STIMULATION OF NUCLEAR ACTIVITY IN ELECTROLYSIS TESTS WITH LIGHT AND HEAVY WATER

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It is shown that in high-voltage electrolysis tests with light and heavy water the following nuclear processes proceed: transmutation of nuclei and generation of nuclides with anomalous isotope composition, generation of tritium, acceleration of α-decay of nuclei of radon ^{222}Rn and ^{220}Rn and generation of induced γ-activity. Mechanisms responsible for processes of *chemo*nuclear synthesis of deuterium are considered.

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1. INTRODUCTION

The significant part of scientific community rejects the results of any investigation of cold synthesis; this denial is based on unconditional recognition of three theoretical bans on proceeding of low temperature transmutation of chemical elements [1]:

1. Impossibility to overcome Coulomb barrier.
2. Maximum low cross-sections of weak processes.
3. Low probabilities of multi - particles collisions.

In the same time the familiarization with extensive experimental results obtained now in the field of investigations named the cold synthesis of deuterium [2, 3, 4, 5] doesn't leave doubt in the real existence of such phenomenon. The revealed now scales of this phenomenon give the grounds of considering the cold synthesis as prospective source of energy on solution of energy and ecological problems of the world. It follows from this that in conditions of cold synthesis the influence of enumerated above theoretical bans on proceeding of processes of synthesis of deuterium in the system deuterium-metal appears to be suppressed. Therefore the study of conditions under which the cold synthesis of deuterium is realized is of high scientific and practical interest. Last year the article of one of authors of presented paper was published; nuclear processes in the system deuterium-metal and hydrogen-metal were described there [6]. The English version of this article was presented in the present proceedings [7]. The author [6] shows that the cold synthesis represents a chain of related physical, chemical and nuclear processes which under some conditions may emerge spontaneously in the systems deuterium-metals and hydrogen-metal and provide undamped manner of synthesis of deuterium; the author also proposes the scenario of this process.

Such scenario of the synthesis can't be describes in terms of generally accepted definitions and was named the *chemo*nuclear synthesis of deuterium. It is pointed in paper [6]:

"Even a first sight on processes constituting the *chemo*nuclear picture gives the base to expect that reactions with the release of heat and helium will be intensive. So, the increase of deuteron energy from $E = 0.05...0.1\,eV$ (such energy is usually accepted for deuterium on considering processes of cold synthesis) to anticipated in real conditions of energies in the system deuterium-metal $E = 0.2...2\,keV$ increases the rate of $2D$-synthesis by hundreds of orders". Another example - the accepted hypothetical bineutron mechanism of nuclear reactions explains the whole class of set in experiment but not understand phenomena of cold synthesis: fission and transmutation of nuclei, generation of chemical elements of anomaly composition, generation of fast protons, neutron, tritons and α-particles, simultaneous release of three fast α-particles and others from low volumes of CR-detector. The fact that obtained during the experiment energy of each of enumerated above particles has the value close to that obtained from bineutron mechanism calculated values represents the convincing evidence of bineutron nature of reactions of cold synthesis.

It is shown in the paper [6] that the system with natural hydrogen has also the serious prospective for its use as the source of energy. Processes in this system are initiated by the reaction of hydrogen with deuterium which is present in the hydrogen of nature composition as impurity.

Author of the paper [6] notes that presented model of synthesis of deuterium is hypothetical and

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must be theoretically and experimentally studied. However he emphasizes that demonstrated in the paper numerous experimental confirmations of the model of *chemo*nuclear synthesis gives ground for developing of works for study and mastering of new ecologically clean source of energy.

2. EXPERIMENTAL PART

2.1. Goal of the work, equipment and methodology of investigation

The goal of presented work is to demonstrate how the presented model [6] of synthesis explains nuclear phenomena in electrolyze tests with light and heavy water. It was shown in a whole range of investigations [2] and, in particular, in our work dated 2001 y [8]. that such phenomena really exist. In the work [8] the appearance of induced activity was revealed in the experiment with saturation of niobium in unimolar $Li + D_2O$-solutions in electrolytic cell with the use of high-voltage pulsed discharge (excess of the signal of the more intense lines of spectrum over the level of background by value 6σ). Another irradiation pattern was observed with the use of light-water electrolyte $Li + H_2O$. In the experiment with light-water electrolyte the excess of the level of intensity peak over background by value higher 3σ was not observed. This gave the reason to state [8] that "during high voltage pulsed saturation of niobium in deuterized water electrolytes $Li + D_2O$ nuclear reactions proceed in electrolytic cell".

Fig.1. *Photo of the complex for the measurement of γ-activity*

However, the construction of the experimental system used in the work [8] had an essential defect - the fast disassembly of the discharge unit was not possible. Besides, another structural features of the system had promoted to the decrease of registration efficiency of γ-quanta emitted by the target. Therefore in the work [8] the short-living nuclides were not studied. Nuclides responsible for the detected induced activity also were not identified. On preparing the described experiment the construction of electrolysis system and the chamber of γ-detector was modernized. Now the disassembly and recharging of γ-detector may be carried out during 5...10 minutes. On recharging cathode, anode and another parts of discharging unit are laid out in tracing cloth over the aluminum protecting cover of germanium γ-detector. The vessel with electrolyte is placed in the chamber of detector. Such modernization of the system had promoted to the amplification of the signal activity by 8...10 times in comparison with experiment [8].

