Nuclei transformations in electric discharge conditions

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ABSTRACT. The products obtained through a low-energy electric discharge between carbon electrodes in glycerin's water solution are investigated by means of Mass Spectrometry, Raster Electronic Microscopy, and X-ray Fluorescence Analysis. The residue formed during experiment is found to possess chemical composition differing from the initial components by its chemistry and macrostructure. The mechanism and the catalyst of a low-energy nuclear transformation course are discussed.

Keywords: liquid, electric discharge, low-temperature plasma, magnetic field, transformation of chemical elements.

1 Introduction

The first communication concerning nuclei transformation under high temperatures appeared in 1922 (see [1]). The article stated a confidently observed formation of He under electric explosion of thin W wires in vacuum under 30 KV potential applied. The next significant works (see [2-4]) demonstrated that within an electric explosion of Ti in a liquid both isotopic distortion of the proper Ti and formation of a series of new elements were documented. Electric explosion was initiated by discharge of a capacitor battery with 5 KV potential, while the current of pulse discharge reached 150 KA. Nuclear transformations under electric discharge between carbon electrodes in water were documented also within a low-energy initialization in [5]. In this paper, direct-current voltage 25 V was used and the discharge current not exceeded 20 A. A low-energy method for synthesis of various ele-

ments from water under electric discharge between copper electrodes was given in the paper [6].

The objectives of the present article are:

1) complementary confirmation of low-energy transformation of chemical elements under electrical discharge,

2) discussion of mechanism and catalyst in the course of low-energy transformation of chemical elements.

2 Experimental installation and investigation methods

In the experiments described later the electric discharge was carried out between carbon electrodes ø6 mm of High Purity type 7-2 in 30% solution of glycerin (type PK-94) in distilled water. The pattern of electric discharge cell with indicated components enabling to maintain discharge automatically is shown on Fig.1. Earlier we used a similar discharge cell in [7] as well. In the present paper, with the aim to secure experimenters against adverse chemical and other influence, the system of automated discharging was introduced along with some elements of remote control. The task of controlled behavior of upper carbon electrode 1 (with the lower electrode being fixed) was performed by an automatic electrode lifting/lowering device 3. The automatic mode of the device work was provided by the unit 4 at the expense of included current feedback via the ballast resistor R. In the automatic mode of the discharge device, the current interruption frequency was 2 to 5 Hz, while the maximum discharge current not exceeded 30 A under constant voltage 80 V of electric power supply source. The Helmholtz coils 2 served for separation of arising magnetic radiation while photo films 7 were used for registering this radiation.

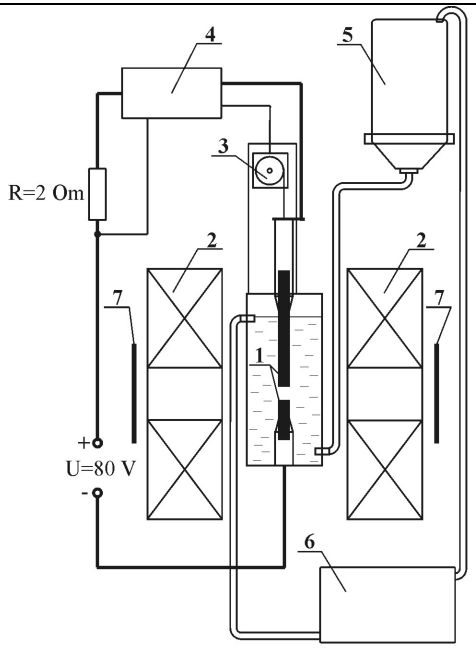

Fig.1. Scheme of the electric discharge cell.

1 is carbon electrodes (moving upper and fixed lower),

2 are Helmholz coils,

3 is moving electrode lifting/lowering device,

4 is the control unit for lifting/lowering device,

5 and 6 are sump and feeding tanks, 7 are places for X-ray films.

