Biochemical effects of molecular hydrogen in aqueous systems

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Abstract. Activated water - such water, in which the structural network of hydrogen bonds loosens, water molecules acquire additional degrees of freedom, which facilitates the assimilation of such activated water by the cells of living organisms and accelerates the removal of biological slags. The essence of water activation is the destruction of cluster structures to saturate water with monomolecules. The cluster of activated water contains 5-6 molecules (ordinary water 13-16 molecules). Such water is considered more active in terms of biophysical and biological indicators. Water, activated in any way, has a high fluidity (has a low surface tension) and a dissolving power. Water with micronized clusters has higher reactive properties, better penetrates through biological membranes, is quickly excreted from the body. Effectively replaces and supplements all kinds of cleansing food supplements and physiotherapeutic procedures. Used for complex purification of the body: neutralization and excretion of slags, toxins, carcinogens and radionuclides. The paper considers experimental data on the determination of the total antioxidant activity of water systems saturated with hydrogen using the coulometric method of analysis, with the water having the highest increase in activity up to 20 times. We studied the functional drink "Arkhyz + Antioxidant = Zhivitsa", all the ingredients that make up it have a natural origin. Saturation of the drink with hydrogen leads to an insignificant increase in the total antioxidant activity (by 16.5% rel.). The presence of active organic compounds in water leads to a decrease in the effect of hydrogen on the total antioxidant activity, probably due to a change in the structure of its aggregates consisting of a different number of molecules.

The first problem is the activation of water and water systems

Hydrogen can serve as a replenished source of energy, but the industrial methods for obtaining it are not environmentally friendly. They are replaced by biological methods with the help of hydrogenases - enzymes, which are responsible for the restoration of protons and the generation of molecular hydrogen in aqueous systems without the participation of platinum, palladium and other metals [1].

Water with negative oxidation-reduction potential (ORP) has reducing properties, and with positive ORP oxidizing properties. Both varieties of water are usually called “activated”. This has a profound biological meaning, reflecting the role of changes in the degree of structuring of water, both within
living organisms and the water of the external environment, in the processes of organization and vital activity of living systems, besides, water creates many problems in industry, energy, ecology, production and storage of food products and other areas of human life [2]. The main technology of water activation is electrolysis. The catholyte and anolyte have a negative and a large positive ORP, respectively. It is generally believed that the processes leading to both a decrease and an increase in ORP occur in the region of the boundary with the surface of the electrodes, where high electric field intensities. A number of studies have been devoted to the investigation of mechanisms of water activation [3].

In the process of electrolysis, molecular hydrogen is formed at the cathode, which is a reducing agent. Therefore, it is natural to assume that the negative value of ORP of catholyte is due to the dissolution of hydrogen in water. It was noted in [4] that saturation of water with hydrogen can not lead to the experimentally observed value of ORP of about minus 600 mV. In the analysis of the process, the reaction $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ was considered as the mechanism of action of hydrogen, the standard potential of which with respect to the normal hydrogen element (NE) at pH = 7 is minus 414 mV [3]. In this paper it is shown that when the water is saturated with hydrogen (concentration ~ 8 $10^{-4}$ mol/l), the ORP values can be minus (500 ÷ 700) mV. The reaction that will provide such a potential, we can consider the process: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ for which the standard potential is relatively n.h.e. is minus 828 mV. Thus, the ORP value achievable by electrolysis can be explained by dissolving hydrogen and diffusing it throughout the entire volume of the liquid.

Hydrogen (food additive E949), finds application in the food industry as a propellant, which helps to prevent oxidation and spoilage of products. As a food additive, it is allowed in the Russian Federation and the EU, but it is banned in the US, Australia and New Zealand. Hydrogen is non-toxic and its use in food production is considered safe. Today in science and medicine it is known that one of the most important parameters of water is its ORP. When ordinary drinking water penetrates the tissues of the human body, it takes electrons away from cells and tissues that consist of water by 80-90%. As a result, the biological structures of the body undergo oxidative destruction. So the body wears out, grows old, vital organs lose their function. These negative processes can be slowed down if in the body with a drink and food will receive a fluid that has the properties of the internal environment of the body, that is, has protective restorative properties. This is confirmed by numerous studies in specialized scientific centers in Russia and abroad. If the liquid that enters the body, in particular, drinking water has an ORP close to the ORP value of the internal environment of the human body, then the “vital energy of the organism” is assimilated, since it has the best biological compatibility with the human body in this parameter. For the treatment of water, aqueous solutions of salts, juices and other beverages, various devices are used to change their oxidation and reduction properties, including by saturation with hydrogen to produce a liquid medium with a negative oxidation-reduction potential [5].