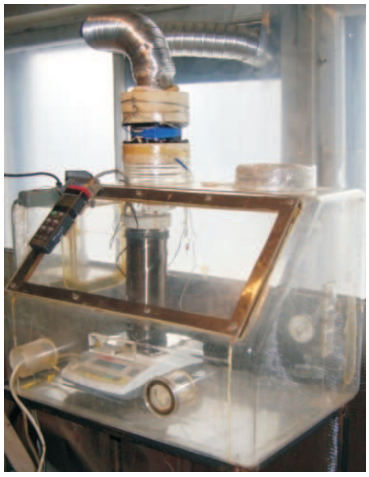

Fig.2. *Photo of ventilated box, where the tests with electrolysis were performed*

Fig. 1 and 2 show the photos of the complex for measurement of γ-activity and the section for the tests with electrolysis saturation. In the complex for the measurement of activity the HPGe-detector with nitrogen cooling was used (Inspector 2000 of the company Canberra Industries). Double-layer protection (see Fig. 1) was used for maximum suppression of the background; such protection consists of inner lead protection (the lead thickness is 55 mm) and outer protection made of "stop-blocks". The use of "stop-blocks" absorbing neutrons had allowed to decrease the background inside the protection by 12...15 %. Dependence of the value of background suppression on energy of γ-spectra is shown on Fig. 3. It is seen on Fig. 3 that the use of protection box allows to suppress the background by 50 times (in maximum).

The basic arrangement of the section of electrolysis is shown on Fig. 4. The details of the experiment are presented below.

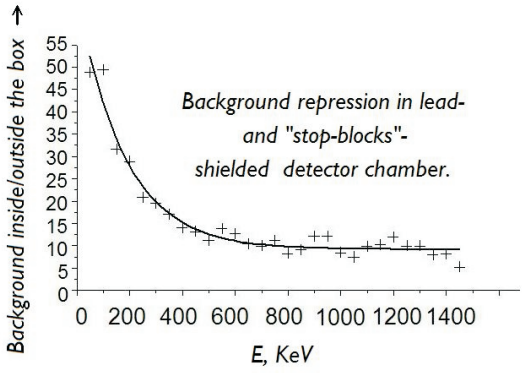

Fig.3. *Dependence of the level of background amplification on energy of γ-spectrum. Continuous line is the plot of data approximation by exponent*

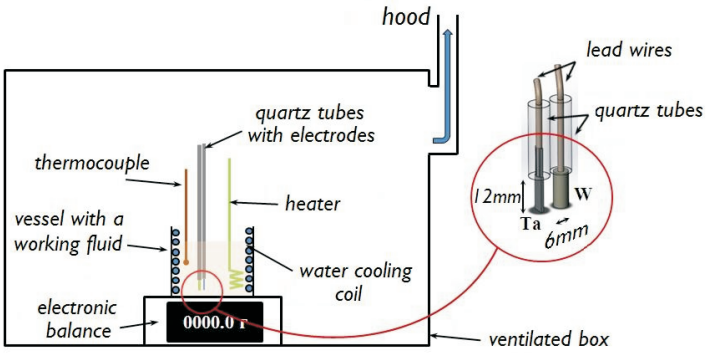

Fig.4. Schematic diagram of the electrolysis site

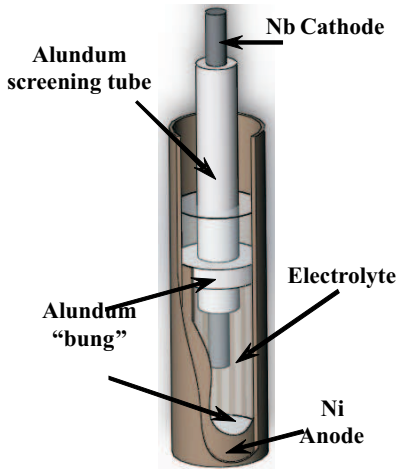

Fig.5. Appearance of discharging device (view in section) (experiment with $Nb - 1\,M\ Li + D_2O$)

2.2. Experiment in light water electrolyte

0.2-mole solution of K_2CO_3 in twice distillated water of natural composition was used as electrolyte. Tantalum of $99,8\%$ purity is used as material of cathode. Discharge device (marginal note on Fig. 4) consists of cathode - tantalum plate with dimensions $12 \times 4 \times 1\,mm$ and of anode - tungsten rod with diameter $5\,mm$, disposed on distance $6\,mm$ from one another by quartz tubes. Cathode was cut out from tantalum band of industrial rolling, annealed in vacuum ($p \approx 10^{-6}\,Torr$) at temperature $1000\,^{\circ}C$ during $3\,hours$. Process of electrolytic saturation had proceeded in pulsed regime. Duration of the pulse was $\tau = 135...145\,\mu s$, period $T = 790\,\mu s$. Voltage in the pulse was $U_{puls.} = 150...170\,V$, current - $I = 0.8^{-1}\,A$. Electrolytic power of the discharge was on level $60...75\,W$. Cooling of the system was realized by running water. Duration of the experiment was $4\,hour$. After the bombardment the disassembling of the system was performed. During the withdrawal from electrolyte cathode was heated up to $70...90\,^{\circ}C$ and splitted on several parts. Cathode and other elements of discharging unit were arranged in the chamber of γ-spectrometer. The reservoir with worked out electrolyte ($10\,ml$) was also arranged in the chamber of spectrometer. Registration of flashing spectrum started with the interval of 11 minutes. Structure of cathode surface and also its chemical and isotope composition (see Sec. 3) were studied after the ending of the process of γ-spectrum registration.