The volume of glycerin solution in electric discharge cell was 300 ml. The 5 minutes of discharge operation gave us essential heating up of the solution. Under temperature increase, a decomposition of glycerin is known to occur. In order to prevent both overheating and changes in the solution, the discharge cell we used was constructed as a continuous-flow system with circulation and cooling of working liquid. The volumes of sump 6 and feeding 5 tanks are 5 litre. The velocity of liquid circulation was chosen in dependence on temperature changes and was set within the range 400 to 500 ml/min. A typical period of single cycle of electric discharge occupied 40 to 60 minutes.

To determine the chemical composition and investigate the microstructure we used Mass Spectrometry, Electron Microscopy, and X-ray Fluorescence Analysis technique.

The mass spectroscopy was carried out on Perkin Elmer mass-spectrometer with inductively coupled plasma ICP-MS ELAN DRC II. The electron microscopy was carried out on JEOL raster microscope JSM-

6460LV equipped with Oxford INCA Energy 300 energy-dispersive spectrometer (EDS), which made it possible to investigate the chemical composition of resulting products by means of the integral and point-wise analysis as well as to carry out microstructure investigation for some samples. To obtain the images we used electron detectors. The qualitative element analysis was carried out on "Spektroskan-U" X-ray fluorescence spectrometer (manufactured by Spektron LLC, Sankt-Peterburg, RF).

Reaction products were investigated in samples obtained from residue formed in the discharge zone. The changes in element composition of electrodes participated in the experiments were also controlled.

In order to evaluate the chemical composition of electrodes in course of electric discharge, after experiment's termination, the surface layers of electrodes (<1 mm) were separated off and then grinded.

To extract the residue from working liquid obtained as experiment's result the ash-free Filtrak 390 paper filters were applied. The residue remaining after solution's filtration was evaporated to obtain a power-like sample.

We should note that, in preserving experimental conditions, the quantity of impurities formed in solution notably changes along with experiments. If we take for a quantitative value the weight of residue formed in course of discharge, then one can state that the quantity of synthesized elements in different experiments could change from 2 to 10 times. The possible cause of that poor reproducibility of experiments will be discussed later.

3 The mass spectrometry investigation of electrodes' and sedimentary products

In order to determine the quantities of the chemical impurities in carbon electrodes the mass spectrometry was carried out. In doing so, the electrodes were investigated both before and after discharge (anode and cathode). The residue formed directly in glycerin during discharge was also investigated by means of Mass Spectrometry. The preparation of samples was carried out it has been described above. The typical results of semiquantitative analysis of element composition of the electrodes and residues for one of variants of experiments is listed in Table 1. In total, residue and electrodes sample were investigated after 7 experiments identical by the way of discharge producing. The qualitative composition of the newly formed elements in all cases was same; however, the relative quantities of elements formed in residues vary in a range notably exceeding the frames of measuring error (±10%).

Table 1. Semiquantitative Analysis of samples (error ±10%)

Element	Initial electrode, μg/g	"Cathode", μg/g	"Anode", μg/g	Residue, μg/g
Mg	8	160	36	415
Al	8	13	14	189
K	-	36	36	566
Ca	-	36		274
Cr	-			19
Mn	-	14		85
Fe	-	58	11	2547
Ni	-			47
Cu	-	36	11	2264
Zn	-	36		387
Ag	-			57
Sn				26

The results listed in Table 1 show that after discharge has been carried out a significant quantity of new elements arises on both surfaces of electrodes and in residue.

4 The raster electron microscopy and micro X-ray spectroscopic analysis

The microstructure of initial electrode represents crystalline graphite. By means of the microprobe analysis the quantitative composition of electrodes was determined as follows: 94.03 0.5 mass percent for Carbon and mass percent 5.97 0.5 for Oxygen.

A typical electron-microscopic photography of residues can be found in Fig.2. The microphotography shows a mixture of particles varying by their size. By its topological form they are flattened, irregular, slightly elongated packs of thin plates, flakes. By analyzing the microstructure of plates in vari-

ous magnifications one can deduce that they possess layered pattern with layer thickness about 1 to 1.5 μm. Fig. 3 represents a fragment of flattened "bark-like" aggregate with a blistered rough surface. The picture's view creates an impression of a melt surface. Pure Carbon by itself does not give us similar surfaces; however, with the presence of other elements in Carbon that "melted" surface is possible to appear in.

