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EFFECT OF ELECTROMAGNETIC IRRADIATION AND ASPIRIN ON SURFACE TENSION OF HUMAN BLOOD PLASMA *IN VITRO*

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In this work the effect of EMI EHF on change of the surface tension coefficient of human blood plasma under the effect of acetylsalicylic acid (ASA) as well as dependence of this parameter change on ASA effect duration and electromagnetic irradiation duration have been studied. It was shown that the plasma irradiation results in changing of the surface tension coefficient. At irradiation during 60 *min* the value of the given parameter increases, though, the further repeating irradiation does not induce an enhancement; some decrease is observed, but it remains higher, than the original value. It was also shown that ASA prevents development of relevant changes of blood plasma properties, particularly the value of the surface tension coefficient of plasma under the effect of EMI in millimeter range changes.

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***Keywords*:** human blood plasma, acetylsalicylic acid, electromagnetic irradiation, surface tension coefficient.

Introduction. Electromagnetic irradiation (EMI) is mutually connected variable electric and magnetic fields or waves, spreading in the space. Spreading in the medium that possesses the certain properties, the irradiation interacts with that medium and induces some changes in it. Electromagnetic fields have binary nature: they possess wave and quantum properties. Depending on the wavelength there are gamma-irradiation, X-ray, ultraviolet, visible light, infrared irradiation, radio-waves and low-frequency electromagnetic oscillations. Electromagnetic waves are distinguished by the mode of obtaining, registration and character of interaction with compound [1, 2].

The studies showed that the effect of EMI on biological system depends on the oscillation frequency [3].

In the evolution process living organisms were adapted to natural electromagnetic field. As a result of various activities of human in the sphere of technologies the whole electromagnetic background of medium changes, EMI intensity depending on artificial sources increases, which makes the topic of the effect of the given physical factor on living organisms as well as the adaptation ability in changeable conditions.

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Cellular connection, satellite connection, radio- and television broadcasting contribute to EMI intensity increasing [4–6]. Revelation of resonant character of EMI effect on biological systems and effect on functioning of living organisms permit elaborating EMI application methods in biology and medicine. Particularly, EMI is used in extremely high frequency (EHF) therapy with fixed frequencies 42.2, 53.5, 60.1 *GHz* and microwave resonant therapy (MRT) irradiation frequency in 52–78 *GHz* diapason. Curing effect of electromagnetic fields are used at hyperthermia, laser surgery, physiotherapy etc. [4, 7].

We have shown that EMI in millimeter range (MM) affect albumin, invoking the certain conformational reconstructions in its dimensional structure [8]. As it was shown MM EMI affect not only proteins, but also whole cell, resulting in changes of electrokinetic potential of erythrocytes of rat blood [9].

Blood is a fluid of connective tissue; component of organism internal medium and the changes of blood properties can indicate alterations in organism, induced by the effect of different physical and chemical factors.

Blood, as a tissue, includes blood cells and plasma. Ratio between plasma and cells – hematocrit is relatively constant. Human volume of plasma composes about 55–60%, cells – 40–45% from whole volume of blood [10].

Acetylsalicylic acid (ASA) is widely applied for treatment of inflammatory processes, rheumatic diseases, pain syndrome and for prophylactic of thrombosis. Pharmacological effects of ASA depend on daily dose value. In small doses (from 50 to 325 *mg*) ASA possesses anti-heparin action. In doses 1.5–2.0 *g* ASA has an analgesic and heat-reducing action. In high doses (4–6 *g*) ASA possesses anti-inflammatory effect [11].

This work was aimed at studying of EMI EHF effect on change of surface tension coefficient under the effect of ASA, value dependence on ASA effect time and EMI effect duration. Determination of surface tension of plasma, serum, urine and spinal fluid is applied as a diagnostic test and ASA has a relevant value for diagnosis of number of diseases.

Materials and Methods. Study of EMI EHF effect on change of surface tension coefficient of irradiated plasma under the effect of ASA was carried out using the method of du Nui [12]. The method was based on force measurement, necessary for detachment of solid ring from surface layer of fluid.

In experiments human blood plasma was used from blood bank. The variants of experiments, in which ASA effect on non-irradiated blood plasma was studied, served as control. Surface tension was determined immediately after insertion of ASA dose in plasma through 0 *min*, 1 *min* (variant 1), 5 *min* (variant 2), 10 *min* (variant 3), 15 *min* (variant 4), 20 *min* (variant 5), 25 *min* (variant 6), 30 *min* (variant 7), 35 *min* (variant 8), 40 *min* (variant 9), 45 *min* (variant 10).

