PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY

Chemistry and Biology 2018, **52**(2), p. 105–109

Biology

EFFECT OF MILLIMETER ELECTROMAGNETIC WAVES ON BUFFER CAPACITY OF ALBUMIN

M. A. SHAHINYAN [*], M. S. MIKAELYAN, M. R. DARBINYAN, A. V. NERKARARYAN

Chair of Biophysics YSU, Armenia

The effect of millimeter range electromagnetic waves (MM EMW) on albumin buffer capacity has been studied. It was shown that MM EMW irradiation of albumin in 0.9% NaCl solution leads to protein buffer capacity change and the direction of this change depends on the irradiation frequency. At the same time the physiological solution, in which the protein is dissolved, does not possess the buffer capacity. At the irradiation of albumin solution by water resonant frequency 51.8 *GHz* protein buffer capacity increases. At the irradiation by non-resonant frequency for water, 42.2 *GHz*, albumin buffer capacity decreases.

***Keywords*:** millimeter range electromagnetic waves, irradiation, physiological solution, albumin, buffer capacity.

Introduction. Electromagnetic waves of biosphere are the integral part of external factors affecting living organisms [1, 2]. Meanwhile, nowadays the intensity of these waves enhances because of increasing the number of artificial sources of electromagnetic waves [3]. Connected with this the studies directed to the revelation of possible consequences of the influence of millimeter range electromagnetic waves (MM EMW) on biological systems become valuable. Over evolution the living organisms differently get adapted to this factor impact. Natural background of these waves is not high and the natural selection preserves those forms that survive in the given conditions. However, the mentioned factor of the environment is not indifferent to living organisms: it was shown that MM EMW affect biological objects being on any level of organization [4–6]. Influencing the biological systems MM EMW alter physico-chemical parameters of these systems.

One of the important constituents of biological systems of higher animals is blood. It was shown earlier that the effect of MM EMW results in alteration of various physico-chemical parameters of the blood: plasma surface tension, erythrocyte surface charge, albumin fluorescence, thermostability and etc. [7–10]. Apart from the main functions (transport and osmo-regulation) albumin also contributes to homeostasis establishment. Taking into consideration the relevant functional value of albumin, the aim of this work was to study MM EMW effect on one of physico-chemical characteristics of protein–buffer capacity.

[*] E-mail: m.shahinyan@ysu.am

Materials and Methods. Human serum albumin ("Sigma", USA), 0.9% NaCl containing physiological solution, Na-citrate were used in experiments. Generator G-141 ("Istok", USSR) with 37.5–53.5 *GHz* working interval and 64 $\mu W/cm^2$ power flux density served as MM EMW source. The specific absorption rate was equal to 4 *mW*/*kg*, this meant that it did not invoke thermal effects [4]. Electromagnetic field was homogeneous and the sample was placed on 180 *mm* distance from the waveguide and entirely was under MM EMW action zone. The irradiation was carried out in Petri dishes that were covered by cellophane layer, preventing water evaporation. The width of the irradiated solution was 1 *mm*. The samples were irradiated during 60 *min*. In the vicinity of the irradiated sample the temperature was almost 25°*C* and did not change over the irradiation process. Buffer capacity was measured through pH-meter (Jenway). For pH measurements glassy electrode and reference electrode were used. To measure buffer capacity the studied solutions were titrated adding 0.03 *mL* 0.1 *N* HCl each time and pH was detected. Titration was continued until the value of pH was changed by one unit.

Results and Discussion. Physiological solution and 1% albumin dissolved in physiological solution were irradiated by EMW with 42.2 and 51.8 *GHz* frequencies. The choice of these frequencies was based on the fact that the irradiation by frequencies in 41.8–42.2 *GHz* interval significantly influences the living organisms and is applied in medical practice [11], the frequency 51.8 *GHz* is resonant for water the choice of the latter is conditioned by high content of water in biological liquids [12].

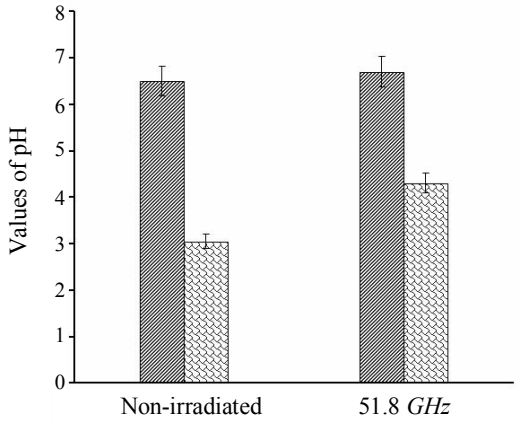

Fig. 1. Change of pH values of physiological solution at the addition of solution of HCl.

Values of pH of non-irradiated and irradiated samples of physiological solution at addition of HCl were presented in Fig. 1. Calculations showed that at addition of 0.03 *mL* 0.1 *N* HCl the value of pH of non-irradiated physiological solution decreases by almost 53%. Addition of 0.03 *mL* HCl to physiological solution irradiated by 51.8 *GHz* frequency leads to decreasing of pH values by 36%. From these data follows that the physiological solution does not possess a buffer capacity. Moreover, MM EMW irradiation results in relevant increasing of pH of physiological solution (if the value of pH decreases from 6.5 to 3.05 in non-irradiated sample, in irradiated sample it takes from 6.7 to 4.3). It can be conditioned by the fact that the physiological solution irradiation leads to releasing of water molecules bound to Na^+ and Cl^- ions [13]. Released from hydrate layer of ions the water molecules form ordered structures in consequence of which, most

apparently, protons enter into the composition of hydrate layers of ions and the value of pH of physiological solution after the irradiation increases by one unit.