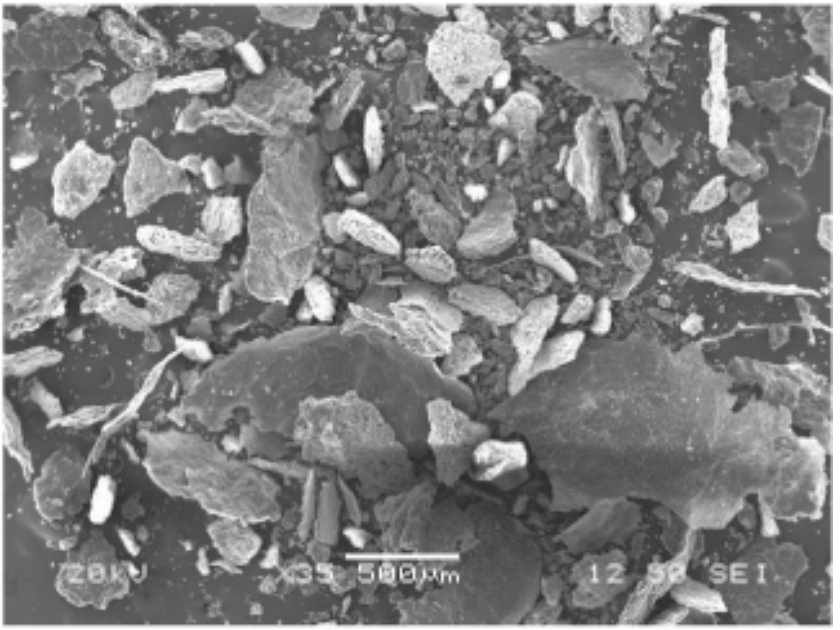

Fig. 2. General view of residues particles

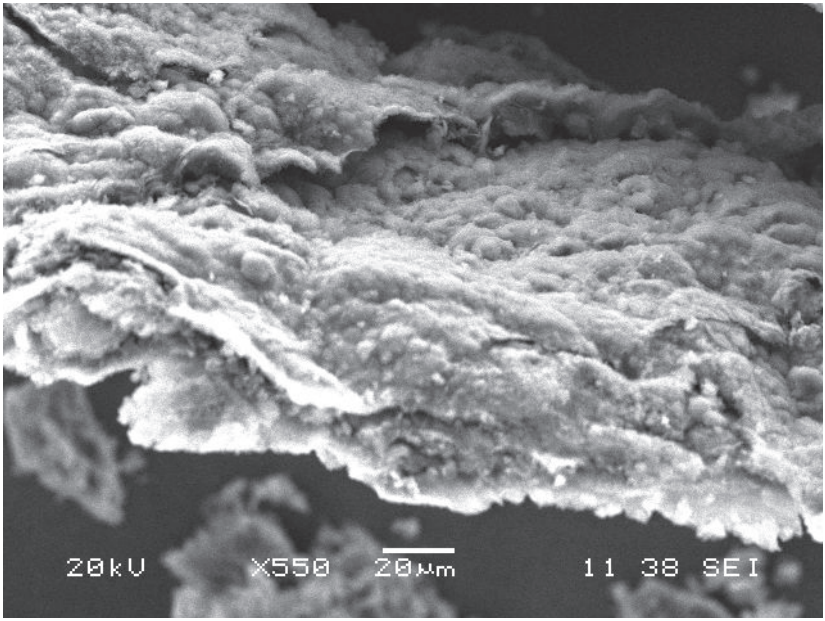

Fig.3. Structure of residue's plates

The next microphotography (see Fig. 4) shows "ball-like" and "cup-like" aggregates of sediment particles composed by even smaller "balls". The microprobe element analysis was carried out in 6 zones marked by frames. The selected area of each zone corresponds to a microprobe domain. The results of investigation are given by Table 2.