After insertion of aspirin the blood plasma was irradiated during 60 *min*. EMI with the frequency 42.2 *GHz* and the surface tension of each sample was determined. EMI EHF irradiation of plasma was carried out during 4 days, every day with duration 60 *min*.

As a source of EMI EHF G4-141 generator with working interval 37.5–53.5 *GHz* was used. Irradiation was carried out in far working zone of radiation with power flux density 0.6 mVt/cm^2.

Surface tension coefficient of plasma was calculated using the surface tension coefficient of water. At first, the real force of detachment from water was determined: $P_{H_2O}=P-p$, where P_{H_2O} is a detachment force from water, *mg*; *P* is detachment force, obtained in experiment; *p* is ring mass with water. Surface tension coefficient of water was calculated by the formula:

$$\sigma = \frac{0.981 \cdot P_{H_2O}}{\pi D}, \tag{1}$$

where *D* is platinum ring diameter; σ is surface tension coefficient of water.

To determine the surface tension of the studying fluid the ratio of the ring detachment force from the given liquid to the ring detachment force from water at the given temperature was calculated:

$$Q_x = \frac{P_{pl}}{P_{H_2O}}, \tag{2}$$

where Q_x is a ratio of the ring detachment force from plasma (P_{pl}) to the ring detachment force from water (P_{H_2O}). Q_x is connected to relative surface tension of the given liquid by the dependence that can be expressed by the equation:

$$Q_{real} = Q_x K - K + 1, \tag{3}$$

where Q_{real} is a relative surface tension of the given liquid. Ratio of the surface tension of the given liquid to the water surface tension is called a relative surface tension. Q_x is determined from the equation (2); *K* is empiric constant, determining for each ring. They determine the detachment force of the given ring from water and from any other liquid, the absolute surface tension of which can be found in tables. Often for this aim ethanol is applied (96%).

$$K = \frac{\frac{\sigma_{eth.}}{\sigma_{H_2O}} - 1}{\frac{P_{eth.}}{P_{H_2O}} - 1}, \tag{4}$$

where $\sigma_{eth.}$ is a surface tension of ethanol; $P_{eth.}$ – detachment force from ethanol.

Plasma surface tension coefficient was calculated by the formula:

$$\sigma_{pl} = \sigma_{H_2O} \cdot Q_{real}, \tag{5}$$

where σ_{pl} is surface tension coefficient of plasma (*din*/*cm*). All measurements were carried out at room temperature. The error in experiments does not exceed 5–10%.

Results and Discussion. The study of EMI EHF and ASA effect on the surface tension coefficient of plasma was carried out by the following Fig. 1: a) study of ASA effect on plasma surface tension; b) irradiation effect on this system.

EMI EHF irradiation of plasma was carried out during 4 days each day with duration 60 *min*. ASA effect was studied during 45 *min* according to the scheme, after single injection of ASA, the surface tension of plasma was determined after each EM irradiation by the frequency 42.2 *GHz*.

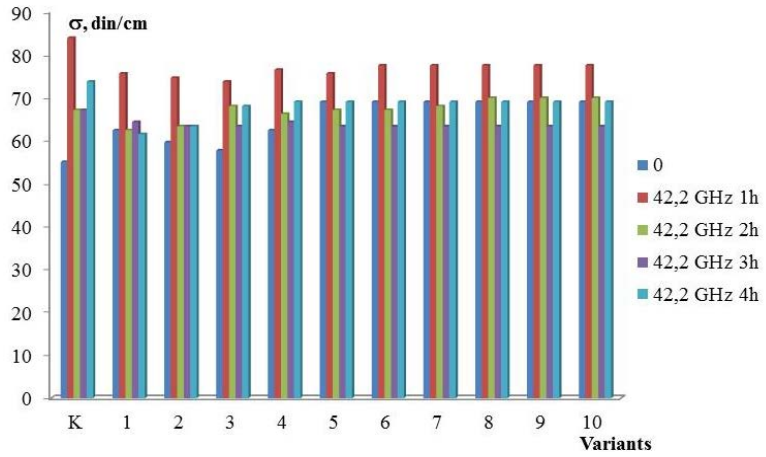

Fig. 1. Dependence of values of plasma surface tension coefficient on duration of ASA effect and EMI effect with the frequency 42.2 *GHz*.