2.3. Experiment in heavy water electrolyte

1-mole solution of Li in D_2O was re-used as electrolyte, the same solution was also used in the experiment [8] in 2001. Before the experiment electrolyte was tested for residual radioactivity. The testing had showed that in the spectrum of γ-irradiation there is no peak the intensity of which exceeds the background by 3σ. Niobium of $99,8\%$ purity was used as material of cathode (rod with diameter $3\,mm$); rundlet made of nickel foil (purity $99,9\%$) with the length $30\,mm$ and diameter $13\,mm$ was used as anode (Fig.5). Similarly to the experiment with light water the process of electrolytic saturation was carried out in pulsed regime. Duration of the pulse was $\tau = 165...175\,\mu s$, period - $T = 790...800\,\mu s$. Voltage in the pulse was $U = 500...600\,V$, current - $I = 100...250\,mA$. Electrical power of the discharge was on the level $50...60\,W$. Cooling of the system was realized by running water. The experiment lasted $3.5\,hours$. After the completion of electrolysis the system was disassembled. The part of cathode bulged out the alundum shield ($\sim 8\,mm$) was broken off (niobium during saturation losses plasticity), anode unfolds into a tape. After this the parts of discharge unit and reservoir with electrolyte ($10\,ml$) was placed in the detector chamber near the surface of germanium γ-detector and registration of γ-irradiation started $14\,minutes$ passed from the moment of discharge switch off to the start of spectrum registration.

3. CHANGE OF CHEMICAL AND ISOTOPE COMPOSITION OF TANTALUM TARGET

3.1. Chemical composition

Study of the surface structure and X-ray spectrometric measurement od composition was carried out on scanning electron microscope JEM-7001F and X-ray EDS microanalyzer OXFORD INCA with accelerating voltage $20\,kV$. Computation of X-ray spectra was performed by the program Oxford Instruments INCA 4.11. Fig.6 gives the electron image of cathode surface. During the electrochemical exposure the tantalum surface was subjected to hard erosion. Erosion pits, cavities and extended defects of "channel" type (probably, the grain boundary erosion) were formed on the material surface. Microcracks were observed in some area of the surface.

Table 1 and Fig. 7 show the results of X-ray analysis of composition of cathode surface before and after experiment.

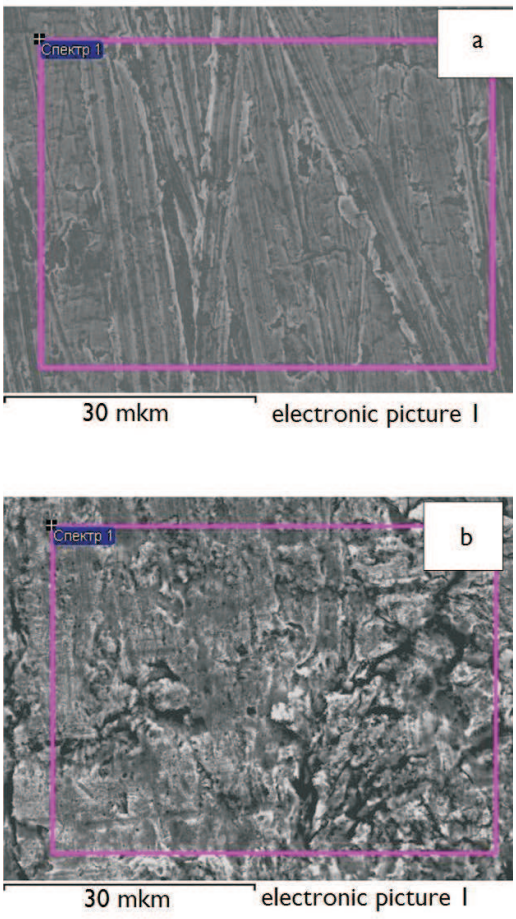

Fig.6. *Electron image of surface: a - of initial specimen of Ta; b - after 4 hours of treatment (experiment with* $0.2\,M\ K_2CO_3 + H_2O$ *)*

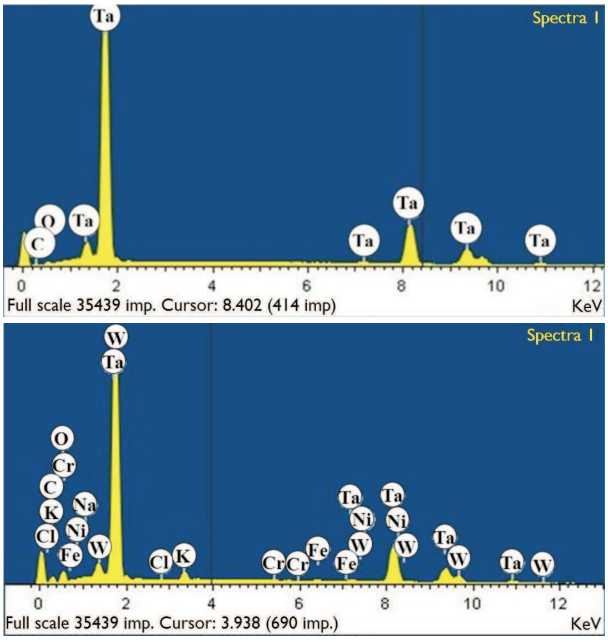

Fig.7. *Results of X-ray microanalysis: a - for initial specimen of Ta; b - for specimen after 4 hours of treatment (experiment with* $0.2\,M\ K_2CO_3 + H_2O$*)*

