

# The Initiators of the Appearance of Organic Compounds on Earth, the Distribution of Natural Radionuclides in the Plant Mass

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**Abstract:** An experiment was performed on the synthesis of organic substances from a mixture of carbon monoxide and hydrogen on the surface of iron and cobalt, coated with carbide clusters, formed during processing at 573 K in an atmosphere of carbon monoxide. The obtained results indicate that the most likely direction of the formation of organic substances from mixtures of molecular hydrogen and carbon oxides is the thermal hydrogenation (radiation-thermal hydrogenation has a higher speed) at 300-573 K of carbide clusters covering the surface of metals. A significant fraction of organic matter on the Earth is formed during the solidification and cooling of the surface of a “hot” planet from 600 K to 300 K. Initiation by ionizing radiation creates the real condition for the highly endothermic processes of dissociation of water and carbon dioxide molecules, synthesis of new organic molecules and molecular oxygen. On a completely cooling up to 300 K planet this process continued by the vital activity of living organisms and during photosynthesis. The energy of quanta of visible light is much less than the energy of C=O bonds in the CO<sub>2</sub> molecule and the dissociation energy of the H-O bond in the H<sub>2</sub>O molecules. The value of the energy of gamma quanta emitted by the K<sup>40</sup> isotope is many times higher than the value of the dissociation energy of the H-O and C=O bonds. The analysis of numerous samples of water, soil, vegetation, livestock products showed the presence of K<sup>40</sup> radioisotopes in all samples. The role of gamma radiation of K<sup>40</sup> radioisotope should be taken into account at comprehensive analysis of initial stage of photosynthesis. This conclusion is consistent with the revealed facts of increased plant yields on soils with relatively high concentrations of natural radioisotopes, observation of photosynthesis under thick layers of water in the presence of only long-wave infrared rays or in the absence of chlorophyll and oxygen.

**Keywords:** Synthesis of Organic Compounds, Natural Radionuclides, Plant Mass, Photosynthesis

## 1. Introduction

Studying the distribution of toxic elements in the soil is an urgent task to solve problems related to environmental safety. The accumulation of large amounts of harmful substances in the soil causes the risk of their entry into living organisms by translocation and migration paths along the soil-water-vegetation chain [1, 2].

The main part of the soil is formed by chemical compounds in the form of various minerals. Studying the various forms of the presence of chemical elements in minerals, organic residues and emissions, soil colloids, determining the amount of oxides, hydroxides, carbonates, bicarbonates, nitrates, nitrites, sulfates, phosphates in soil

samples allow us to estimate the ecological state of the soil. The increase in technogenic pressure on the environment, the processing of minerals by outdated technological processes and the consequent pollution of environmental objects with small amounts of xenobiotics can cause the formation of ecological crisis zones. Therefore, there is a need for systematic measurements and studies to obtain results on the distribution of radionuclides in the soil, vegetation, water reservoirs. [2, 3].

## 2. Material and Methods

Radiometric measurements were carried out using the InSpector-1000 and Radiagem-2000 radiometers

(manufactured by Canberra and equipped with alpha, beta and gamma detectors) and the IdentifINDER radiometer identifier (manufactured by Thermo Scientific). Gamma spectrometer with HPGe detector (manufactured by "Canberra"), atomic absorption AA-6800 spectrometer (manufactured by "Shimadzu"), Expert-3L and XRF X-ray fluorescence spectrometers were used in the process of physical-chemical analysis of minerals obtained by evaporation of water samples, weakly acid and weakly alkaline extracts of soil samples, by heating and treatment by nitric acid solution of green grass samples. The soil samples taken were treated with distilled water, weak solutions of acid and alkali with periodic mixing and filtration, isolation of sparingly soluble particles in a centrifuge with further evaporation to obtain minerals, heavy metals and radionuclides after a written description in the journal of taken samples, visual inspection, weighing, drying, cleaning from random foreign objects or pebbles by passing through sieves [3, 4].

Pre-sterilized glassware was used to take water samples and samples were taken, stored and transported in accordance with the requirements of standards (GOST) 24481-80 and 18968-73. When water samples were taken in parallel with radiometric measurements the sensory, chemical and microbiological rapid test analysis were carried out. To determine the compliance of the quality of the water sample with the requirements of the standards for drinking water, stationary laboratory sensory, analytical, physical-chemical and microbiological analysis were carried out in compliance with the conditions and requirements of standards (GOST) 2761-84, 3351-74, 2874-82. We used express test napkins - certified ISO 9001 and 13485 quality control systems - manufactured by R-Biopharm (Germany) for conducting microbiological rapid tests and selective nutrient media produced by Hi-Media (India) and Condalab (Spain), incubators with an automated thermostat and colony counters to determine the number and types of microorganisms in stationary laboratory conditions [4, 5].

