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THE INFLUENCE OF NON-THERMAL COHERENT EMI EHF WITH LOW INTENSITY ON ELECTROKINETIC POTENTIAL OF RAT ERYTHROCYTES

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The influence of electromagnetic irradiation with extremely high frequencies (EMI EHF) on electrokinetic potential of rat blood erythrocytes was investigated. It has been shown that EMI EHF effect on biological system has different direction as well as depends on both frequency of irradiation and effect exposure. It has also been shown that the effect of external physical field on electrokinetic potential of erythrocytes is more expressed in case of suspension irradiation, compared to the rat irradiation, which indicates the stabilizing influence of both blood plasma and the whole organism. The processes stimulated in the organism are directed to the decreasing of external physical field effect.

EMI EHF – irradiation – erythrocytes of rats – electrokinetic potential

Ուսումնասիրվել է ծայրահեղ բարձր հաճախականությամբ էլեկտրամագնիսական ճառագայթման (ԾԲՀ ԷՄՃ) ազդեցությունը առնետների արյան էրիթրոցիտների էլեկտրակինետիկ պոտենցիալի վրա: Ցույց է տրվել, որ կենսաբանական համակարգի վրա ԾԲՀ ԷՄՃ ազդեցությունն ունի տարբեր ուղղվածություն, կախված է ճառագայթման հաճախականությունից և ներգործության տևողությունից: Ցույց է տրվել նաև, որ էրիթրոցիտների էլեկտրակինետիկ պոտենցիալի վրա արտաքին ֆիզիկական դաշտի ազդեցությունն ավելի ուժեղ է արտահայտված էրիթրոցիտների կախույթի ճառագայթահարման դեպքում առնետների ճառագայթահարման համեմատ, ինչը վկայում է արյան պլազմայի և ընդհանուր օրգանիզմի կայունացնող ազդեցության մասին: Օրգանիզմում խթանվում են այնպիսի պրոցեսներ, որոնք ուղղված են արտաքին ֆիզիկական դաշտի ազդեցության նվազմանը:

ԾԲՀ ԷՄՃ – ճառագայթահարում – առնետների էրիթրոցիտներ – էլեկտրակինետիկ պոտենցիալ

Исследовано влияние электромагнитного излучения крайне высокой частоты (ЭМИ КВЧ) на электрокинетический потенциал эритроцитов крови крыс. Показано, что влияние на биологическую систему ЭМИ КВЧ имеет различное направление, зависит от частоты излучения и длительности воздействия. Показано также, что влияние внешнего физического поля на электрокинетический потенциал эритроцитов сильнее выражено при облучении суспензии эритроцитов, чем при облучении крыс, что указывает на стабилизирующее влияние плазмы крови и организма в целом. В организме запускаются процессы, направленные на уменьшение влияния внешнего физического поля.

ЭМИ КВЧ – облучение – эритроциты крыс – электрокинетический потенциал

The life has been arising and developing on our Planet constantly being under the influence of external electromagnetic irradiation (EMI) the natural sources of which are mainly cosmic objects, and particularly the Sun. Moreover, at present the intensity of EMI having anthropogenic origin has been significantly increasing in biosphere. It has been shown that EMI with different wave lengths interacts with biological systems that have different levels of organization [1, 3, 7]. That is why the problem of estimation of complex effect of environment factors on biological systems becomes one of special interest in contemporary ecology. The mechanisms of EMI interaction with biological systems are discussed [1, 5].

Living organisms including human are intensively exposed to effect of EMI with both extremely high frequencies (EHF) and super high frequencies (SHF), so the investigation of these waves is very important. Moreover still now the mechanisms of non-thermal effect of EMI on cell and the whole organism are not thoroughly revealed. Results of investigation directed to the elucidation of mechanisms of effect of EMI EHF with low intensity are discrepant. For instance, irradiation of suspension of erythrocytes of human blood by coherent EMI EHF with low intensity and 20 min exposure results in changing of membrane physical-chemical properties, which in its turn leads to decrease in stability of erythrocytes at irradiation by frequencies that are near to water resonant frequencies [9]. It has been shown that in experiments *in vitro* the effect of millimeter waves on blood during 20 min increases the osmotic stability of erythrocytes as well as the activity of α-amylase, decreases the intensity of lipid peroxide oxidation, and does not effect the alanine aminotransferase activity of blood serum [8]. Authors point that one of the reasons of increasing of α-amylase activity used in water catalyze act, may be activation of water molecules by millimeter waves. In [6] decreasing of membrane osmotic stability of erythrocytes under the influence of EMI EHF was shown. The decreasing of membrane permeability to potassium ions on 30-40% was revealed compared with non irradiated samples. This effect is not conditioned by thermal impacts [2, 3]. Despite the permeability to EMI EHF is less, the effect on living organisms is significant and depends on irradiation frequency [10,13], besides millimeter waves possess high biological activity, even at low values of energy flux density, and EMI frequencies that are near by magnitude to water resonant frequencies may induce differently directed responses of biological system.