Table 1. *X-ray analysis of the surface content. The average content by the surface*

Element-line	mass, %	mass, %
$C-K$	2.81	-
$O-K$	2.51	10.56
$Ta-M$	94.68	85.19
$Na-K$	-	0.28
$Cl-K$	-	0.18
$K-K$	-	2.05
$Cr-K$	-	0.17
$Fe-K$	-	0.46
$Ni-K$	-	0.26
$W-M$	-	0.85
	The surface of the original Ta sample	The surface of the exposed Ta sample

It is seen from table 1 and plot on Fig. 7 that during electrolysis the impurities of several chemical elements form on the cathode surface. Appearance of W and K may be explained by the experiment technology but the appearance of another elements may be explained by different reasons (see Sec. 6).

3.2. Isotope composition

Surface of tantalum target after electrolysis experiment with $K_2CO_3 + H_2O$ was analyzed with industrial laser mass-spectrometer EMAL-2. Mass-spectrometer EMAL-2 is constructed according to the classic diagram Mataukh-Gertsog with energy and mass focusing with the use of laser-plasma source of ions and with system of ion registration on photographic film $UF-4$. Such method allows to analyze the surface layer of thickness 500...800 nm by its evaporation with laser into one line passage. Mass-spectrometric investigation of tantalum target was carried out for detection of variations in element composition of target impurities and heir isotope distribution after experiment. For analysis the surface of initial specimen was cleaned by quartz scrapper and was washed in twice distilled water. Table 2 shows the content of impurity elements in analyzed surface layer of tantalum target before and after experiment. After experiment measurements were performed in three points:

- central part of irradiation spot;
- periphery of irradiation spot;
- unirradiated part of target in the region of mounting.

Table 3 shows the results of analysis of isotope distribution of impurities according to the results of three measurements of the target after electrolysis experiment.

Table 2. *Content of main impurity components in tantalum target before and after experiment*

Element	mass, %	mass, %	mass, %	mass, %
C	0.007	0.02	0.01	0.025
N	0.0006	0.001	0.0004	0.001
O	0.3	2.05	1.02	2.3
F	0.0005	0.002	0.0009	0.001
Na	0.007	0.07	0.04	0.008
Al	0.017	0.006	0.003	0.01
Si	0.016	0.05	0.009	0.01
P	0.0004	0.0004	0.0004	0.0004
S	0.002	0.03	0.02	0.003
Cl	0.0025	0.04	0.02	0.003
K	0.0004	2.64	0.95	0.03
Ca	0.0015	0.03	0.035	0.06
Ti	0.006	0.005	0.0035	0.002
V	< 0.0001	0.0006	< 0.0001	< 0.0001
Cr	0.0007	0.02	0.004	0.01
Mn	0.002	0.001	0.0005	0.002
Fe	0.018	0.2	0.04	0.1
Ni	0.001	0.02	0.004	0.008
Cu	0.007	0.2	0.09	0.02
Zn	0.002	0.25	0.006	0.005
Nb	0.07	0.07	0.07	0.065
Mo	0.007	0.007	0.007	0.007
W	0.037	0.42	0.36	0.025
	Original sample surface (tipped before analysis)	Surface area witout exposure	Peripheral exposure	Central part of the exposure

As it is seen from Table 3 measured isotope distribution of impurities in central part of the irradiation spot are significantly different of natural distributions and for some chemical elements (Chrome, Iron, Zinc, Molybdenum, Tungsten) are beyond the bounds of standards systematic error of analyzer. The standard systematic error of analyzer $EMAL-2$ is cause first of all by the system of photoregistration and is in the limits of 3...7 % and doesn't exceed 10%.

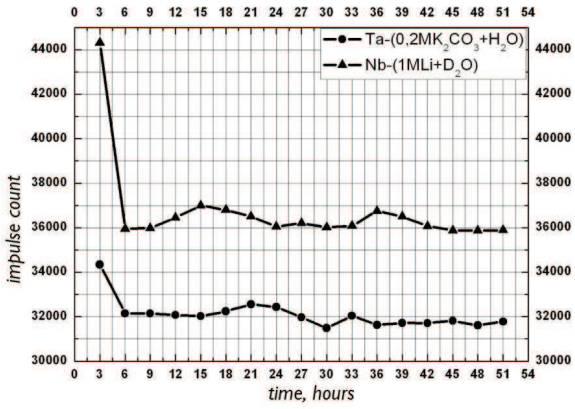

Fig.8. *Comparison between the sum activity of heavywater and lightwater experiments*

