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The Influence of Mechanical Vibrations With The Acoustic Frequency on The Properties of Ordinary Water

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Abstract. The paper presents the results of studying the effect of mechanical vibrations with the acoustic frequency on ordinary water. A strong dependence of the occurrence of ionizing radiation on the shape of the signal fed to the piezoceramics for sound generation is shown, which is not related to the process of cavitation in water under the action of ultrasound. An example of the dependence of the effect on the concentration of hydrogen ions in water is given. A hypothesis is made about a possible mechanism for the generation of ionizing radiation under the influence of sound on ordinary water. A mechanism is proposed for the formation of sonoluminescence under the influence of ultrasound radiation on a liquid.

Keywords: γ-radiation, ultrasound, nuclear processes, fluoride ions, thermal neutrons

1. Introduction

It is known [1-13] that mechanical effects on deuterium containing solids and acoustic effects on heavy water lead to neutron emission. In [6], direct correlations of changes in the intensity of neutron flares with signals of acoustic radiation associated with the cracking of titanium and palladium saturated with deuterium were obtained. The authors of papers [1-13] relate neutron emission to the process of low-temperature nuclear fusion in heavy water according to the DD-reaction scheme. In similar experiments performed on pure water, the authors of [3] did not observe neutron emission. Due to cavitations of bubbles in solutions of heavy water [7-13], when high temperatures are reached, a phenomenon called sonoluminescence appears which is accompanied by nuclear synthesis inside the collapsing gas bubbles. According to other authors, the high temperature inside the bubble is more a consequence of the synthesis reaction than its cause. In these papers, the authors convincingly prove the presence of neutron emission under the influence of ultrasonic radiation and associate it with the realization of low-temperature nuclear fusion. However, some arguments and explanations of the observed processes seemed insufficiently justified; therefore, we investigated the phenomenon of acoustic influence on processes occurring in ordinary water.

2. Results and Discussions

The source of the ultrasonic radiator was piezoceramic washers with a titanium concentrator tuned to a resonant frequency of 19.3 kHz. The sound level at resonance was about 120 dB. Ordinary drinking water was chosen as the object of study. When water was exposed to ultrasound with these parameters, we did not find any radiation, in spite of the fact that cavitation bubbles were clearly visible which, according to the literature, a prerequisite for observation of nuclear processes are. However, when the shape of the electrical signal applied to the

piezoceramics changes from the sinusoidal to the rectangular shape, the DKS-04 dosimeter and the RUP-1 radiometer recorded γ-radiation in the absence of capitation bubbles. Moreover, γ-radiation was also recorded far from acoustic resonance with a sound level of $75-80dB$ or less. Figure 1 shows the dependence of the γ-radiation level on the sound frequency in the range from 100 to $1000Hz$. As follows from the graph, the mainly linear increase in the γ-radiation level is observed. Such a character of the dependence can be interpreted as an increase in the number of sound pulses affecting the water per unit time. Another interesting phenomenon is the change in the level of γ-radiation over time for the same frequency of sound. Fig. 2 shows the dependence of the γ-radiation level on the time of exposure, measured for liquids with different pH values. Curve 1 corresponds to the measurement on ordinary drinking water, curve 2 shows the results of measurements on an aqueous solution of $NaOH$ with $pH \approx 10$, and curve 3 corresponds to measurements for an aqueous solution of HCl acid with $pH \approx 1$. An interesting fact is that the level of γ-radiation is higher in solutions, where the concentration of hydrogen ions is higher.

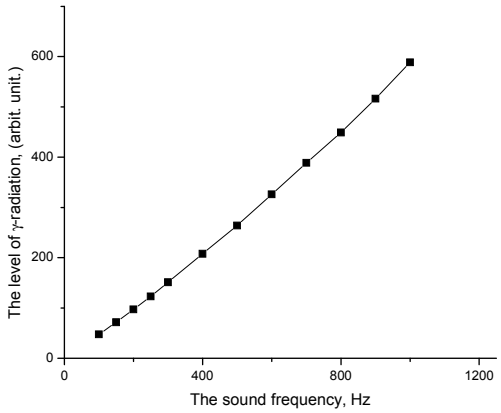

Fig. 1. Dependence of the γ-radiation level on the sound frequency from 100 to 1000 Hz

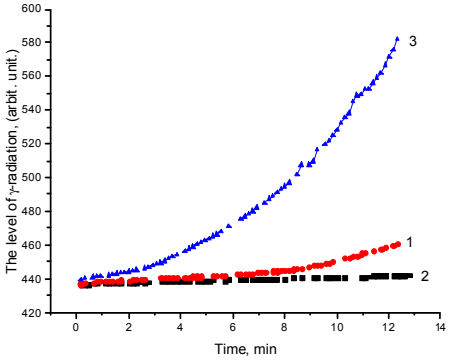

Fig. 2. Dependence of the γ-radiation level on the time of sound exposure for ordinary water (1), aqueous alkaline solution with $pH = 10$ (2) and acidic aqueous solution with $pH = 3$ (3)

The presence of γ-radiation indicates possible nuclear processes that occur in the experimental setup. It is accepted that for the realization of nuclear reactions the conditions of high temperature $T \approx 10^8 K$, high pressure $P \approx 10^6\ atm$ are necessary, and the corresponding Lawson criterion ($n\tau > 10^{14}$ sec/cm^3, where n is the density of the high-temperature plasma, and τ is the retention time in the system). In our experiments, there are no two first conditions for the realization of nuclear processes and, accordingly, the basis for the confirmation of nuclear fusion. Another condition for achieving nuclear processes is the presence of thermal neutrons, in which the cross section for the reaction is high. The absence of the need to overcome the Coulomb barrier and achieve high kinetic energy of the particles, create the conditions for the realization of nuclear reactions at a relatively low temperature.

