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Features of Energy of Chemical Reactions under the Action of Non-Lethal Acoustic Weapons

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Abstract

The main features of energy of chemical reactions at low-frequency acoustic influences are experimentally defined in researches of scientific group of MSTU. N. Bauman in 2013-2017. Based on known experimental data (Table 1), attention was focused on the frequency range, including infrasound (up to 17 Hz) and the beginning of the sound range (up to 50 Hz). In experimentally established fundamental differences between the results of the influence of low-frequency acoustic oscillations of the action of ultrasound.

Frequencies, *Hz*	15-Feb	10-Feb	7-Jun	10-May
Intensity of Frequencies, deciBels	95-105	125	90	135
Reaction organism's	Slowdown visual reactions	Unpleasant feelings internal bodies'	Violation the alpha-rhythm brain	Rapid heartbeat

Table 1: Influence of acoustic vibrations on the human body.

Experimental Result

The study of clathrates of iodine [1,2] revealed the *extreme nature of the effect* of infrasonic oscillations. It is established that the action of low acoustic frequencies (from 1 to 50 Hz) is determined by *the optimal frequency at which the speed of a particular sound chemical transformation is maximal*. To determine whether the detected sensitivity to low-frequency effects is a feature of individual complexes or it is inherent in all clathrate structures, special experiments were conducted. It turned out that even the components of starch – amylose and amylopectin, which are close in composition, are sensitive to different frequencies in the formation of the corresponding clathrate complexes with iodine [2]:

- Amyloidin- to infrasonic frequencies 12-15 Hz,
- Amylopectin- to the beginning frequency sound range 20-22 Hz.

On the basis of the conducted experiments, it can be concluded: biochemical systems sensitive to the external infrasound effect, having clathrate structure, can serve as a basis for the development of antidotes against non-lethal acoustic weapons [3-5]. It was interesting to find out whether this behavior is related to the special properties of clathrates, or sensitivity to low-frequency effects is inherent in other biochemical active structures. As biochemically active models that have a chelate structure, different from the clathrate were taken from the polyvinylpyrrolidone-iodine. Destabilization of this compound in the field of low-frequency effects [6-8] proves that sensitivity to the action of low-frequency oscillations is a property of a significant number of biochemical active structures. This fact, established by the conducted research, indicates the principal directions of creation of antidotes against non-lethal acoustic weapons.

Discussion of Results

Experimental researches have allowed to establish the main: *can be active only part of the energy of the JAC of acoustic waves, which is absorbed by the system* (similar to the law of Grothus - Draper in photochemistry). The rest of the energy pulsating with low-frequency acoustic effects of bubbles under the condition of "*undeveloped*" cavitation is consumed:

- Local electrification of bubbles,
- The creation of the cavitation surge,
- The formation of cumulative jets.

As a consequence, in energy and kinetic calculations should not take into account all the acoustic energy introduced into the solution, but only its share spent on the formation of ions, free radicals or restructuring of the structure of molecules (for example, the translation of dimers into monomers or back) and other processes. This energy is called the chemical-acoustic energy E_{ca}. Its connection with the total acoustic energy of the E_{ac} was proposed by L. D. Rosenberg [9] to estimate via the constant η_{ca}, which, in essence, is the efficiency of the sound chemical process:

$$E_{ca} = \eta_{xa} \bullet E_{ac}$$

Where η_{ca} is chemical-acoustic efficiency. In the study of physical and chemical processes occurring in the cavitation bubble and the adjacent volume of liquid, it is assumed that the energy released in the process of acoustic effects is sufficient to excite, ionization and dissociation of water molecules, gases and substances with high pressure of saturated steam inside the cavitation bubble. At this stage, the action of acoustic oscillations on substances penetrating into the cavity is direct, i.e. *direct action*.

The so-called *indirect action* of acoustic oscillations is carried out after the transition to a solution of active particles that have arisen in the system. They react with dissolved substances, solvate with solvent molecules or move to a different state than the original. Thus, the reaction of particles formed during sonolysis can be divided into two types:

- Recombination in the cavitation bubble;
- Reactions in the volume of the solution.

To assess turning Margulis MA, et al. [10] introduced the concept of elementary chemical acoustic output FR. The value of FR is equal to the number of particles of sonolysis products formed for every 100 eV of the spent chemical and acoustic energy and transferred to the solution (without taking into account their further reactions in the solution). To account for further transformations, the concept of F_{R2} - secondary energy yield of chemical reactions (or chemical-acoustic output F_{R2}) was introduced. This value is equal to the number of particles formed (or disappeared) for every 100 eV of absorbed chemical and acoustic energy.

The fundamental characteristic of acoustic energy (as well as other types of radiation) is the *recombination coefficient* β_R - the ratio of chemical-acoustic outputs of recombinant particles F_{R2} to the value of F_R particles before recombination:

$$\beta_R = F_{R2} / F_R$$

The value of β_R - depends on many factors: the density or concentration of energy, the size of the impact area and its localization, the number and concentration of the resulting particles and other factors. Given the General nature of the recombination coefficient βR, it can be used to compare the acoustic energy with other types of physical effects on the studied structures.

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