### 3. Discussions of the Results

The results of analyzes of the mineral composition of soil, water (rivers) and plant (green grass) samples taken from all regions of the country, taking into account their fluctuations, are presented below.

The main mineral balance (sulfates, chlorides, nitrates, nitrite, carbonates, Na, K, Sr, Fe, Mn, Zn, J, i.e.) of the samples of drinking water varies in the interval 0.3-3.5 g/l. The concentration (radiation activity) of the  $\text{Na}^{22}$  and  $\text{K}^{40}$  isotopes in minerals of drinking water samples respectively is 0.3-1.4 Bq/l and 0.1-0.4 Bq/l. These values are characteristic low values for rivers and springs water.

About 30-35% (300-350 g/kg) of the total content of soil is water. The amount of oxygen in composition of dried soil samples is 240-260 g (in wet soil this indicator is approximately 50% or 500 g), carbon 18-20 g., silicon 310-330 g., aluminum 62-80 g. The total amount of moisture,

oxygen, carbon, silicon, aluminum is 980 - 990 g / kg. The quantity of Mg compounds in water reservoirs is in the range of 6-25 mg/l, in plants 50-60 mg/kg. In some samples of plant P found in trace amounts. Concentrations of Mg compounds equals 80-90 mg / kg and the trace amounts of "microelements" As, Sn, Cu, Cr, Zr, Mo, Br, Ba below 1 mg/kg are observed in soil samples. The light /Si, C, Al, P, Mg/ and heavy /Ti, Zr, Ba, Sn, Cu, Mo, Co, Eu, Ra, Th/ elements have relatively stable concentrations. Concentrations of heavy elements are traceable. The total amount of other inorganic components (sulfates, chlorides, nitrates, nitrite, carbonates, Na, K, Sr, Fe, Mn, Zn, J, i.e.), that determine the soil fertility is 10-20 g/kg. The total amount of these inorganic components of green plants is only 5-17 g/kg.

The radiation activity of the  $\text{Na}^{22}$  and  $\text{K}^{40}$  isotopes in minerals of soil samples respectively is 1.0-3.0 Bq/l and 0.8-2.5 Bq/l. The dose rate of gamma radiation from the background of these regions is 0.02-0.15  $\mu\text{Zv/h}$ .

The radiation activity of the  $\text{Na}^{22}$  and  $\text{K}^{40}$  isotopes in minerals of green grass samples respectively is 0.6-2.0 Bq/l and 0.8-3.0 Bq/l.

The comparison of the indices of minerals of water, vegetation and soil samples, shows approximately close values for the activity of the  $\text{K}^{40}$  isotope in 1 kg soil and in 1 kg vegetation samples. These values are 7-10 times exceeding the corresponding activity value of the  $\text{K}^{40}$  isotope for 1 liter of water taken from the same site. This ratio for other radioactive elements varies in range 1,4-1,7. These values show that the process of assimilation by plants the  $\text{K}^{40}$  from water and soil samples is more efficient than the process of assimilation by plants other natural radioactive elements.

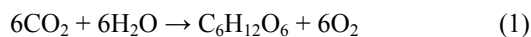
As is known, photosynthesis is the largest biochemical process on Earth and it is a complex chemical process of converting light energy and infrared radiation into the energy of chemical bonds of organic substances with the participation of photosynthetic pigments (plant chlorophylls, bacteriochlorophyll bacteria, archaea bacteriorhodopsin). The binding energy of the hydrogen atom with the hydroxyl group of the water molecule is 5 eV / molecule [4, 5].

The established low values of the energy of light quanta (much less than 5 eV) allow us to conclude that the nature of the course of photosynthesis is complex and the complex biochemical mechanisms of the process of dissociation of water molecules in plants are proposed.