Value of change depends on EMI EHF effect duration and ASA effect. At addition of ASA 2 *mg*/*mL* into plasma, the value of the surface tension coefficient begins changing. Through 1 *min* after injection of ASA the surface tension coefficient increases by 13.5%, then gradually decreases, but is not compared to the original value (Fig. 2).

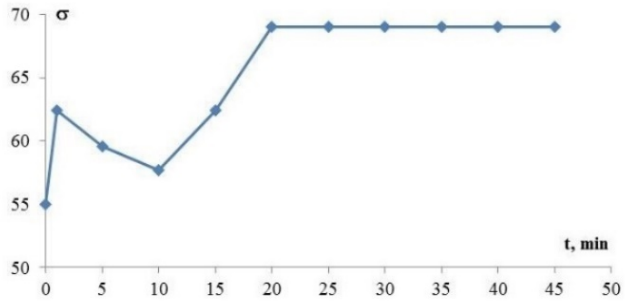

Fig. 2. Dynamics of change of surface tension coefficient of human blood plasma under the effect of ASA.

Through 10 *min* after injection of ASA (variant 3) the surface tension coefficient of plasma is higher, than that of control by 4.9%. Through 20 *min* after injection of ASA (variant 4) the surface tension coefficient of plasma is higher, than that of control by 25.5%; then the dependence comes out on plateau and further does not increase up to 45 *min*. The obtained results indicate the viscosity enhancement of human blood plasma in the presence of ASA with concentration 2 *mg*/*mL* (0.2%).

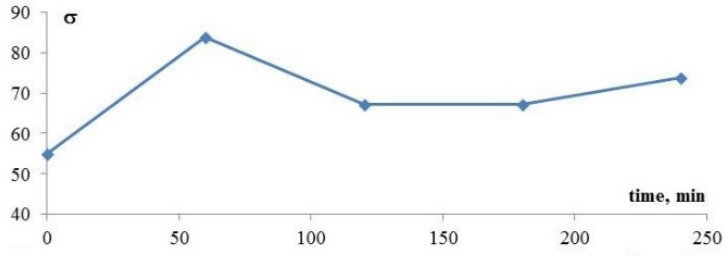

Fig. 3. Dynamics of change of surface tension coefficient of human blood plasma under the effect of EMI with the frequency 42.2 *GHz*.

Irradiation effect of EMI with the frequency 42.2 *GHz* on the surface tension coefficient of plasma was studied and its dependence on ASA was constructed (Fig. 3). It was shown that after 60 *min* of EMI irradiation with the frequency 42.2 *GHz*, the value of σ_{pl} increases by 52.5%. Plasma irradiation, containing ASA during 60 *min* also resulted in increasing of the surface tension coefficient value of human blood plasma (Fig. 1, 4, 5).

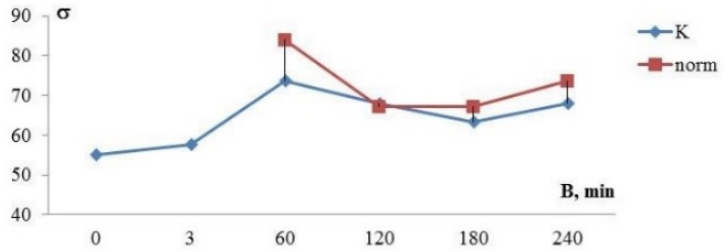

Fig. 4. Dynamics of change the surface tension coefficient of human blood plasma. *K* is non-irradiated variant 3 and irradiated variant 3. Norm-irradiated plasma without ASA.

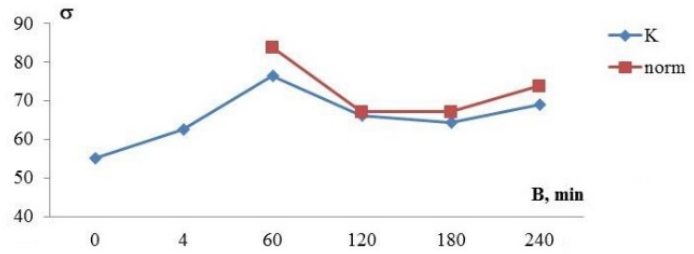

Fig. 5. Dynamics of change of the surface tension coefficient of human blood plasma. *K* is non-irradiated variant 4 and irradiated variant 4. Norm-irradiated plasma without ASA.