Table 3. *Isotope analysis of impurities of tantalum target after experiment*

Element	Natural isotopic abundance, %	Measured isotopic abundance, % *	Change from natural abundance, % *	Measured isotopic abundance, % **	Change from natural abundance, % **	Measured isotopic abundance, % ***	Change from natural abundance, % ***
^{35}Cl	75.8	74.26	-2.03	75.75	-0.07	74.47	-1.75
^{37}Cl	24.2	25.73	+5.45	24.24	+0.17	25.53	+5.5
^{39}K	93.3	93.49	+0.2	93.47	+0.18	93.7	+0.43
^{41}K	6.7	6.51	-2.83	6.53	-2.54	6.3	-5.97
^{50}Cr	4.35	3.86	-11.26	4.13	-5.06	5.3	+21.8
^{52}Cr	83.8	84.15	+0.4	85.12	+1.58	80.39	-4.07
^{53}Cr	9.5	9.55	+0.5	8.26	-13.05	11.48	+20.84
^{54}Cr	2.36	2.44	+3.39	2.48	+5.08	2.82	+21.55
^{54}Fe	5.8	5.82	+0.34	5.9	+1.7	6.45	+11.2
^{57}Fe	2.25	2.23	-0.9	2.15	-4.44	1.59	-29.33
^{58}Ni	67.8	69.95	+3.17	68.5	+1.03	68.69	+1.6
^{60}Ni	26.4	23.35	-3.97	25.69	-2.7	25.51	-3.37
^{61}Ni	1.16	1.17	+0.9	1.16	-0	1.16	-0
^{62}Ni	3.71	3.52	-5.12	3.71	-0	3.71	-0
^{63}Cu	69.1	66.07	-2.12	70.05	+1.37	71.43	+3.37
^{65}Cu	30.9	33.97	+4.75	29.95	-3.07	28.57	-7.54
^{64}Zn	48.9	48.7	-0.41	50.88	+4.05	45.79	-6.36
^{66}Zn	27.8	28.3	+1.79	26.65	-4.13	27.22	-2.08
^{68}Zn	18.6	18.3	-1.61	17.77	-4.46	22.28	+19.78
^{92}Mo	14.8	12.21	-17.5	14.17	-4.26	9.73	-34.26
^{94}Mo	9.1	7.92	-12.97	9.91	+2.3	11.5	+26.37
^{95}Mo	15.9	14.19	-10.75	16.19	+1.82	19.47	+22.45
^{96}Mo	16.7	17.16	+2.75	17.0	+1.8	15.49	-7.25
^{97}Mo	9.5	11.22	+18.1	10.53	+10.84	11.94	+25.68
^{98}Mo	24.4	27.06	+10.9	22.27	-8.73	22.57	-7.5
^{100}Mo	9.6	10.23	+6.56	10.53	+9.68	9.3	-3.12
^{182}W	26.3	25.08	-4.64	25.64	-2.51	34.09	+29.62
^{183}W	14.3	14.88	+4.05	13.67	-4.4	12.5	-12.59
^{184}W	30.7	30.77	+0.23	31.62	+3.0	25.0	-18.57
^{186}W	28.6	29.26	+2.3	29.06	+1.6	28.41	-0.66

^{19}F, ^{23}Na, ^{27}Al, ^{31}P, ^{55}Mn, ^{93}Nb, - 100 % isotope, C, N, O, Si, Ca - no measurements made.
* Surface area witout exposure; ** Peripheral exposure; *** Central part of the exposure.

4. INDUCED γ-ACTIVITY

4.1. Sum induced γ-activity of spectra

Fig. 8 gives the comparison of activity of spectra $1\,MLi + D_2O$ and $0.2\,MK_2CO_3 + H_2O$ experiment. Each point on the plot represents the sum of pulses by all channels in the range 50...2000 keV for time intervals of 3 $hours$. These data allow to analyze nuclear processes responsible for emergence of activity. We examine the time dependence of activity decay and we can make two preliminary conclusions:

1. One of the main sources of induced nuclear activity in elecrolysis experiments with heavy and light water are reactions of decay of ^{222}Rn.

2. During the experiment with $1\,MLi + D_2O$ and $0.2\,MK_2CO_3 + H_2O$ the long-lived γ-activity is generate. Its intensity for spectrum of heavy-water experiment is 10...12% higher than that in spectrum of light-water experiment.

4.2. Energetic spectrum of induced γ-activity

In the result of the study of γ-spectra for experiments with $K_2CO_3 + H_2O$ and $Li + D_2O$ a number of decaying lines was detected.

Table 4. *Parameters of some lines of decay products of ^{222}Rn for light water and heavy water experiments*

$Ta - (0.2M\,K_2CO_3 + H_2O)$

Presumed nuclide	γ-radiation energy, keV*	Half-life,** min	σ-level above the back-ground
^{214}Pb	352(37.6%)	$37 \pm 16(27)$	6.4
^{214}Pb	295.2(19.3%)	$30 \pm 50(27)$	2.33
^{214}Pb	242(7.4%)	* * *	* * *
^{214}Bi	1765(15.4%)	$70 \pm 42(20)$	4
^{214}Bi	1120(15.1%)	$23 \pm 9.7(20)$	1
^{214}Bi	609(46.1%)	$19 \pm 22(20)$	3.2

$Nb-(1M\ Li+D_2O)$

Presumed nuclide	γ-radiation energy, keV^*	Half-life,** min	σ-level above the background
^{214}Pb	352(37.6%)	$30 \pm 3(27)$	29
^{214}Pb	295.2(19.3%)	$36 \pm 17(27)$	21
^{214}Pb	242(7.4%)	$18 \pm 3.4(27)$	9.6
^{214}Bi	1765(15.4%)	$44 \pm 26(20)$	4.2
^{214}Bi	1120(15.1%)	$49 \pm 14(20)$	5.1
^{214}Bi	609(46.1%)	$81 \pm 23(20)$	19

$*$ - *in parentheses the tabulated values of the line intensities are listed;*
$**$ - *in parentheses the tabulated values for the half-life of the nuclide are listed;*
$***$ - *No data.*

As the treatment had showed the more reliable (3σ and more) were the lines of decay products of ^{222}Rn - Table 4 and Fig. 9. At the same time in the presented work there is a considerable quantity of lines reliability of which is lower than reliability of lines presented in Table 4; due to this these lines remained not identified.