Two types of pigments were found in living organisms (the retinal vitamin A derivative is less common, and chlorophylls are involved in photosynthesis in most organisms). In accordance with this biochemical mechanism, chlorine-free and chlorophyll photosynthesis are isolated. The efficiency of chlorophyll-free photosynthesis is relatively low (one  $\text{H}^+$  is transferred to one absorbed quantum of light). This process is found in the mating membrane of halobacteria. As a result of the operation of the light-dependent proton pump (bacteriorhodopsin) of the membrane, the energy of sunlight transforms into the energy of the electrochemical gradient of

protons on the membrane. Chlorophyll photosynthesis is more energy efficient. At least one  $H^+$  is transferred to each absorbed light quantum against the gradient, and energy is stored in the form of reduced compounds (ferredoxin, etc.). Oxygen-free chlorophyll photosynthesis (purple, green bacteria and heliobacteria) proceeds without oxygen evolution. Oxygen chlorophyll photosynthesis (higher plants, algae, cyanobacteria, etc.) is accompanied by the release of oxygen. In the initial (photophysical) stage of photosynthesis, light quanta are absorbed by pigments, they transition to an excited state and energy is transferred to other molecules of the photosystem (plastoquinone). In the photochemical stage, charge separation occurs in the reaction center. The chlorophyll molecule transferring its electron to plastoquinone turns into a radical-cation and under its influence the water molecule break up into hydrogen ion and hydroxyl group losing their electron. Formed under the influence of positively charged manganese ions hydroxyl groups are converted into oxygen and water molecules. In the chemical stage, light quantum is absorbed by another chlorophyll molecule and it transfers its electron to ferredoxin. Next, biochemical reactions of the synthesis of organic substances using energy accumulated at the already described light-dependent stages take place.

However, the proposed biochemical mechanism does not unambiguously explain the inconsistencies of some thermodynamic parameters. The process of photosynthesis is described by the equation of the total reaction:



This reaction is characterized by high endothermicity (3080 kJ / mol), the energy of H-O bond dissociation in  $H_2O$  molecules is 485-498 kJ / mol (5.0-5.2 eV / molecule) and the energy of C=O bonds in the  $CO_2$  molecule is equal to 799 kJ / mol (8.3 eV / molecule). These data indicate excessively high values of the potential energy barrier of these processes and the great difficulty in initiating them (the practical impossibility of carbon dioxide dissociation) by the energy of visible light quanta having energies much less than 5 eV.

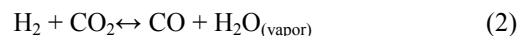
The energy of gamma rays (1.45 MeV) emitted by the  $K^{40}$  isotope is many times higher than the value of the energy of H-O bond dissociation in  $H_2O$  molecules (5 eV) and the energy of C=O bond dissociation in the  $CO_2$  molecules (8.3 eV / molecule). In addition,  $K^{40}$  isotopes were found without exception in all the samples taken from the environment, and the geometric dimensions of the studied vegetation samples were directly proportional to the activity (concentration) of  $K^{40}$  detected in them.

We concluded that for a complete description of the multi-stage processes photosynthesis, in addition to the biochemical mechanism shown in the scientific literature, the radiochemical mechanism of water and carbon dioxide molecules dissociation under the influence of gamma rays of natural isotopes (in mostly  $K^{40}$ , having the greatest activity in vegetation), that we have proposed should also be taken into account. A comparative analysis of the geometric, qualitative, organoleptic characteristics of the vegetation cover of

different areas is in good agreement, proportional to the concentration of  $K^{40}$  in these plants. The high energy of gamma rays of  $K^{40}$  and the relatively high activity (relatively high concentration) are the reason for the increase in the current concentration of radicals in the mass of the plant, which is equivalent to the acceleration of high-barrier endothermic process of dissociation of water and  $CO_2$  molecules. The analysis of numerous samples of water, soil, vegetation, livestock products showed the presence of  $Na^{22}$  and  $K^{40}$  radioisotopes in all samples, without exception.

As is known, after completion of reactions in spurs, the values of the primary radiation-chemical yield of water gamma radiolysis products at pH=4-9 are:  $G(H^+_{aq})=3.4$ ;  $G(e^-_{aq})=2.9$ ;  $G(H)=0.6$ ;  $G(OH)=2.9$ ;  $G(O)=0.0067$ ;  $G(H_2)=0.45$ ;  $G(H_2O_2)=0.75$ ;  $G(OH^-_{aq})=0.6$  ion / 100 eV. The value of  $G(H^+_{aq})$  is 4.25  $H^+ / 100$  eV [6-11]. Taking into account the average value of  $K^{40}$  activity in 1 kg of plant mass (1.2-3.0 Bq/kg), radiation exposure from this isotope during the year leads to the formation of  $4.7 \cdot 10^{12} H^+$  / (year.kg), i.e. 2.5 (quanta/(sec.kg))  $(4.25 H^+_{aq} / 100 eV) \cdot (1.46 \cdot 10^6 eV / quanta) = 15 \cdot 10^4 H^+_{aq} / (s.kg) = 4.7 \cdot 10^{12} H^+ / (year.kg)$ . This is lower than the value of the resulting  $H^+$  ions which were participated in photosynthesis.