It should be mentioned that the induced changes are less expressed. Particularly, the increase of the surface tension coefficient of human blood plasma in variant 3 composes 34% as compared to control, but in variant 4 – 39% as compared to control. Similar results are observed at the irradiation during 180 *min*, 240 *min*.

After 180 *min* of irradiation of plasma by 42.2 *GHz* the value of σ_{pl} increases by 22%, for 240 *min* duration – by 34%. In variant 3, after 180 *min* irradiation the value of σ_{pl} increases by 15%, after 240 *min* irradiation – by 23%.

In variant 4 after 180 *min* of plasma irradiation with the frequency 42.2 *GHz*, the value of σ_{pl} increases by 17%, after 240 *min* of irradiation – by 25.4%.

Conclusion. Analyzing the results, we conclude that the plasma irradiation results in alteration of the surface tension coefficient. At the irradiation during 60 *min* the value σ_{pl} increases, but further the repeating irradiations do not induce an increase of σ_{pl}, some decreasing of the latter is observed, meanwhile the surface tension coefficient does not return to the original value, it remains higher, than the original value.

Comparing the data one can also conclude that ASA prevents development of relevant changes of blood plasma properties, particularly, values of the surface tension coefficient of plasma, viscosity of plasma under the effect of MM EM waves.

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ԷԼԵԿՏՐԱՄԱԳՆԻՍԱԿԱՆ ՃԱՌԱԳԱՅԹՄԱՆ ԵՎ ԱՍՊԻՐԻՆԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ՄԱՐԴՈՒ ԱՐՅԱՆ ՊԼԱԶՄԱՅԻ ՄԱԿԵՐԵՎՈՒԹԱՅԻՆ ԼԱՐՎԱԾՈՒԹՅԱՆ ՎՐԱ *IN VITRO*

Աշխատանքում ուսումնասիրվել են ԾԲՀ ԷՄՃ ազդեցությունը մարդու արյան պլազմայի մակերևութային լարվածության գործակցի մեծության վրա ացետիլսալիցիլաթթվի (ԱՍԹ) ազդեցության ներքո, ինչպես նաև այդ մեծության կախվածությունն ԱՍԹ-ի և ԷՄՃ ներգործության տևողությունից: Ցույց է տրվել, որ պլազմայի ճառագայթահարումը հանգեցնում է մակերևութային լարվածության գործակցի փոփոխությանը: 60 *րոպե* տևողությամբ ճառագայթահարման դեպքում տվյալ պարամետրի արժեքը մեծանում է, սակայն հետագայում կրկնվող ճառագայթահարումներն այդ մեծության աճ չեն հրահրում, դիտվում է որոշակի նվազում, սակայն դա մնում է ելքային արժեքից ավելի մեծ: Ցույց է տրվել նաև, որ ԱՍԹ-ն կանխում է արյան պլազմայի հատկությունների էական փոփոխությունների զարգացումը, մասնավորապես՝ պլազմայի մակերևութային լարվածության արժեքը միլիմետրային տիրույթի էլեկտրամագնիսական ալիքների ազդեցության ներքո:

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ВЛИЯНИЕ ЭЛЕКТРОМАГНИТНОГО ИЗЛУЧЕНИЯ И АСПИРИНА НА ПОВЕРХНОСТНОЕ НАТЯЖЕНИЕ ПЛАЗМЫ КРОВИ ЧЕЛОВЕКА IN VITRO

В работе исследовано влияние ЭМИ КВЧ на изменение величины коэффициента поверхностного натяжения плазмы крови человека под воздействием ацетилсалициловой кислоты (АСК), а также зависимость величины этого изменения от времени воздействия АСК и длительности облучения. Показано, что облучение плазмы приводит к изменению коэффициента поверхностного натяжения. При облучении в течение 60 *мин* значение данного параметра увеличивается, однако дальнейшие повторные облучения не вызывают его повышения, наблюдается даже некоторое уменьшение, однако значения коэффициента поверхностного натяжения остаются выше его исходного уровня. Показано также, что АСК предотвращает развитие значительных изменений свойств плазмы крови, в частности величины коэффициента поверхностного натяжения плазмы под действием электромагнитных волн *мм* диапазона.