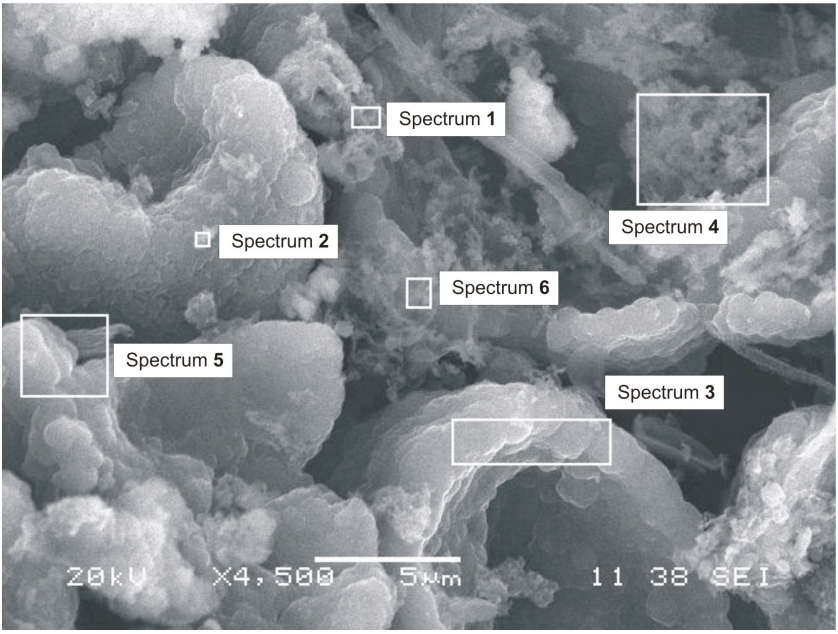

Fig.4. Microstructure of residue's plates

Table 2. The results of element analysis of residue particles from the domains selected on Fig. 4. (mass percent error for C, O is within ± 0.5, for remaining elements this value does not exceed ± 0.02 mass percent).

Spectrum #	C	O	Na	Mg	Al	Si	P	K	Ca	Mn	Fe	Cu	Zn
1	58	25.4	0.9	0.23	0.69	3.39	0.73	1.42	2	1.09	5.5		0.19
2	53	28.1	1.3	0.35	0.46	3.09	0.49	2.01	1.27	1.09	9.1		0.13
3	95	5.01							0.2				
4	62	28.2	0.8	1.59	0.08	0.31			0.95		1.03	0.45	4.5
5	63	29.7	1.6	1	0.2	0.53			2.69		1.11	0.29	
6	88	9.51		0.64		0.28			0.11		0.34		1.43

The domains 3 and 6 consist practically of Carbon with little impurities' content, while the domain 2 which is morphologically equivalent to the domain 3, contains a significant quantity of impurity elements. This circumstance gives evidence of a non-unique correspondence between the particle shape and its chemical composition.

The structure depicted on Fig. 5 represents a fibrous, tubular form aggregate. Individual parts of the aggregate have elongated shapes with sharp length prevalence over the wideness.