In the 1980s, the radiation-chemical chain processes of conversion of  $H_2$ - $CO_2$  mixture to mixture of  $CO$ - $H_2O$  and conversion of  $CO$ - $H_2O$  mixture to  $H_2$ - $CO_2$  mixture was studied [7-9]. The total reaction (2) of conversion of mixture of  $H_2$ - $CO_2$  to mixture of carbon monoxide and water vapor is endothermic ( $\Delta H_2=41.2$  kJ/mol.), the total inverse reaction (-2) of the conversion of the mixture of carbon monoxide with water vapor to mixture of carbon dioxide and molecular hydrogen is exothermic ( $\Delta H_{-2}=-41.2$  kJ/mol.). The total reaction (2) of conversion of mixture of  $H_2$ - $CO_2$  to mixture of carbon monoxide and liquid (condensed) water at low temperature conditions is exothermic ( $\Delta H_2=-2.8$  kJ/mol.).



$$\Delta H_2 = 41.2 \text{ kJ / mol.}$$



It should be noted that the elementary reactions leading the chain process are reactions (7) and (8). The rate constant for reaction (8) at 300 K is  $3.7 \cdot 10^7 M^{-1} \cdot s^{-1}$ . The limiting stage of process is the elementary reaction (7) and this reaction is endothermic ( $\Delta H_7=102.91$  kJ/mol.). The low rate of this elementary reaction does not allow the conversion of the mixture of carbon dioxide with  $H_2$  to mixture of carbon

monoxidewith water vapor at 300 K. The values of the rate constant of the elementary reaction (7) at different temperatures were calculated according to the reference data [6, 10]:

$$k_7 = A_7 \cdot T^n \exp(-E_7 \cdot 4.18 \cdot 1000 / (R \cdot T)) \quad (10)$$

where  $A_7 = 10^{12.8}$ ,  $n=0$ ,  $E_7 = 25.9$  kcal / mol.s,  $R = 8.31$  J / (mol.K),  $T$  is the temperature in K.

$$\Delta G_7^0 = \Delta H_7^0 - T \Delta S_7^0 \quad (11)$$

$$\Delta G = -R \cdot T \ln K_{\text{equilibrium}} \quad (12)$$

The necessary thermodynamic parameters for calculating the reaction rate constant (7) are determined for the interval 1073-1323 K. To calculate the reaction rate constant at other temperatures, it is necessary to enter the value of the corresponding temperature in the equation (10).

Thus, the calculations made it possible to establish the values of reaction rate (7) at temperatures from 300 K to 1000 K:

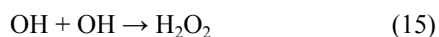
$$\begin{aligned} 300 \text{ K}, k_7 &= 10^{12.8} \exp(-25.9 \cdot 4.18 \cdot 1000 / (8.31 \cdot 300)) = 1 \cdot 10^{-3} \text{ sm}^3/\text{mol. s} = 1 \cdot 10^{-6} \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 400 \text{ K}, k_7 &= 0.056 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 600 \text{ K}, k_7 &= 2.7 \cdot 10^3 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 700 \text{ K}, k_7 &= 4.0 \cdot 10^4 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 800 \text{ K}, k_7 &= 5.9 \cdot 10^5 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 1000 \text{ K}, k_7 &= 1.6 \cdot 10^7 \text{ M}^{-1} \cdot \text{s}^{-1}. \end{aligned}$$

As can be seen, the value of the rate constant for reaction (7) at 300 K is  $1 \cdot 10^{-6} \text{ M}^{-1} \cdot \text{s}^{-1}$ , at 600 K this value increases to  $2.7 \cdot 10^3 \text{ M}^{-1} \cdot \text{s}^{-1}$  and at 800 K to  $k_7 = 5.9 \cdot 10^5 \text{ M}^{-1} \cdot \text{s}^{-1}$ . At 600 K and higher, the value of the rate of this reaction acquires rather large values, allowing the occurrence of this elementary reaction and the conversion of hydrogen to carbon monoxide, which at a temperature above 600 K acquires a chain character.

$\Delta G_7^0 = \Delta H_7^0 - T \Delta S_7^0$  was calculated using the appropriate thermodynamic parameters. The equilibrium constant of the reversible elementary reactions (7, -7) was determined using the equation ( $\Delta G = -R \cdot T \ln K_{\text{equilibrium}}$ ).

The values  $K_{\text{equilibrium}} = (k_7 / k_{-7}) = 8.4 \cdot 10^{-16}$ ;  $k_{-7} = 1.2 \cdot 10^9 \text{ M}^{-1} \cdot \text{s}^{-1}$  at 300 K are determined by calculations.

