,00002	0,99923±0,00002	0,99924±0,00002
90	0,99820±0,00002	0,99925±0,00002	0,99923±0,00002
120	0,99821±0,00002	0,99924±0,00002	0,99925±0,00002

It follows from Tables 1 and 2 that when irradiated with bi-distilled water with modulated resonant and non-resonant frequencies, the density of solutions does not change within the experimental error. For water-salt solutions and water-salt DNA solutions, when irradiated with frequencies resonant for vibrations of water structures (64.5 GHz and 50.3 GHz) with a modulation of 1 Hz, a similar pattern is observed (with an increase in the duration of irradiation, the density of water-salt solutions and DNA increases), which was observed without modulation. In our experiments, the DNA molecules, as a regular double-helix structure did not manifest themselves, and behave like a polyanione. However, as follows from Table 1, when irradiated with a frequency of 64.5 GHz, which corresponds to the resonant frequency of vibrations of free, non-hexagonal water structures (triads) of water molecules, a more noticeable increase in density is observed. When irradiated with a 16 Hz modulation MEMW, opposite results are observed for the resonant oscillation frequencies of hexagonal structures (50.3 GHz) and triads of water (64.5 GHz) [3]. With an increase in the duration of irradiation at a carrier frequency of 64.5 GHz, the density of water-salt solutions increases, but the relative increase in density is slightly less than with irradiation at 1 Hz modulation. At a carrier frequency of 50.3 GHz, as follows from Table 2, with an increase in the duration of irradiation, the density of water-salt solutions decreases: the opposite result is observed compared to the modulation frequency of 1 Hz. The decrease in the density of water-salt solutions may be due to an increase in the ordering of water molecules: an increase in the proportion of hexagonal structures in the solution or the formation of new (cubic, etc.) ordered water structures. Consequently, modulating the carrier resonant frequency of vibrations of aqueous molecular structures at the molecular level can lead to a change in the structuring of aqueous solutions. Depending on the values of the carrier and modulating frequency, an increase or decrease in the density of water-salt solutions is observed.

4. Conclusion

Thus, when water-salt solutions are irradiated with non-thermal modulated millimeter electromagnetic waves, depending on the carrier and modulating frequency, an increase or decrease in the density of water-salt solutions can be observed. In all likelihood, the decrease in density is due to an increase in the proportion of the number of molecules included in the hexagonal ordered water structures. It is also possible to form new, non-hexagonal [8] ordered structures of water (for example, cubic).

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