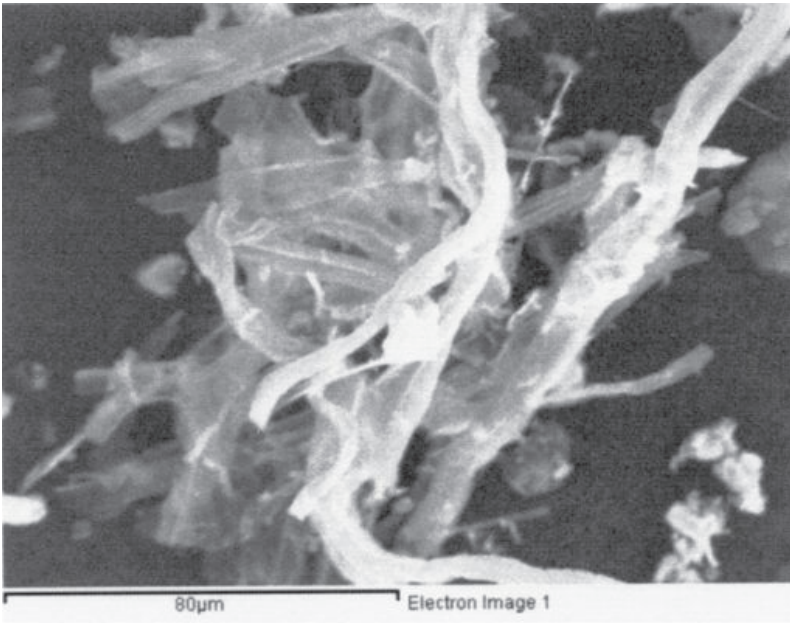

Fig.5. Microstructure of tubular-shape structures

By means of microprobe analysis, it was found that glomerate and pipe-shape clusters are Carbon structures with low impurities of Si, Na, K.

The residues have as well similar solitary particles with large content of synthesized elements. For example, the Fig. 6a represents one of those particles which undergone a mapping over 5 elements (Fig. 6b. to Fig. 6f.). The concentrations of synthesized elements are listed in Table 3.

Table 3. The result of Integral Element Analysis of the particle from Fig. 6 (the mass percent error for C and O is ± 0.5, for remaining elements ± 0.02).

Element	mass percent	atom %
C	24.56	48.63
O	18.22	27.09
Mg	0.11	0.11
Al	0.24	0.21
Si	0.22	0.18
P	0.32	0.25
Ca	0.70	0.41
Fe	50.02	21.31
Cu	1.42	0.53
Zn	3.17	1.15
Pb	1.02	0.12

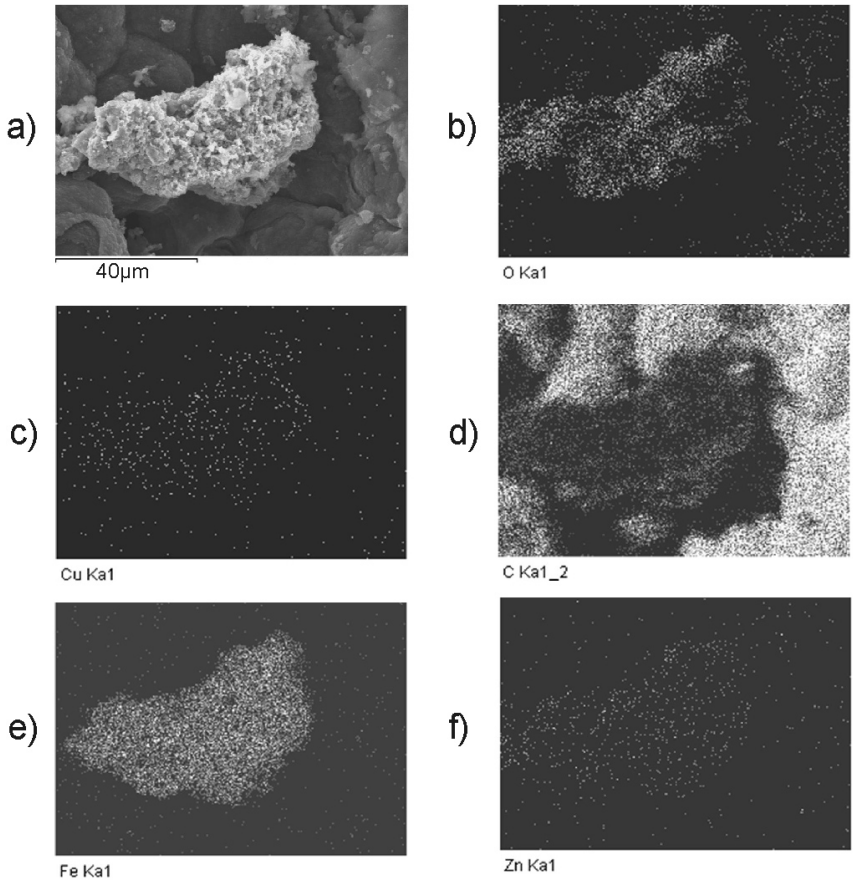

Fig. 6a – particle's image in secondary electrons; mapping of the particle in X-rays, 6b – O, 6c – Cu, 6d –C, 6e – Fe, 6f – Zn.