We outline below the radiation-thermal conversion of the mixture of carbon monoxide with water vapor to the mixture of  $\text{H}_2$ - $\text{CO}_2$ , where, in addition to elementary reactions -2, -7, -8,9, the following reactions also appear:



It should be noted that the elementary reactions leading the chain process are reactions (-8) and (-7). The rate constant for

reaction (-7) at 300 K is  $1.2 \cdot 10^9 \text{ M}^{-1} \cdot \text{s}^{-1}$ . The elementary reaction (-8) is endothermic ( $\Delta H_7 = 62.13$  kJ/mol.). Therefore, this reaction is the limiting stage of process. The low rate of this elementary reaction does not allow the conversion of carbon monoxide in a mixture with  $\text{H}_2\text{O}$  vapor to mixture of hydrogen with carbon dioxide at 300 K. The values of the rate constant of the elementary reaction (-8) at different temperatures were calculated according to the reference data [10]:

$$k_8 = A_8 T^n \exp(-E_8 \cdot 4.18 \cdot 1000 / (R \cdot T)), \quad (16)$$

where  $A_8 = 10^{14.48}$ ,  $n=0$ ,  $E_8 = 21.1$  kcal / mol.s,  $R = 8.31$  J / (mol.K),  $T$  is the temperature in K.

The necessary thermodynamic parameters for calculating the reaction rate constant (-8) are determined for the interval 300-2000 K. To calculate the reaction rate constant at other temperatures, it is necessary to enter the value of the corresponding temperature in the equation (16).

Thus, the calculations made it possible to establish the values of reaction rate (-8) at temperatures from 300 K to 1000 K:

$$\begin{aligned} 300 \text{ K}, k_8 &= 10^{14.48} \exp(-21.1 \cdot 4.18 \cdot 1000 / (8.31 \cdot 300)) = 2 \cdot 10^{-1} \text{ sm}^3/\text{mol. s} = 2 \cdot 10^{-4} \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 400 \text{ K}, k_8 &= 1 \cdot 10^3 \text{ sm}^3/\text{mol. s} = 1 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 600 \text{ K}, k_8 &= 7 \cdot 10^3 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 700 \text{ K}, k_8 &= 8.3 \cdot 10^4 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 800 \text{ K}, k_8 &= 5.7 \cdot 10^5 \text{ M}^{-1} \cdot \text{s}^{-1}, \\ 1000 \text{ K}, k_8 &= 8 \cdot 10^6 \text{ M}^{-1} \cdot \text{s}^{-1}. \end{aligned}$$

As can be seen, the value of the rate constant for reaction (-8) at 300 K is  $2 \cdot 10^{-4} \text{ M}^{-1} \cdot \text{s}^{-1}$ , at 600 K this value increases to  $7 \cdot 10^3 \text{ M}^{-1} \cdot \text{s}^{-1}$  and at 800 K to  $k_8 = 5.7 \cdot 10^5 \text{ M}^{-1} \cdot \text{s}^{-1}$ . At 600 K and higher, the value of the rate of this reaction acquires rather large values, allowing the occurrence of this elementary reaction and the conversion of mixture of  $\text{CO}$ - $\text{H}_2\text{O}$  to the mixture  $\text{H}_2$ - $\text{CO}_2$ , which at a temperature above 600 K acquires a chain character.

$\Delta G_{-8}^0 = \Delta H_{-8}^0 - T \Delta S_{-8}^0$  was calculated using the appropriate thermodynamic parameters ( $\Delta G_{-8}^0 = 59$  kJ/mol.). The equilibrium constant of the reversible elementary reactions (8, -8) was determined using the equation ( $\Delta G = -R \cdot T \ln K_{\text{equilibrium}}$ ) [4, 7-9].

The values  $K_{\text{equilibrium}} = (k_{-8} / k_8) = 5.4 \cdot 10^{-11}$ ;  $k_{-8} = 5.4 \cdot 10^{-11} \cdot 3.7 \cdot 10^7 \text{ M}^{-1} \cdot \text{s}^{-1} = 2 \cdot 10^{-3} \text{ M}^{-1} \cdot \text{s}^{-1}$  at 300 K are determined by calculations.

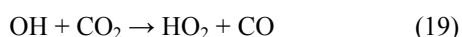
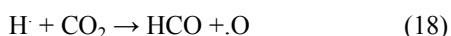
Thus, a comparison of the calculation results using the values of the thermodynamic parameters given in two different scientific literature reference sources showed that the value of the rate constant for the elementary reaction (-8) varies in the range  $2 \cdot (10^{-4} - 10^{-3}) \text{ M}^{-1} \cdot \text{s}^{-1}$ .

