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Investigation on Process of the Water Radiolysis in the Nano Si+H_2O System Under the Influence of Gamma – Quanta

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ABSTRACT

The radiation-chemical yield of the molecular hydrogen received under the influence of gamma quanta (^{60}Co, P=22Rad/s, T=300K) to liquid water of constant volume (V=5 ml) in the process of a radiolysis of water at change of weight (m=0.01; 0.02; 0.06 and 0.12 g) and sizes of silicon particle (d=50 nanometers) is defined. It has been revealed that at increase in mass of the silicon added to water the radiation-chemical yield of the molecular hydrogen received in the process of a water radiolysis grows in direct ratio (m<0.02 g) and depending on the size of particle after a certain mass value (m>0.02 g) the stationary area is observed. In the Si+H_2O system the maximum radiation-chemical yield of molecular hydrogen is equal to 10,9 molecules / 100eV at the sizes of silicon particle d=50 nanometer respectively. The mechanism explaining the received results is offered.

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Introduction

One of current problems of the present is studying of process of a liquid radiolysis, in particular water, in nano - and micro heterogeneous systems under the influence of the ionizing beams (neutrons, protons, γ-quanta, electrons, ions, etc.). Under the influence of γ-beams in systems metal + water and oxide of metal + water, radiation-chemical yields of hydrogen have the greatest values when using nano dimensional materials [1-8]. These works are conducted in two directions:

1) use of suspension of metals or oxides of metals in water of constant volume and

2) adsorption of water on a surface of metals and oxides of metals.

In both cases a radiation-chemical yields of products of water transformation (hydrogen, oxygen, hydrogen peroxide, etc.) depend on type of a solid body, width of the forbidden zone of a solid body; sizes of particles of a solid body; extents of filling of a surface of solid body particles by the adsorbed water; temperatures of the general system; the mass of a solid body; suspended in water.

In the presented work have been calculated the accumulation rate and radiation – a chemical yield of the molecular hydrogen received in the process of the radiation and heterogeneous transformation of water proceeding under the influence of γ-quanta (^{60}Co, P=22Rad/s, T=300K) to clear water (V=5 ml) and added to the same volume the silicon with various sizes of the particles which is evenly distributed by means of the vibrator.

Experimental Part

It has been taken silicon produced by the company "Skysping Nanomaterials. İnc", USA as an object of a research, with sizes of particle d=50 nanometer and purity of 99.9%. Originally silicon has been processed at T=473K, T=72 hours in the air environment, and after determination of the necessary weight is purified in special conditions and added to the ampoule (V=19 ml) which is thermally processed (T=773K). After heat treatment (T=673K) of silicon in an ampoule in vacuum conditions (P=10^{-3} mm Hg) within 4 hours, it has been cooled, and the necessary amount of the double distilled water purified from air in special conditions [9] has been adsorbed on his surface. Then ampoules have been soldered and irradiated in special conditions (by continuous hashing of system by the vibrator

with the purpose to achieve suspension of silicon particles in water) on a source ^{60}Co at the power of dose P=22 Rad/s.
Power of the absorbed dose has been determined by ferro sulfate and methane ways. In the concrete studied object the power of the absorbed dose has been calculated with use of a method of comparison of electronic density [10-19].
The products received by radiation and heterogeneous processes, such as H_2, O_2 and H_2O_2 have been determined by a chromatography method. Some part of O_2 keeps on a surface and H_2O_2 remains in solution and therefore errors are big when determining quantity of these products. Therefore, more exact information on kinetic regularity of process of radiation and heterogeneous transformation of water has been obtained based on amount of molecular hydrogen.
Products of reactions are analyzed on the "Agilent-7890" chromatograph. For confirmation of results the upgraded "Colour-102" chromatograph (accuracy of 8-10%) has been in parallel used. In the "Colour-102" chromatograph the column of 1 m long with an internal diameter of 3 mm has been used. In a column an absorbent carbon with the diameter of particles d=0.25÷0.6mm has been used and the argon of high purity (99.9%) as the gas-carrier in each of two chromatographs has been used.

