Full Length Research Paper

Change of Electrokinetic Potential Value of Rat Blood Erythrocytes Irradiated by EMI EHF

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Abstract. The change of electrokinetic potential (ξ-potential) value of erythrocytes in rat blood has been studied under the influence of electromagnetic irradiation with 41.8 GHz and 42.2 GHz frequencies. It was shown that this physical field with the mentioned frequencies effects on the organisms compared to non-irradiated control ones. Moreover the multiple effect results in more obvious changes of erythrocyte ξ-potential value which indicates that cumulative effect of the factor is observed. It was also shown that the processes start acting in organism directing to weakening of external factor effect.

Keywords: EMI EHF, rat blood erythrocyte ξ-potential value, one-fold and multiple irradiations, cumulative effect

1. INTRODUCTION

Electromagnetic irradiation (EMI) is known to be the carrier of information (Presman, 1997). EMI intensity increasing which is connected with appearing of huge amount of artificial sources of electromagnetic waves attracted a big attention to the problem of safety of this ecological factor for separate organisms and the whole biosphere. EMI from different artificial sources irradiating in different frequency diapasons has a pronounced effect on living organisms. Nowadays it has been shown that EMI with extremely high frequencies (EHF) may influence practically all known types of cells in systems of arbitrary organization level of living material (Babayian et al., 2006; Kalantaryan et al., 2010; Vardevanyan et al., 2013). Thus, it has been revealed that EMI EHF in frequency diapason of 41.6-42.0 GHz results in yeast growth rate changing in logarithmic phase (Grundler and Kaiser, 1992). Short-term irradiation by 42.2 GHz frequency results in enhancement of chromatin condensation in slime membrane cells of human mouth (Shckorbatov et al., 1998).

It is known that in extreme conditions adaptation processes are initiated in organism: mobilization of reserve possibilities, reconstruction of homeostatic mechanisms (Deryugina et al., 2010), plastic and energetic exchange intensity change; a key role in organism metabolism belongs to blood and first of all to erythrocytes that supply the tissues by oxygen (Krylov et al., 1998; Krylov et al., 2009). The overall performance of erythrocyte oxygen transporting function is possible only in the conditions of their fast and unhampered motion through the blood circulatory system due to electrostatic repulsion of cells from both each other and vessel walls (Cook et al., 1961). Consequently, the realization of whole respiratory function by erythrocytes and blood depends on physical properties of erythrocyte membranes. It has been shown that EMI EHF effects on oxygen transporting function as well as antioxidant potential of erythrocytes (Chunyan and Tribat, 2008; Loginov et al., 1999). In blood rheological properties the determining value has surface charge of erythrocyte membranes (Mokrushnikov, 2010; Kunitsyn et al., 2007). It is accepted to judge about phenomena occurring on erythrocyte surface as well as cellular charge magnitude by cell motion rate in electric field – electrophoretical mobility (Deryugina et al., 2010). Electrophoretical mobility as integral criterion of physical-chemical properties of plasma and membranes, serve as an indicator of blood system and whole organism state (Baker and Clark, 1983). Electrophoretical mobility decreasing of erythrocytes may be conditioned by erythrocyte aggregation strengthening, microcirculation degrading, and finally tissue hypoxia developing (Chunyan and Tribat, 2008; Vitebskii et al., 1983; Sokolova et al., 1987). In animals’ organism the surface charge stability of blood erythrocytes is supported and their functional activity is regulated, moreover realization mechanisms of these processes remain hitherto none clear. From
this point of view the study of EMI EHF effect on electrokinetic potential of blood erythrocytes of irradiated animals as a factor inducing stress and organism response reaction to external physical field are quite important.

In present work the results of multiple irradiation effect with 41.8 GHz and 42.2 GHz frequencies on electrokinetic potential ($\xi$-potential) of rat blood erythrocytes are represented.

2. MATERIALS AND METHODS

The blood of nonpedigreed white rats with 70-80g weight was used in experiments. Rats were kept in room illumination, at room temperature (20-25°C) as well as were feed by combined nutriment containing 20% of animal proteins, 5-7% of fats and 70% of granule nutriment. As a source of monochromatic EMI EHF generator G4-141 with 37.5-53.5 GHz working interval region was used. Rats were irradiated by EMI with low intensity as well as 41.8 GHz and 42.2 GHz frequencies. The power flux density was 0.6mWt/cm². Moreover the irradiation was carried out every day, one-fold, with 20 min duration. The rats were irradiated during 5 days. Every day the blood of control (non irradiated) and irradiated animals was taken and erythrocyte mobility rate in electric field was determined. The blood from control animals was taken from carotid artery, but from irradiated ones – ears; then lime acid was added to avoid of blood coagulation. The blood was centrifuged during 10 min with 500g speed (GlobalRoll Model:90-1 Electronic Centrifuge Capacity). Plasma was removed and erythrocytes were suspended in physiological solution with calculation when suspension optic density was equal to 0.7. The obtained suspension was placed in electrophoretic camera via pipette. Electrophoretic camera was glassy. Camera was placed on microscopy table and electric chain was tuned on. Mobility rate of particles was determined during a time necessary for particle to pass distance between two divisions of microscopy ocular grid. Measurements were carried out 40-50 times and middle arithmetic value of mobility rate of erythrocytes in electric field was calculated. $\xi$-potential value was calculated according to the formula:

$$\xi = 140\omega$$

where $\omega$ is particle electrophoretic mobility, i.e. relation of particle linear rate to electric field potential gradient (Panosyan et al., 1989).