When two media come into contact, a double electric layer appears with a field intensity of $10^6 - 10^7\ V/cm.$ Therefore, when an ultrasonic titanium concentrator contacts water, a double electric layer appears on the boundary layer between water and titanium. Titanium acquires a negative charge due to the boundary layer of electrons, and a water layer, close titanium, to due to hydrogen ions, acquires a positive charge. The peculiarity of these layers is that the charged particles make limited thermal motions along the charged surface layer. Naturally, it is possible to change the field of a double electric layer by an electric field [14,15], a sharp mechanical action and a change in the composition of the liquid. Therefore, with a sharp mechanical action of the titanium rod on the liquid in a direction perpendicular to the double electrical layer, it is possible that the layer integrity is violated and the hydrogen ions collide with electrons on the surface layer of the titanium concentrator. Moreover, by analogy with K-capture, the neutron formation reaction is possible:

$$p^+ + e^- \rightarrow n + \upsilon \tag{1}$$

It is known that the neutron, which is formed according to such a scheme, would have the neutron mass defect equal to energy $1.46\ MeV$. To compensate the missing mass $\Delta m = 1.46 MeV/c^2$, the neutron enters into an energetic bond with the nearest nucleus, transforming it into an unstable isotope of this atom, that the nuclear reactions of (n,γ) type is possible. This may be the cause of a high level of γ-radiation due to exposure of the sound on the water. The formed neutrons except the titanium may interact also with the nuclei of the hydrogen atoms with their conversion into the hydrogen isotopes [16]. It is also possible to suppose, that the γ-activity may be related to the conversion of oxygen nuclei, present in the water, into the fluorine nucleus, i.e. there is a transformation of oxygen nucleus into the fluorine nucleus with the emission of γ-quantum: $O(n,\gamma)F$. The half-life of such transformation is 27 seconds [16]. Schematically, such process can be represented as follows:

$$_8O^{18} + n \rightarrow \left(_8O^{19}\right)^* \rightarrow {}_9F^{19} + \beta^- + \gamma \tag{2}$$

Note that the oxygen atom $_8O^{18}$ is the stable isotope of oxygen, the content of which is 0.2% in the natural elements. Fluorine is chemically active element, its affinity for hydrogen is

very great, and it takes the hydrogen from the stable compounds such as water. In the above conditions, while oxygen moves to fluorine in water molecule, one of the hydrogen atoms of water must leave the former molecule, converting it to the another molecule, a molecule of hydrofluoric acid (HF), which is the very aggressive chemical substance. The abandoned hydrogen from the water molecule, in the form of hydrogen ion, will increase the process of neutron production and the number of acts of nuclear conversion of oxygen in the fluorine, and thus the amount of emitted γ-rays will be increased. Perhaps, the mechanism of temporal increase of γ-radiation level can be explained in this way, the results of measurements are shown in Fig. 2. It is not unlikely that the appearance of hydrofluoric acid in water can explain the destruction of the tip of the ultrasonic probe which is lowered into the water. It follows from our experimental results that the correlation between the level of γ-radiation and the necessity of sonoluminescence phenomenon was not observed. The offered mechanism of the electric double layer formation between the contacting media allows one to suggest the sonoluminescence formation mechanism also. In the formation of cavities in the water on the rarefaction stage of acoustic field appear two media, the internal rarefaction cavity, and the external medium, the water, on the border of which there is an electric double layer which arises. At the compression stage the bubbles collapse, and, therefore the electric discharge of the electric double layer of bubbles takes place. Perhaps, this explains the continuous spectrum of sonoluminescence radiation.

To confirm the validity of judgments about possible nuclear processes and the formation of fluorine element (F), measurements were made for the presence of fluoride ions in samples, subjected to acoustic action and initial distilled water. The presence of fluoride ions in water was measured by ion chromatograph DIONEX IC 1000 (USA). As a result, there was a significant formation of fluoride ions in samples exposed to sound. Samples of distilled water were subjected to acoustic action at a frequency of $25\ kHz$. The results of measurements are shown in Fig. 3.