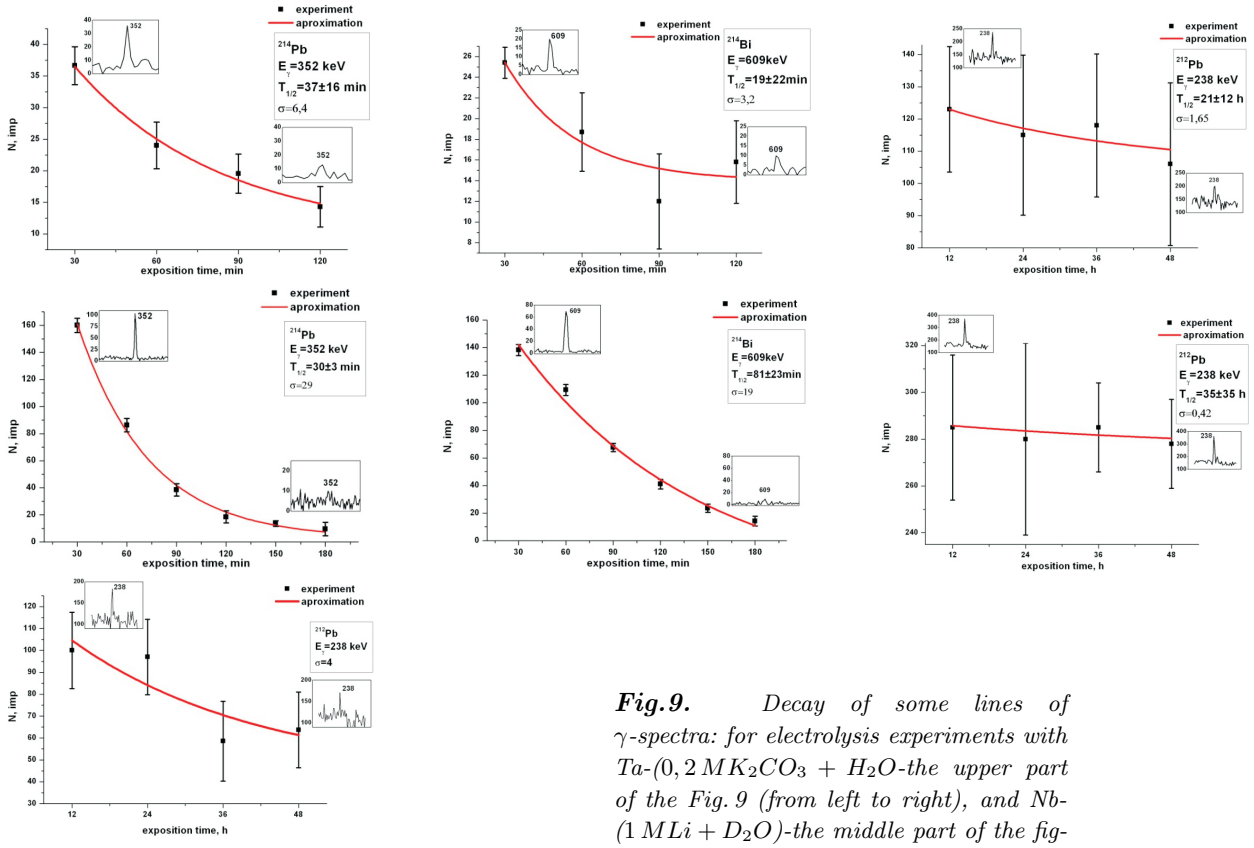

Fig. 9. *Decay of some lines of γ-spectra: for electrolysis experiments with Ta-$(0,2\,M K_2CO_3 + H_2O$-the upper part of the Fig. 9 (from left to right), and Nb-$(1\,M Li + D_2O)$-the middle part of the figure 9; for gas discharge experiment $Pd - D_2$-the bottom part of the Fig. 9, [9]*

It is seen from data presented in Table 4 and Fig. 9[1] that intensity of lines of products of decay of ^{222}Rn for experiments with $Li+D_2O$ is considerably higher than that in experiment with $K_2CO_3 + H_2O$. The sum activity of the spectrum for high water experiment is similar (Fig. 8).

It follows from Fig. 9,e and f that the high level of background activity and low level of useful signal doesn't allow to conclude unambiguously on activation of ^{222}Rn in experiment with light water and experiment with heavy water. But in the experiment with gas discharge with the use of palladium cathode [9] activation of ^{220}Rn was observed (Fig. 9,g).