Different hypotheses of primary target of EMI EHF effect on biosystems were suggested [2, 4, 12, 14]. According to one of these hypotheses the primary target is water.

Investigations carried out on microorganisms and experimental animals have shown that EMI EHF of millimeter diapason effect on growth, development and metabolism of living organisms.

In present work the influence of coherent EMI EHF with low intensity on electrokinetic potential (ξ-potential) of rat blood erythrocytes has been investigated.

Materials and methods. The blood of rats of "Vestar" breed was used in experiments. For obtaining of suspension of erythrocytes several drops of rat blood were added in physiologic solution. As a source of monochromatic EMI EHF Г4-141 generator with work region of frequencies 37.5-53.57 GHz was used. Rats were irradiated by EMI EHF with low intensity with frequencies 49 GHz, 50.3 GHz and 51.8 GHz and power flux density 0.6 m Wt/sm^2. Moreover the irradiation was carried out one-fold with 20 min exposure, and repeatedly with 20 min exposure. Rats were irradiated during 4 days. The irradiation was carried out in distant zone of generator irradiation. The value of ξ-potential was calculated by following formula [11]:

$$\xi = 140\overline{\omega}$$

where $\overline{\omega}$ is electrophoretical mobility of particle that is the ratio of particle linear rate to electric field potential gradient.

Results and Discussion. In present work the influence of repeating irradiations by EMI EHF on ξ-potential of rat blood erythrocytes has been investigated. In complicated colloid systems such as cytoplasm of erythrocytes the motion of dispersion phase versus

dispersion surrounding under the influence of electric field may be realized in result of which potential difference between dispersion phase and dispersion surrounding is formed.

Potential difference on the border of two phases shifting versus each other is called ξ-potential. The surface of erythrocytes contacting with plasma or physiologic solution acquires charge, but in liquid phase near to surface a layer of solution is formed enriched by opposite charge ions – double electric layer is formed. The mutual shifting of phases is observed under the influence of electric field the rate of which depends on ξ-potential magnitude. It is known that increasing of concentration of electrolytes in liquid phase results in decreasing of electrophoretical transfer rate of colloid particles that is decreasing of ξ-potential absolute magnitude [11]. Furthermore effect degree is as more expressed as opposite charge is higher. External physical field superposition changes ξ-potential magnitude of erythrocytes. Investigation of influence of both in vivo and in vitro irradiations on properties of erythrocytes as well as of repeating influence of mentioned factor shows that the effect of EMI EHF has different direction and depends on irradiation frequency. The cumulative effect of influence is observed. The values of ξ-potential after one-fold in vitro irradiation of erythrocytes in suspension and erythrocytes of rat blood irradiated in vivo are represented on fig. 1. The dependence of ξ-potential on irradiation multiplicity is represented on fig. 2. ξ-potential changes in different days of irradiation indicate the induction of processes in organism directed to stress removal conditioned by external physical factor. It is maintained by small changes of ξ-potential of rat erythrocytes at one-fold and twofold irradiations by EMI with 49 GHz frequency. Particularly one-fold irradiation by EMI with 49 GHz frequency and 20 min exposure of suspension of erythrocytes results in increasing of ξ-potential magnitude on 18%. Moreover at one-fold and twofold irradiations of rats by EMI with 49 GHz the potential magnitude of erythrocytes of irradiated animals practically does not differ from that of control animals.