Results and Discussions

In the figure 1 the dependence on time of the molecular hydrogen amount formed as a result of radiolytic transformations in system of pure water with the added silicon ($Si+H_2O$) suspensions (the size of silicon particles d=50 nanometer, weight (m=0.01 (curve 1); 0.02 (curve 2); 0.06 (curve 3) and 0.12 (curve 4)), V_{water}=5ml) under the influence of γ-quanta (^{60}Co, P=22Rad/s, T=300K) is given. In fig. 1 dependence under the same conditions are shown:

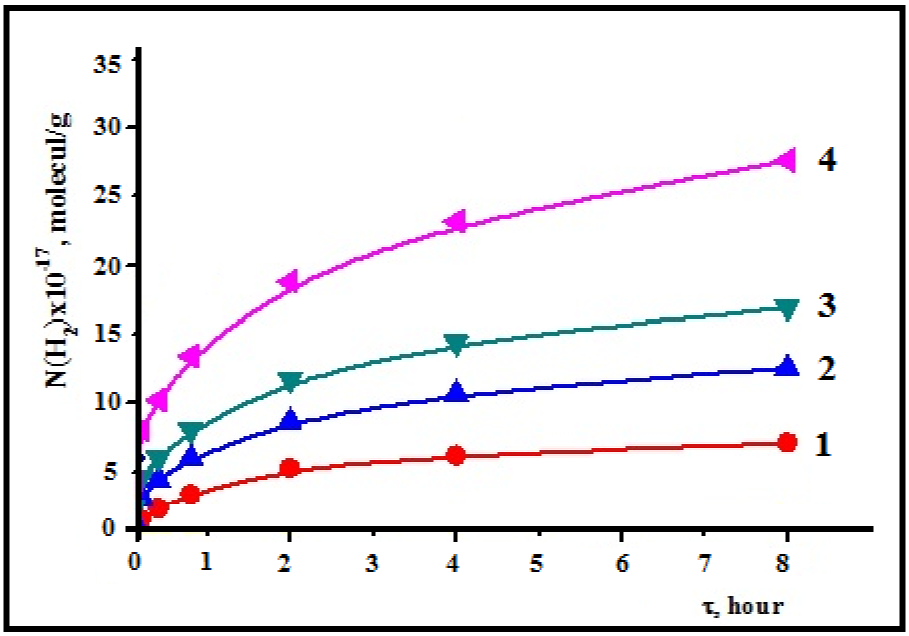

Fig.1. The dependence on time of the molecular hydrogen amount, formed as a result of radiolytic (P=22Rad/s, T=300K) transformations in system of pure water (V=5 ml) with the added silicon (d=50 nanometer) of various weight (m=0.01g (curve1); 0.02g (curve2); 0.06g (curve3); 0.12g (curve4))

From linear parts of the kinetic curves (fig. 1), received based on the studied systems, an accumulation rates - $w(H_2)$ and a radiation-chemical yield of molecular hydrogen $G(H_2)$ on every 100eV of the energy absorbed by the common system, have been determined and these data are shown in Table 1.

Table1. Dependence on the mass of silicon (m(Si)) of an accumulation rate ($w(H_2)$) and radiation-chemical yield ($G(H_2)$) of the molecular hydrogen received as a result of radiation and catalytic transformations (P=22Rad/s, T=300K) in the $Si+H_2O$ system (V_{water}=5 ml, the size of silicon particles d=50 nanometer)

m(Si), g	d = 50 nanometer	
	$w(H_2)\cdot10^{-13}$, molecules/ (g·s)	$G(H_2)$, molecules/100eV
0	0.61	0.436
0.01	5	3.64
0.02	9.67	7.03
0.06	13.4	9.05
0.12	15	10.9

As shown from the figure, a radiation-chemical yield of the molecular hydrogen received in the process of a water radiolysis grows in direct ratio to the mass of the silicon added to water (at m_{Si}<0.02 g), and after a certain mass value (m_{Si}>0.02 g) the stationary area depending on the sizes of particles is observed. In the Si+ H_2O system at the sizes of silicon particles d=50 the maximum radiation-chemical yield of molecular hydrogen was equal to 10.9 molecules/100eV respectively.

Conclusions

On the basis of the conducted research, it is possible to come to conclusions that:

- Due to the energy transmitted from a firm phase to a liquid phase under the influence of γ-quanta in the nano-Si+H_2O system, radiation-chemical yields of the molecular hydrogen received as a result of radiolytic transformation of water are equal to $G(H_2)$ = 10.9 molecules/100eV for particles with sizes d=50 nanometer respectively that is notable more in comparison with clear water ($G(H_2)$ = 0.45 molecules/100eV)
- With increase in concentration of particles of silicon in the Si+H_2O system, the energy transferred to water grows and it in turn is the reason of increase in a yield of molecular hydrogen. Radiation–chemical yield of the molecular hydrogen received in the process of a water radiolysis grows in direct ratio (m<0.02 g) and depending on the sizes of particles after a certain mass value (m>0.02 g) the stationary area is observed. In the same system has been defined the dependence between a yield of the molecular hydrogen formed at radiation and catalytic transformation of water under the influence of γ-quanta and the mass of silicon - $G(H_2) = f\ (m_{Si})$
- Regularities of dependence of a radiation-chemical yield of the molecular hydrogen formed at radiation and heterogeneous transformation of water in the Si+H_2O system from the sizes of particles have been revealed.

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