5. CONTENT OF TRITIUM IN LIQUIDS FROM EXPERIMENTS WITH $0,2\,M\ K_2CO_3 + H_2O$ and $1\,M\ Li + D_2O$

For heavy water electrolyte and electrolyte representing the solution of $0.2M\ K_2CO_3$ in usual water analysis for determining of specific content of tritium was performed. Analysis was performed in the Institute of geochemistry of environment of NASU in the laboratory of nuclear geochemistry and space chemistry. Measurements were carried out on low background $\alpha - \beta$-spectrometer Quantulus - 1220-003. The specific activity of background specimen was $3Bk/kg$. Results of analysis are presented in the Table 5. It follows from this table that level of tritium accumulation in both experiments strongly exceeds the possible error of measurement.

[1] *Let's label graphics in Fig. 9 by: a, b, c, d, e, f, and g, from left to right.*

Table 5. *Content of tritium in liquids in heavy water and light water experiment*

Composition of electrolyte	Material cathode-anode	Content of tritium, Bk/kg	Excess over background, times
$1M\ Li + D_2O$	$Nb - Ni$	1340	450
$0.2M\ K_2CO_3 + H_2O$	$Ta - W$	160	53

6. DISCUSSION OF RESULTS

6.1. Variation of chemical and isotope composition of the surface of tantalum cathode

The change of chemical and isotope composition of cathode surface during lightwater and heavywater electrolysis experiments is an convincing evidence of nuclear processes proceeding. As follows from Tables 1-3 and diagrams on Fig. 7 these changes occurred on defined areas of tantalum cathode in our light water experiment.

Let us examine this situation in more details. Two processes occur simultaneously on the surface of tantalum cathode during electrolysis experiment. The first process: evaporation and dissociation of water base of electrolyte and as consequence the saturation of tantalum cathode surface by hydrogen of nature composition in the zone of discharge. So, conditions for *chemo*nuclear synthesis and generation of products emerge [6].

The second process proceeds simultaneously in the zone of electrolysis - this is the process of transfer of tungsten from anode to cathode and precipitation of different impurities from electrolyte. In the result a layer of composite material forms on the cathode surface; this layer is probably formed by transferred tungsten and precipitates from electrolytes: salts, oxides, carbides etc. In the zone of maximal density of discharge this composite layer breaks down; this causes the exposure of metal surface and amplification of the process of *chemo*nuclear synthesis of deuterium in this part of cathode.

As is seen from Table 3 considerable changes of isotope composition of impurities occur only for surface which is not covered by composite layer.

Such pattern of processes observed on the cathode surface explains the results presented in Tables 1-3 and on Fig. 7-9 and allows to make conclusion about stimulation of nuclear processes in electrolysis experiments.

Table 3 shows that during light water electrolysis some chemical elements form in the tantalum cathode; these elements are: chromium, iron, zinc, molybdenum and tungsten, the isotope composition of these elements is different from natural one. The change of isotope composition of these elements is out of standard systematic error of analyzer. Let us show on the example of one element - molybdenum - how the detected changes in chemical and isotope composition of these elements agree with the presented scheme of *chemo*nuclear synthesis [6].

Molybdenum is not presented in Table 1 and on diagram of Fig. 7. It means that concentration of molybdenum in cathode ($\leq$0,01%) is insufficient for be recorded by X-ray microanalyzer. In the same time according to the data of laser spectrometry (see Table 2) molybdenum was detected in the layer 500...800 nm. In this case molybdenum has the isotope composition different from natural composition for each of its isotopes. Such composition is characteristic for fission fragments.

According to [6] fission of nuclei in conditions of cold synthesis is realized by bineutron mechanisms and is caused by excitation of nucleus up to high levels [14, 15] before fission.

Characteristic signs of nuclei fissison according to bineutron mechanism are the following:

a) Stable fission fragments form [14, 16].

b) Fission of nuclei is not accompanied by neutron release and instant γ-radiation [14,16].

c) Formed fission fragments have relatively close (in comparison with fission products of uranium) masses [6, 15].

Now we will consider how these signs manifest in our test. Signs a) and b) are considered in point 6.2. It is shown that in light water and heavy water tests γ-radiation (signal $\geq 3\sigma$) belongs to products of decay of ^{222}Rn. Induced activity which can be identified as activity of fragment of tantalum fission has the activity considerably lower than 3σ. It is expected that nuclides with not standard isotope composition (including ^{96}Mo) are the fission products of tantalum and should be not active [16]. As to the sign c) it must be noted that according to bineutron mechanism of fission

$$^{181}Ta +^{2} n \rightarrow f \rightarrow \left\{ \begin{array}{l} ^{96}_{42}Mo \\ ^{87}_{36}Sr \end{array} \right.$$

(see Table 3.1 in point 7 of paper [6]) the first fission fragment is one of molybdenum isotope and the second fragment may be stable isotope of strontium with

appropriate mass. Relatively close values of fragment masses in this reaction according to the sign "c") confirm the bineutron character of tantalum fission in our test.

6.2. Stimulation of α-decay of nuclei and formation of induced γ-activity in electrolysis tests with light and heavy water

It was shown early in our works [11, 12] that in some cases during the tests with gas discharge emergence of local induced radioactivity may be the pseudo effects induced by the transfer of natural ^{222}Rn and its fission products in the area of discharge. A weak induced radioactivity was revealed in these works; it is difficult to identify this radioactivity. Therefore the authors have concluded that additional investigations are necessary to make the final conclusion on the role of nuclear processes in stimulation of α-decay. Study of this problem was one of the tasks of presented work.