After threefold irradiation ξ-potential of erythrocytes is a little less than control value, but after fourfold irradiation is less compared with control on 31%. Most probably organism does not succeed in neutralization of external physical field effect.

Irradiation by EMI with 50.3 GHz and 51.8 GHz frequencies and 20 min exposure of suspension of erythrocytes increases ξ-potential value compared with control one on 39% and 51% respectively. One-fold irradiation of rats by EMI with 50.3 GHz and 51.8 GHz frequencies also induces the increasing of ξ-potential values of erythrocytes. Thus after irradiation of rats by EMI with 50.3GHz frequency and 20min exposure ξ-potential of erythrocytes increases on 29%, and with 51.8GHz - on 20%.

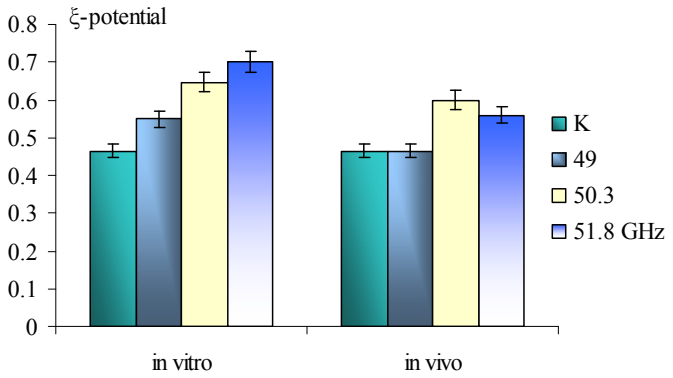

Fig. 1. The influence of EMI EHF on ξ-potential of erythrocytes of both rat blood suspension irradiated one-fold *in vitro* and blood of one-fold irradiated rats *in vivo*.

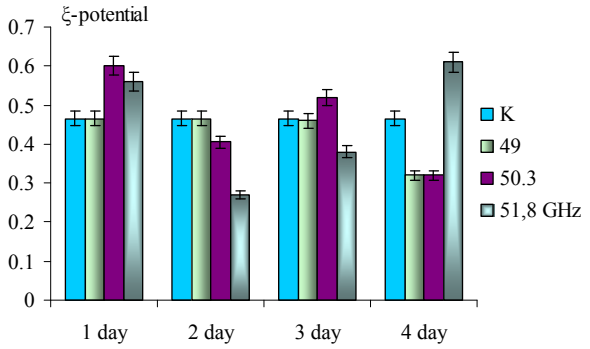

Fig. 2. The influence of EMI EHF on ξ-potential of erythrocytes of blood of irradiated rats.

After two-fold irradiation the direction of organism reaction is changed: the magnitude of ξ-potential of erythrocytes of irradiated rats is less than the control values by 13%. After threefold irradiation ξ-potential increases in 1.2 times compared to control. But fourfold irradiation results in significant decreasing of studying parameter: after four days of irradiation of rats ξ-potential of erythrocytes is less compared with control values by 43%. Another character of changes is observed at irradiation of rats by EMI with 51.8 GHz frequency. After two-fold irradiation ξ-potential of erythrocytes of irradiated rats strongly decreases: it becomes less from control values by 42%, but the magnitude of change compared with potential after one-fold irradiation composes about 62%. Further irradiation results in increasing of ξ-potential: after three days of irradiation it becomes less from control values on 18%, but after fourfold irradiation exceeds the control value by 31%.

The change in the ξ-potential magnitude may be conditioned by alteration of physical characteristics of both plasma and membrane of erythrocytes. As ξ-potential magnitude is changed not only at suspension irradiation of erythrocytes, but also at irradiation of animals, it may be assumed that irradiation results in changing of membrane properties. On the other hand the degree of change and the dependence character of magnitude of observed changes on one-fold and repeating irradiations indicate that plasma exhibits a stabilizing effect and in some way limits the change of both surface charge magnitude and charge of opposite ions in double electric field.

Therefore, based on the obtained results, it can be assumed that the effect of external physical field reflects stronger on studied parameter of erythrocytes in case of suspension irradiation of erythrocytes which in its turn indicates the stabilizing effect of blood plasma and the whole organism. The processes running in organism are directed to the decrease in external physical field effect. Besides, the magnitude of response and the direction of changes depend on EMI frequency.

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