The concentrations of the starting components determine the direction of the process. At high concentrations of molecular hydrogen and carbon dioxide, the total process

prevails (2); at high concentrations of carbon monoxide and water vapor, the reverse total reaction proceeds (-2). At temperatures above 600 K, both processes proceed in a chain mode. With certain ratios of these components (appearing in the equation describing the equilibrium of the rate of direct and reverse reactions), an equilibrium occurs between these processes.

$$W_2=k_2.[H_2].[CO_2]=W_{-2}=k_{-2}.[CO].[H_2O] \quad (17)$$

Possible other elementary reactions due to too high activation energies (60-99 kJ / mol), therefore, due to several orders of low speeds, one can neglect:



The rates of the compared two mutually reversible chain radiation-chemical processes (2, -2) are determined by the rates of their limiting stages, i.e. rates of elementary reactions (7) and (-8), respectively.

$$W_7=k_7.[H].[CO_2], W_{-8}=k_{-8}.[H].[H_2O] \quad (21)$$

$$(W_7 / W_{-8})=k_7.[CO_2] / k_{-8}.[H_2O] \quad (22)$$

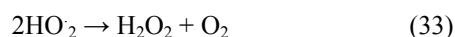
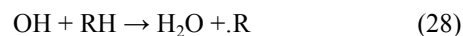
The value of the rate constant of reaction (-8) at 600-700 K is approximately 2 times higher than the value of the rate constant of reaction of (7), and at 800 K their values are almost completely equalized. If you take into account that the ratio of the rates of these reactions is determined by the equation (22), one can state equal concentrations of CO<sub>2</sub> and H<sub>2</sub>O in the studied mixtures at 800 K after reaching the equilibrium stage of these two mutually reversible radiation-chemical processes. At this temperature (800 K) at high concentrations of CO<sub>2</sub>, the process is directed towards the formation of CO, and at high concentrations of H<sub>2</sub>O, the speed in the mixture is directed towards the formation of molecular hydrogen, until an equilibrium is reached between these reverse processes.

However, the formation of any organic components were not detected during numerous experiments to study these processes.

In the same way, in the case of a radiation-thermal reaction, the conversion mixed with organic molecules of carbon dioxide to carbon monoxide due to the relatively low rates (in comparison with competing reactions), the following reactions can be neglected:



The joint course of these processes and the radiation-thermal conversion of carbon dioxide (in a mixture with organic molecules) to carbon monoxide can be described by the following scheme, where, in addition to elementary reactions 5, 7, -8, 9, 13, 14 and 15, the following reactions also appear.



All described processes occur with different speeds in the mass of green plants. Similar to the radiation-chemical process (2) closed cycles of elementary reactions (7, 8, 28) in plant mass also take place in the presence of K<sup>40</sup> and Na<sup>22</sup>. After decomposition of water (13), carbon dioxide (5) molecules and molecules of the organic matrix of green plants (26) under influence of ionizing radiation the further continuation (7, -7, 8, -8, 27, 28, 30, 31, 32, 33) elementary stages involving active particles proceed. The recombination reactions (9, 14, 15, 29, 34, 35, 36) of active centers, characterized by very low speeds.

Initiation of the process by ionizing radiation (the formation of radicals, atoms and ions) and further elementary reactions creates the real condition for the highly endothermic processes, dissociation of water and carbon dioxide molecule and synthesis of new organic molecules and molecular oxygen in addition to the synthesis processes, proceeding as provided by the biochemical mechanism of photosynthesis [4, 7-9].

Therefore, we presented the process of photosynthesis with the following image:



Figure 1. Proposed by us schematic illustration of photosynthesis.

The role of gamma radiation of the natural radionuclides should be taking into account in a comprehensive analysis of photosynthesis. This conclusion is supported by the multiplicity

of intermediate products of water radiolysis (the radiation-chemical yields of which are given above), possibility of multiple participation of active particles ( $H^\cdot$ ,  $OH^\cdot$ ,  $R^\cdot$ ,  $H^+$ ,  $H_{aq}^+$ ,  $e^-_{aq}$ ,  $R^+$ ,  $CO^+$ ) of radiolysis of water,  $CO_2$  and organic matrix in the cycles of elementary reactions. Little exothermicity (2.8 kJ / mol) of the total reaction of the radiolytic conversion of a mixture of hydrogen and carbon dioxide to mixture of liquid (condensed) water and carbon monoxide. The formation of new radicals and ions during many elementary reactions occurring in the plant mass also testifies in favor of this conclusion.