The second problem is the analysis of aqueous systems saturated with hydrogen

To study aqueous systems saturated with hydrogen was used technique of determination of the total antioxidant capacity (DTAC) [4] of the samples in mg Routine (Ru) per 1 dm$^3$. The measurement was carried out at rest and with stirring by means of a magnetic stirrer or by passing air. We estimated the potential populations of clusters according to their DTAC in terms of the standard sample in mg of routine (Ru) per 1 dm$^3$ through the modal value (mode Mo) [6].

For the research, drinking cold water was used, which was pre-treated by municipal services and met the requirements of SanPiN 2.1.4.1074-01 “Drinking water”. The water was purified through a household reverse osmosis filter Atoll, reverse osmosis systems manufactured in Russia (according to TU 3697-009-18261557-03) and the USA (NSF / ANSI Standard 058). Purified water has the following parameters: oxidation-reduction potential from +200 to +343 mV, total mineralization from 25 to 130 mg/l, pH from 6.9 to 8.3. Saturation of the samples with hydrogen was carried out under pressure in standard polyethylene terephthalate bottles with a volume of 0.5 dm$^3$ using a device for aerating and sealing liquid contained in a container [7].
The hydrogen saturated samples of the functional beverage “Arkhyz + Antioxidant = Zhivitsa” were studied, which is produced by CJSC Visma-Arkhyz.

To test the technique, we conducted studies of the effect of hydrogen on the antioxidant activity of water and a food drink.

The content of dissolved hydrogen in water can be from 1.6 to 10 mg/l and depends on the pressure. The ORP of water in this case is from minus 600 to minus 50 mV, but the total mineralization of water and pH does not change. The solution does not lose substantially its properties for 30 days, which allows it to be transported and stored. When the solution is sealed in glass containers, the storage life is up to one year [8].

Figure 1 shows that the fall of the DTAC of water activated by hydrogen when the sample is standing in a 100 dm$^3$ polyethylene measuring cup in open air is described by the linear equation $Y = -1.697x + 86.805$, for $R^2 = 0.970$. According to the above equation, DTAC decreases by 47% rel. in 25 minutes. In the control sample of the initial water, the DTAC of the original water sample twists within the measurement error and averages $4.28 \pm 0.36$ mg Ru per 1 dm$^3$, a similar effect was observed by us when studying the effect of temperature on the DTAC water [9].

While stirring the activated water with a magnetic stirrer, the DTAC falls to the maximum value of the control sample ($4.28 \pm 0.36$ mg Ru per 1 dm$^3$) in 5.7 minutes and is described by equation $Y = -8.214X + 49.948$, for $R^2 = 0.953$, and when air is passed through it for 9.6 minutes ($Y = -5.084X + 52.53$, for $R^2 = 0.965$). We studied the functional drink “Arkhyz + Antioxidant = Zhivitsa”, all the ingredients that make it have a natural origin. And most importantly - this useful energy drink does not contain caffeine and taurine, which, if over-consumed, have a negative effect on health. The basis of the drink is the water “Arkhyz” with the addition of the biologically active additive “Flavomix-R” (dihydroquercetin of high purity), the natural flavoring (Limon-Lime), the natural color “Sugar Colors” E 151a, vitamin C (ascorbic acid). Due to the BAA, the beverage exhibits a DTAC, twisting between values of 268.50 and 304.78, an average value of $286.64 \pm 18.14$ mg Ru per 1 dm$^3$. Saturation of the drink with hydrogen leads to an insignificant increase (by 16.5% rel.) of the DTAC to 333.81 mg Ru per 1 dm$^3$.

$$Y = -1.697x + 86.805$$
$$R^2 = 0.970$$

Figure 1. The fall of the total antioxidant capacity of hydrogen-activated water in a 100 dm$^3$ polyethylene measuring cup in air in open form without stirring.

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