5 **X-ray fluorescent analysis.**

To carry out the X-ray fluorescent analysis (X-RFA) we used particles of volume ~ 0.2 cm3 which were extracted from residues obtained after several electric discharge cycles. In investigating the X-RFA-spectra, the presence of

proper hardware spectrum and possible content of analyzed elements in the initial state of electrodes were taken into account. The summarized contribution of these effects is depictured by light bars on the histogram on Fig.7. The dark bars show the intensities of X-RFA lines of the residue obtained after electric discharge. The histogram provides evidence of new elements appearance after electric discharge.

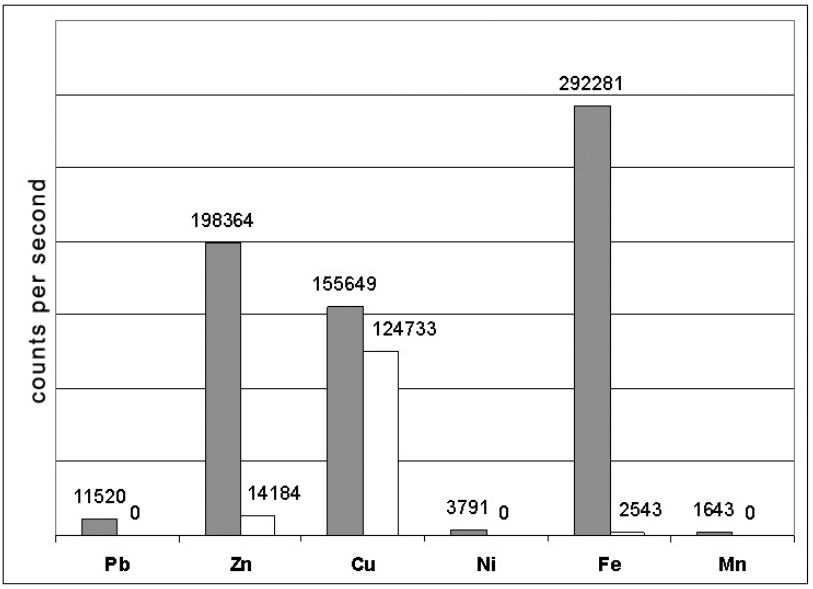

Fig. 7. Relative intensities of X-ray spectral lines of the residue.

6 Discussion of results and conclusions

The research carried out by authors resulted in the conclusion that, during a low-energy electric discharge in the water solution of glycerin, a transformation of the nuclei of initial chemical elements is observed. The results of this paper coincide qualitatively with the results in [2-6], which gives us a base to speak on identity of flowing reactions' mechanism.

In discussing the question on a mechanism of the course of chemical element low-energy transformation under electric discharge, by our opinion, one

should pay a special attention to the three basic features of all these experiments.

First of all, instability with respect to the velocity of flowing processes. These features were first noticed in [1], where an 18-fold variation of received quantities of He under W electric explosion in the vacuum was observed in practically the same conditions of experiments. In addition, in the demonstration paper [6], where the electric discharge was carried out in water, almost twenty-fold spontaneous variation of the product synthesized quantity was noted in experiments carried out in different times but under permanent basic conditions of the experiments. The present article allows us to state the evident observation of essential variation of synthesized elements quantities under preserving the mode of discharging.