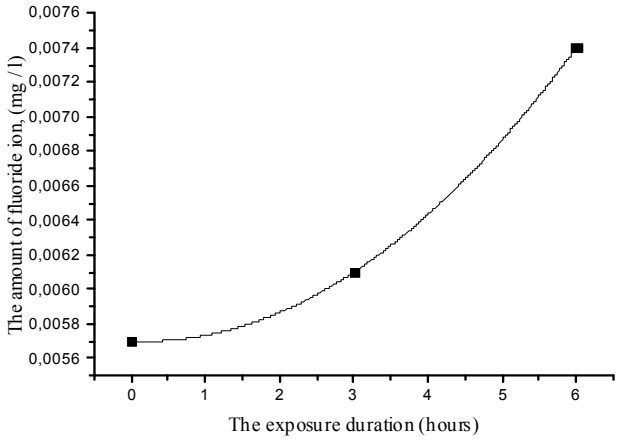

Fig. 3. The dependence of the of fluoride ions amount on the duration of the action of acoustic radiation on water

The graph shows the change in the fluoride ions amount in ordinary water at different exposures of sound. The increase in the fluoride ions amount with increasing duration of the sound effect is clearly seen, which is described by the nuclear reaction (2). However, with a significant increase in the exposure's duration (more than 8 hours), a decrease in the fluoride ions amount is observed, which can be explained by the possible capture of quasineutrons by fluoride ion nuclei and in accordance with the $F(n,\gamma)Ne$ reaction by the nuclear conversion of fluorine to neon. Table 1 shows the results of measuring the fluoride ion for longer exposure to ultrasound in water.

Table 1

Sample number	pH	Content of fluoride ions, mg / l	Duration of ultrasonic radiation exposure (hours)	Average value of fluoride ions (mg / l) for one hour
1	6.24	0.095	24	$395{,}83 \cdot 10^{-5}$
2	6.22	0.015	48	$31{,}25 \cdot 10^{-5}$
3	6.19	0.013	26	$50{,}00 \cdot 10^{-5}$
4	6.09	0.012	168	$7{,}14 \cdot 10^{-5}$
5	6.09	0.009	240	$3{,}75 \cdot 10^{-5}$

3. Conclusion

The results of our studies confirmed the presence of nuclear processes in ordinary water under the condition of mechanical action on it with steep fronts (less than 50 microseconds). This phenomenon is observed when the water is exposed to ultrasonic, audible, and infrasonic frequencies. To register γ-radiation, there is no need for the phenomenon of cavitations in water and the presence of sonoluminescence. The mechanism of neutron formation due to a double electric layer is presented. They are the cause of nuclear processes. The mechanism of the sonoluminescence appearance and the cause of the continuous optical spectrum of radiation are also explained. A possible mechanism for the erosion of surfaces of metal structures in the event of cavitations in water is proposed.

References

[1] Lipson A.G., Sokov D.M., Kliuev V.A. etc. Pis'ma Zh. Eksp. Teor.Fiz. [Sov. Phys.JETP Letters], **49** (1989) 588.
[2] Lipson A.G., Deriagin B.V., Kliuev V.A., Havroshkin O.B. etc.Technical Physics, **62** (1992) 121.
[3] Taleyarkhan R.P., Block R.C., Lahey (Jr.), Nigmatulin R.I. and Xu Y. Physical Review Letters, **96** (2006) 034301.
[4] Matula T. J., Roy R. A., Mourad P. D., McNamara W. B., Suslick K. S. Phys. Rev. Lett. **75** (1995) 2602.
[5] Moss W.C., Clarke D.B., White J.W., Young D.A. Physics Letters A, **211** (1996) 69.
[6] Eberlein C. Phys. Rev. Letters **76** (1996) 3842.
[7] McNamara W. B., DidenkoY. T., Suslick K.S. Nature **401** (1999) 772.
[8] Nigmatulin R.I. Gimaldinov I.K., Sharapov V.Sh., Dokladi Akademii Nauk. (Proceedings of the Russian Academy of Sciences (RAS)), № 3 (2001) 133.
[9] Nigmatulin R.I., Sharapov V.Sh., Gimaldinov I.K., Galimhanov M.N. Dokladi Akademii Nauk (Proceedings of the Russian Academy of Sciences (RAS)), **378** (2001) 763.
[10] Nigmatulin R.I., Akhatov I.Sh, Topolnikov A.S., Bolotnova R.Kh, Vakhitova N.K., Lahey (Jr.), Taleyarkhan R.P. Physics of Fluids **17** (2005) 107106.
[11] Taleyarkhan R.P., Block R.C., Lahey (Jr.), Nigmatulin R.I. and Xu Y. Physical Review Letters, **96** (2006) 034301.
[12] Lahey R.T., Taleyarkhan R.P., Nigmatulin R.I. Nuclear Engineering and Design, **237** (2007) 1571.
[13] Nigmatulin R.I., Lahey R.T. (jun.), Taleyarkhan R.P., Vest K.D., Blok R.S. Physics-Uspekhi, **184** (2014) 947.
[14] Balasanyan R. N. and Kostanyan R. B. Physics Journal, **2**, (2016) 45.
[15] Badalyan G.R. Balasanyan R.N. and Gambaryan I.A. Armenian Journal of Physics, **8** (2) (2015) 85
[16] Properties of inorganic compounds. Reference book / Efremov A.I and etc. - L. : Chemistry, 1983, 392.