![Fig: 1. Absolute values of $\xi$-potential of erythrocytes of control animals and irradiated animals by 41.8 GHz and 42.2 GHz frequencies during 5 days](image)

3. RESULTS AND DISCUSSIONS

EMI effect with 41.8 GHz and 42.2 GHz frequencies on electrokinetic potential of rat blood erythrocytes was studied. On figure 1 absolute values of $\xi$-potential of blood erythrocytes of control and irradiated during 5 days animals are presented. At one-fold irradiation of animals with 41.8 GHz and 42.2 GHz (fig. 1, 1st day) significant increasing of $\xi$-potential absolute value compared to control is observed. Repeating irradiations increase a degree of change of $\xi$-potential value of experimental animal erythrocytes.

Dynamics of $\xi$-potential magnitude changes of erythrocytes of animals irradiated by EMI with 41.8 GHz and 42.2 GHz frequencies differs. During the first two days of experiment the magnitude of $\xi$-potential value of animals’ erythrocytes exposed to one-fold and two-fold irradiation by 41.8 GHz frequency, increases 1.43 and 1.4 times respectively compared to control. Moreover at irradiation by 42.2
GHz frequency, organism’s bigger response is appeared: after one-fold and two-fold irradiations the determining parameter increases 1.62 and 1.66 times respectively compared to control. After three-fold EMI irradiation with 41.8 GHz frequency determining parameter change degree increases and this tendency is observed in the case of animals exposed to four-fold irradiation. ξ-potential of irradiated animals exceeds control values 1.82 and 2.47 times respectively. In the 5th day of experiment ξ-potential value decreases a little moreover significantly exceeding control values (2.37 times).

At EMI irradiation with 42.2 GHz frequency the effect on organism develops slowly: in the third day of experiment ξ-potential value is approximately the same as in the case of erythrocytes of animals exposed to one-fold and two-fold irradiation – is higher from control values 1.69 times. Further the value of change sharply increases and this tendency is preserved, in the fifth day in spite of the results obtained at irradiated animals by 41.8 GHz frequency, ξ-potential value continues increasing compared to control and is higher than that of animals exposed to four-fold irradiation: four-fold irradiation of animals induces ξ-potential increasing 2.46 times and five-fold irradiation – 2.64 times compared to control.

Character of ξ-potential value changes after multiple irradiations indicate about cumulative effect of EMI EHF. Calculated data according to determining parameter change degree after each irradiation compared to precursor irradiation are presented on fig. 2. Determining parameter change degree depends on EMI frequency. Based on the changes of ξ-potential value, after each irradiation, EMI with 42.2 GHz frequency effects stronger on biological system than EMI with 41.8 GHz frequency. The dynamics of changes differs as well: in the second day of EMI effect organism response to the external factor decreases which may be connected with homeostasis, moreover the repeating irradiation destabilizes internal medium of organism and the destabilizing effect of EMI with 41.8 GHz frequency is expressed stronger. Biological system responses differently to multiple effects of EMI with different frequency: the degree of ξ-potential value changes after EMI irradiation with 41.8 GHz frequency in the second and the fifth days of irradiation is less than in precursor days which may indicate about development of processes in organism directing to suppression of development of processes induced by external physical field. The character of changes induced by EMI with 42.2 GHz frequency points to suppression of organism protecting mechanisms.

There exist works showing that EMI with super high and extremely high frequencies results in different changes of hematological parameters of rats up to blood-creating organs (Demisa et al., 2004; Zaghloul, 2011; Ali et al., 2003).

![Fig 2](image-url)  
**Fig 2:** Dynamics of ξ-potential value change degree of blood erythrocytes of rats exposed to multiple effect of EMI

### 4. CONCLUSION

ξ-potential magnitude is determined by surface charge value of erythrocytes. ξ-potential change at animal irradiation indicates EMI EHF effect on membrane properties. This effect may be a consequence of immediately effect of electromagnetic waves on membranes of cells, or mediated – through the change of organism internal medium properties, particularly changes of water properties that result in changing of physicochemical properties of organic molecules, and as a consequence, cellular membranes.
REFERENCES


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