Earlier, as proof of the theory of evolution, the formation of organic substances from a  $CO_2$ - $H_2O$  mixture on a "hot" planet Earth was explained by changes in this mixture due to frequent lightning strikes in the Earth's atmosphere.

In recent publications, scientists reported that the formation of active particles for the synthesis of organic substances from carbon dioxide and water vapor was carried out under the influence of electric current using special electrodes and solar panels that convert light to electricity. It is known that ionizing radiation can simultaneously decompose numerous molecules of carbon dioxide and water, which are very difficult to decompose under the influence of other initiators. The formation of molecular hydrogen is observed with a radiation-chemical yield 7-8 molecules / 100 eV during radiolysis of water and the formation of molecular CO is observed with a radiation-chemical yield 4.5-7.8 molecules / 100 eV during radiolysis of  $CO_2$  [6, 10-15].

Our studies have established that in all samples taken from environmental objects, there are trace concentrations of radioactive isotopes of potassium / $K^{40}$ / and sodium / $Na^{22}$ / [5]. Given the presence of radionuclides emitting numerous gamma rays on the "hot" planet Earth, the probability of radiation-chemical processes of the destruction of carbon dioxide and water vapor with the formation of CO and  $H_2$  was quite possible. The formation of trace amounts of organic substances was also possible only with too large ionizing radiation powers incompatible with life due to the recombination of numerous radicals and atoms H, C, CO, OH, HCO, etc.

However, all three processes described above are clearly not enough to create a global organic (green) surface of the Earth.

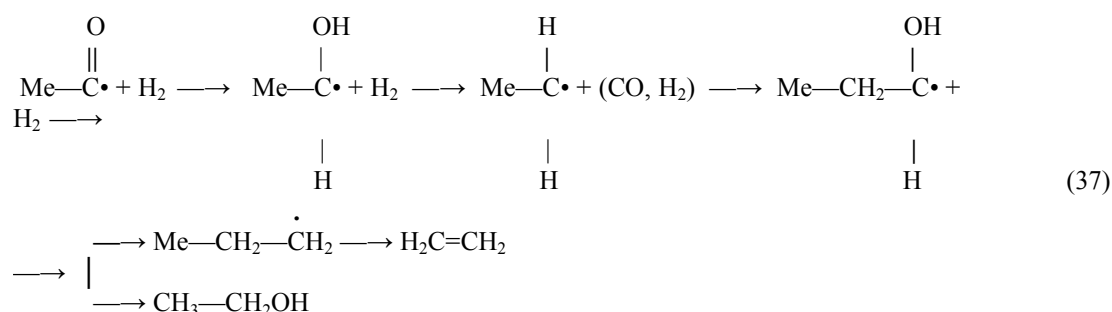
The possibility of the formation of CO,  $H_2$ ,  $H_2O_2$ ,  $O_2$  as the products of radiolysis was determined by studying the

thermodynamic parameters (enthalpies, activation energies, rate constants at various temperatures, approximate estimated speed values) of numerous elementary reactions of carbon dioxide with water vapor under the influence of ionizing radiation. The experiments carried out at different temperatures and different ratios of the initial components of the  $CO_2$ - $H_2O$  mixture irradiated by ionizing rays and gas-chromatographic analyzes of the products allowed us to determine the kinetics of the formation of the products ( $CO$ ,  $H_2$ ,  $H_2O_2$ ,  $O_2$ ) of the radiation-thermal transformation of the studied mixtures. With carefully performed experiments, no organic components were found among the reaction products.

At the initial stages of the Earth's formation at high temperatures, the liquid metals solidified after a certain cooling period and took the form of a crystal lattice at the nodes of which there were metal atoms. This process took place in the atmosphere, containing high concentrations of nitrogen, carbon oxides, hydrogen, possibly water vapor, the presence of which is very likely for a "hot" planet Earth. In the presence of "ubiquitous" radionuclides on the planet (according to our research), the formation of water may well be accompanied by a radiation-chemical reverse process of decomposition of water with the formation of molecular hydrogen and oxygen.

Slow and prolonged cooling of the surface of the molten metal was accompanied by adsorption of carbon oxides. Due to a shift in the electron density during adsorption from the metal surface to the carbon monoxide molecule the bond  $C=O$  was relaxed. The rupture of this bond led to the disproportionation of carbon monoxide to carbon and carbon dioxide and to the accumulation of carbon on the metal surface (carbide clusters on iron, cobalt, rhodium, ruthenium, osmium, etc.). Such carbide clusters can form and exist on many parts of the surface of a "hot" planet.