Secondly, in [2], under electric explosion of metal in liquid, both a transformation of chemical elements and a "strange" radiation (fixed as unusual interrupted tracks) were registered simultaneously. In [7], a similar by their features tracks generated by electric discharge in liquid are fixed on newly prepared X-ray sensitive films. What is more, the quantity of the tracks fixed also varies strongly in time under completely same experimental conditions.

Finally, the third (and very important by our opinion) fact is that all the chemical elements synthesized in course of electric discharge are stable isotopes.

What is the mechanism of processes fixed by experiments in which the synthesis (or transformation) of elements has been observed?

At present time, no theoretical models exist which would explain the course of observed low-energy nuclear reactions. The only known paper [8] contains a suggestion that a certain catalyst exists which joins the nuclei into a cluster, creates resonance conditions, and initiates a nucleons' exchange. The role of such a catalyst, by the opinion of the authors of this paper, can be played by G. Lochak's magnetic monopole which is a magnetically excited neutrino, i.e., a lepton, and can participate in electrically-weak interactions. Such a monopole can be born, for example, within "electromagnetic phenomena in condensed media".

Unfortunately, the authors of [8] did not concretize the conditions for both generation of the proper magnetic monopole and conditions under which the magnetic monopole might initiate low-energy nuclear processes. Nevertheless, the idea by itself for explanation of the nuclear transformations' flow influenced by strong magnetic field seems for us to be rather attractive.

Since any electric charge can be represented as (no matter that it is a short event) plasma state of moving ions, therefore the influence of magnetic field on the plasma state is to be taken into consideration. Such an analysis was

carried out in I.V. Kurchatov's experimental work [9]. It was shown there that, under some non-stationary conditions of a strong magnetic field creation over the moving plasma in a gas discharge, an excitation of thermonuclear reactions is possible. In this situation, the maximal value of plasma current achieved is 500 KA. Under these values of the flowing current in a thin plasma channel the estimate of the magnetic field is about >104 T.

If one will draw an analogy with paper [9], then it is necessary to find a source of strong magnetic field, because the currents used in electric discharge (< 100 A) cannot create magnetic field of a large magnitude. However, a transformation of chemical elements is readily observed under these conditions. The necessary strong magnetic field can be expected in neighborhood of the magnetic monopole. In its presence, following the conjectures stated in [8], low-energy nuclear processes might flow.

As was noted in [2,7], electric discharge is accompanied with a "strange" radiation and, as experiments indicated, this radiation carries purely magnetic character. If these peculiar tracks on nuclear emulsion and fresh X-ray films of high quality are left by magnetic monopoles, then what is the nature of their appearance? Following G. Lochak's assumptions (see [10]), a magnetic monopole is a magnetically excited neutrino. To verify this assumption we placed into constant magnetic field of 2 T the source of beta rays (Sr90) and X-films of the necessary quality. As a result, the X-ray films showed quite typical tracks! (see [7]). However, it turned out that these specific tracks in a lower quantity appear on X-ray films placed into magnetic field without source of beta rays. Consequently, in the magnetic field, a beta decay of a certain component of the space radiation flows. The proof of this conjecture is the significant time variation of the quantity of tracks fixed during the same time of films' exposition in a constant magnetic field. In addition, we fixed the direct correlation between the number of fixed tracks and the value of magnetic field [7]. This phenomenon possesses a threshold nature and is observed only in magnetic fields exceeding the magnitude H = 0.5 T. Under weaker magnetic fields no tracks were fixed.

We also observed a quantitative correlation between the number of tracks fixed on films in constant magnetic field H = 2 T and the number of tracks fixed on films near the place of electric discharge. Both the experiments were carried out synchronized (simultaneously) within the same laboratory.

Taking into account the experiments described, one can understand the cause of time variations of quantities of elements synthesized under electric discharge and conditions of appearance of G.Lochak's magnetic monopoles.

Hence the present paper enlarges the series of experimental confirmations in favour of real existence of Lochak's monopole and its role as a catalyst in

the course of chemical elements transformation reactions in plasma of electric discharge.

In the conclusion, we express our sincere gratitude to Prof. L. Urutskoev for fruitful discussion of this work.

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