In the presented work authors have used high-voltage pulsed electrolysis instead the glow discharge used in the work [12]; this electrolysis allowed to obviate conditions necessary for the effect of pseudo radioactivity. Detected in electrolysis tests stimulation of decay of ^{222}Rn must be considered as obvious evidence of nuclear phenomena functioning.

The additional evidence of nuclear phenomena in activation of α-decay were obtained in the described tests during study of the decay of radon ^{220}Rn for which the effect of pseudo radioactivity must be strongly reduced [12].

Results obtained in the presented work may be considered as direct evidence of nuclear processes participation in stimulation of α-decay of ^{220}Rn and ^{222}Rn in conditions of *chemo*nuclear synthesis.

What can be said today about mechanism of stimulation? Now we have no enough data for plotting the activation mechanism of α-active nuclei. But the most important preconditions for the activation of α-decay exist in conditions of *chemo*nuclear synthesis. On our opinion such preconditions are the following:

a) During the *chemo*nuclear synthesis of deuterium the zone of synthesis and surrounding areas are penetrated by intense flow of energetic ($E = 6.5...7\,MeV$)conversion electron [6] Electrons scatter on nuclei of radon ^{222}Rn present in tantalum as impurity and by interchange of virtual γ-quanta transfer energy to nucleus and shift the nucleus on suitable excited level with a very small, albeit a certain probability. At energy of conversion electrons the cross-section of this process corresponds to the area of inelastic scattering with excitation of discrete levels of nucleus [13].

b) α-decay of excited nucleus is accompanied by emission of α-particles with energy exceeding the energy of α-particles of unexcitated nucleus by value of excitation energy. According to Geiger-Nuttall rule[2] survival life of such nucleus is lower than survival life of nucleus in ground state. Therefore in conditions of *chemo*nuclear synthesis concentration in tantalum target of ^{214}Pb and other decay products of radon ^{222}Rn will be higher than nature one. On stoppage the deuterium synthesis process which stimulates α-decay of radon ^{222}Rn system restores into initial state by α-decay of ^{214}Pb and other decay products of radon. This is registered as decay of induced γ-activity in our tests.

c) Phenomena enumerated in a (and b) have low level of intensity and this fact determines very low level of nuclear processes, which were described by mechanism of stimulation. Such conclusion agrees with data obtained in cold synthesis experiments: relationship of intensity of reaction with release of heat and helium to intensity of processes of transmutation and nuclei fission was determined as $\sim 10^{10}$ [2, 3]. Similar conclusions can be also made for acceleration of α-decay of radon ^{220}Rn.

6.3. Generation of tritium in electrolysis tests with light and heavy water

It was shown in [6] that the main process responsible for generation of tritium in tests of cold synthesis is reaction of deuteron with bineutron:

$D +^2 n \rightarrow T\,(1.56\,MeV) + n\,(4.64\,MeV)\,.$

Lower quantities of tritium are generated be the reaction:

$^3_2He + n \rightarrow^3_1 H\,(0.191\,MeV) +^1_1 p\,(0.573\,MeV).$

Generation of tritium in electrolysis tests in quantities exceeding its natural content by many orders testifies to existence of nuclear processes according the *chemo*nuclear synthesis of deuterium [6].

7. CONCLUSIONS

It is determined that in high-voltage electrolysis tests with heavy and light water nuclear processes proceed: transmutation of nuclei and generation of nuclides with anomalous isotope composition, generation of tritium, acceleration of α-decay of nuclei of ^{222}Rn and ^{220}Rn and generation of induced γ-activity. It is shown that each of these phenomena may be satisfactory explained in within the bounds of *chemo*nyclear synthesis of deuterium [6] and therefore the results of presented paper may be considered as experimental confirmation of this scenario. Publication of presented paper and of paper [6] in one journal allowed to reduce considerably extent of the paper and to facilitate the understanding of presented material.

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СТИМУЛИРОВАНИЕ ЯДЕРНОЙ АКТИВНОСТИ В ЭЛЕКТРОЛИЗНЫХ ОПЫТАХ С ЛЕГКОЙ И ТЯЖЕЛОЙ ВОДОЙ

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Показано, что в высоковольтных электролизных опытах с легкой и тяжелой водой идут ядерные процессы: трансмутация ядер и наработка нуклидов с аномальным изотопным составом, наработка трития, ускорение α-распада ядер радона ^{222}Rn и ^{220}Rn и генерирование наведённой γ-активности. Рассмотренны механизмы, ответственные за протекание процессов ядерного синтеза дейтерия.

СТИМУЛЮВАННЯ ЯДЕРНОЇ АКТИВНОСТІ В ЕЛЕКТРОЛІЗНИХ ДОСЛІДАХ З ЛЕГКОЮ І ВАЖКОЮ ВОДОЮ

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Показано, що у високовольтних випробуваннях електролізу з легкою і важкою водою протікають ядерні процеси: трансмутація ядер і напрацювання нуклідів аномального ізотопного складу, генерація тритію, прискорення α-розпаду ядер радону ^{222}Rn і ^{220}Rn і генерації наведеної γ-активності. Розглянуті механізми, відповідальні за процеси ядерного синтезу дейтерію.