In the presence of molecular hydrogen on a cooled metal mass coated with carbide clusters, even at moderate temperatures (298-573K),  $CH^-$ ,  $CH_2^-$ ,  $CH_3$  groups can easily form by successive addition of hydrogen atoms to adsorbed carbon atoms. The synthesis of hydrocarbons and alcohols according to a chain scheme on a metal surface from CO and  $H_2$  were studied by sequential accumulation of surface radicals:



We reproduced experiments on the synthesis of organic substances from a mixture of CO and  $H_2$  on the surface of iron and cobalt, coated with carbide clusters, formed during

processing at 573 K in an atmosphere of carbon monoxide. The results of gas chromatographic analyzes showed the formation of  $CH_4$ ,  $C_2H_6$ ,  $C_3H_8$ ,  $C_4H_{10}$  (with the ratio 3: 3: 2: 1

of their concentrations) and  $\text{CH}_3\text{OH}$ ,  $\text{C}_2\text{H}_5\text{OH}$  (1: 1) from mixtures of  $\text{CO}$  and  $\text{H}_2$  at temperatures of 300-573K on the surface of metals (iron, cobalt) coated with carbide clusters. The relatively high speed of reaction is explained by the formation of active centers (free radicals) under the action of ionizing radiation. The use of radiation thermal initiation at increase in temperature from 300 K to 573 K led to an increase in the process speed by a factor of 5–7. An increase in temperature above 600 K leads to the transformation of carbide clusters into graphite and, consequently, to a decrease in the rate of the process. The process on the surface of metal oxides also led to a significant decrease in the speed of the process.

The obtained results indicate that the most likely direction of the formation of organic substances from mixtures of molecular hydrogen and carbon oxides, therefore, the initiator of the appearance of life on Earth is the thermal hydrogenation at 300-573 K of carbide clusters covering the surface of metals (radiation-thermalhydrogenation has a higher speed). A comparative analysis of the results allows us to conclude that a significant fraction of organic matter on the Earth is formed during the solidification and cooling of the surface of a “hot” planet from 600K to 300K. Further formation of heavy hydrocarbons from light hydrocarbons can occur according to reactions (19, 20, 23, 24, 31, 34, 36) both with the participation of ionizing rays and under the influence of UV rays. In addition to these reactions on a completely cooling (up to 300 K) planet this process continued also by the vital activity of living organisms and during photosynthesis.

## 4. Conclusions

The most likely direction of the formation of organic substances from mixtures of molecular hydrogen and carbon oxides, therefore, the initiator of the appearance of life on Earth is the thermal hydrogenation at 300-573 K of carbide clusters covering the surface of metals (radiation-thermal hydrogenation has a higher speed). A comparative analysis of the results allows us to conclude that a significant fraction of organic matter on the Earth is formed during the solidification and cooling of the surface of a “hot” planet from 600 K to 300 K. Further formation of heavy hydrocarbons from light hydrocarbons can occur with the participation of ionizing rays and under the influence of UV rays. In addition to these reactions on a completely cooling (up to 300 K) planet this process continued by the vital activity of living organisms and during photosynthesis.

The process of assimilation by green plants the  $\text{K}^{40}$  isotope from water and soil samples is more efficient than the process of assimilation by plants other natural radioactive elements. The energy of gamma rays (1.45 MeV) emitted by the  $\text{K}^{40}$  isotope is many times higher than the value of the binding energy of hydrogen with a hydroxyl group in water molecules (5 eV).  $\text{K}^{40}$  isotopes were found without exception in all the samples taken from the environment, and the geometric dimensions of the studied vegetation samples were

proportional to the activity (concentration) of  $\text{K}^{40}$  detected in them. The established low values (lower than 5 eV) of the energy of light quanta allow us to conclude that the nature of the course of photosynthesis is complex. Initiation of the process by ionizing radiation and further elementary reactions creates the real condition for the highly endothermic processes, dissociation of water and carbon dioxide molecules, synthesis of new organic molecules and molecular oxygen in addition to the biochemical synthesis processes. The participation of natural radionuclides in photosynthesis are confirmed with the presence of  $\text{K}^{40}$  in all samples taken from environmental objects, with increasing plant yieldsproportional to concentrations of natural radionuclides in soil and with observation of photosynthesis in the mating membrane of extreme halobacteria. This conclusion is confirmed also with observation of photosynthesis under thick layers of water, in the presence of only long-wave infrared rays or in the absence of chlorophyll and oxygen.

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