The irradiation effect on buffer properties of human serum albumin was also studied. In physiological conditions the buffer capacity of albumin is not high in blood plasma. Irradiation of albumin solution changes protein buffer properties (Fig. 2).

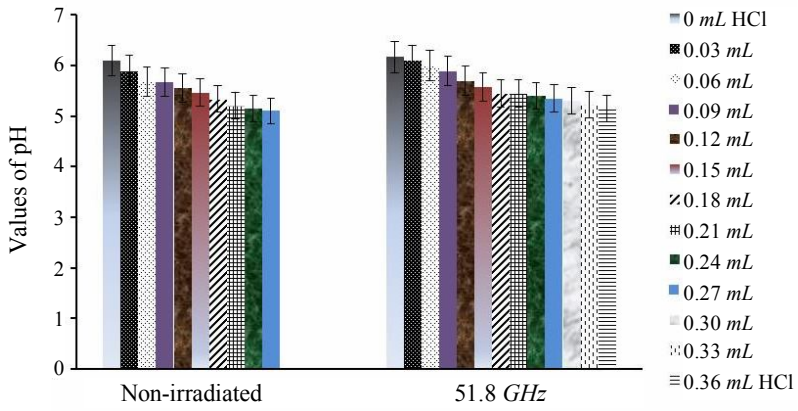

Fig. 2. Change of values of pH of non-irradiated and irradiated by 51.8 *GHz* frequency solutions of albumin at titration by solution of HCl.

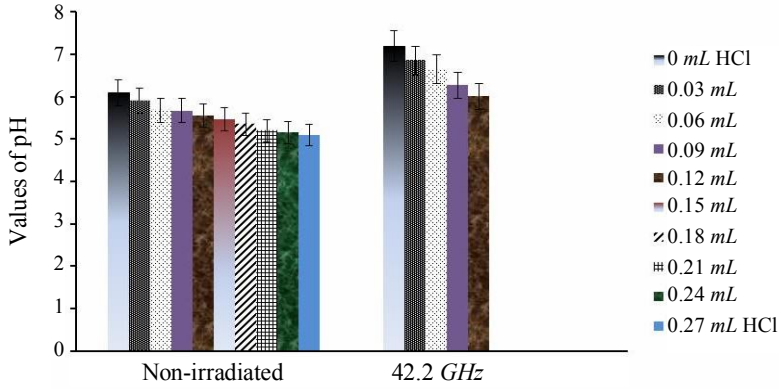

Fig. 3. Change of values of pH of non-irradiated and irradiated by 42.2 *GHz* frequency solutions of albumin at titration by solution of HCl.

Values of pH of non-irradiated (control) and irradiated by 51.8 *GHz* frequency albumin solutions were presented in Fig. 2, it is obvious, that 51.8 *GHz* frequency irradiation leads to strengthening of albumin buffer properties: thus in non-irradiated sample at addition of the first portion of HCl (0.03 *mL*) the value of pH decreases by 0.2 units, in irradiated sample the value of pH decreases by 0.07 units. It means that higher amount of acid (0.36 *mL*) is required to decrease the values of pH by one unit compared with non-irradiated albumin solution (0.27 *mL*). Irradiation of the solution leads to the enhancement of its buffer capacity by almost 22%. At the irradiation of albumin solution by 42.2 *GHz* frequency albumin buffer capacity decreases by 56%, the value of pH changes by one unit at the addition of 0.12 *mL* HCl (Fig. 3).

The enhancement of albumin buffer properties after irradiation by 51.8 *GHz* frequency, most apparently, is conditioned by the change of medium physico-chemical properties and by conformational alterations of macromolecules that lead to becoming of protein charged groups, responsible for buffer properties, more available. It is also indicated by the fact that at irradiation protein hydration degree decreases, though, water molecules transit to the more ordered (clustered) state, which decreases their mobility nearby protein molecule; probably, the amount of vacancy, hydrophilic groups that are able to interact with free ions of medium, increases [13]. In this case the amount of H^+ interacting with these groups of protein increases and albumin buffer capacity enhances. Earlier it was shown that at irradiation of albumin solutions by non-resonant frequency for water, albumin conformational state changes [10], and the results of the given study make it possible to assume that such change of protein conformation occurs which brings about decreasing of the number of vacancy hydrophilic groups on protein surface. Availability of protein ionized (hydrophilic) groups for protons decreases as well. Therefore, protein ionized groups become screened from H^+ and at low amount of HCl the change of pH by one unit is attained, i.e. the buffer capacity decreases.

Thus, MM EMW irradiation of albumin solution results in protein buffer capacity alteration. At irradiation changes of albumin hydration degree and solvent water component take place. The value and direction of protein buffer capacity changes depend on EMW frequency. At the irradiation of albumin solution by resonant 51.8 *GHz* frequency for water protein buffer capacity increases. At the irradiation by non-resonant 42.2 *GHz* frequency for water albumin buffer capacity decreases. Differently directed changes of the buffer capacity can be conditioned by the fact that various components of the system serve as targets for EMW of different frequencies. Generalizing the obtained data we assume that the buffer capacity of macromolecules can be modulated through such physical factor as MM EMW, which may have an important biological value.

Received 19.03.2018

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