Excess Heat and Nuclear Transmutation Data Analyzed Using the TNCF Model

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Abstract

Experimental data of nuclear transmutation and the excess heat in electrolytic systems of Pd-Pt and H_2SO_4 in D_2O and H_2O generating Au and Ag supplied by Dash et al. are analyzed using the TNCF model with a value of the pararneter $n_n \sim 10^{12}$ cm^{-3} which is in the range of values obtained in analyses of various experimental data by many other researchers.

1. Introduction

It has been more than nine years since the announcement of the cold fusion phenomenon by Fleischmann and Pons. The atmosphere around researchers of this new field has been changing gradually from total denial to partial acceptance, due to the many research reports which have substantiated the validity of the phenomenon. Of course there are still some cold fusion skeptics, scientists with minds as closed as clams to new paradigms.

Then there are those researchers whose minds are fixated on the $d - d$ direct fusion concept, even though there are now kits available which clearly demonstrate that there are events which have been proven in deuterium and protium systems other than the initial objects of the excess heat and neutrons.

One of most remarkable events recognized is nuclear transmutation (NT), which has been observed in the surface layer of the cathodes for several years. The present authors have given a consistent explanation of them[1-3] based on the TNCF model proposed before[4]. The nuclear transmutation of nuclei occurs in deuterium and in protium systems with various materials for the cathodes in the electrolytic systems. The products seem only explicable by a decay or a fission of nucleus formed by neutron absorption in the systems and they are named by us as nuclear transmutation by a decay (NTD) and that by a fission (NT_p).

In a series of experiments done for several years, Dash et al.[5-8] found the

excess heat generation and nuclear transmutation on the Pd cathodes with Pt anodes. Their interpretation of the resulting NT is similar to ours in the use of thermal neutrons, but their origin of the relevant neutrons is different from ours. In this paper, we give a consistent explanation of the data obtained by Dash et al.[6] using the TNCF model.

2. Experimental Data

There were two kinds of Pd cathodes used in the experiment by Dash et al.[6] The Pd cathodes were (A) a cold-rolled 0.35 mm-thick polycrystalline sheet and (B) a 0.055 mm thick foil. The anodes were Pt foils of 0.03 mm thickness in both cases. The Pd cathodes which produced the excess heat were first cleaned ultrasonically in deionized water and then examined with a scanning electron microscope (SEM) equipped with an energy dispersive spectrometer (EDS).

Experiment A with Pd sheet of 0.35 mm thick and recombination catalyst.

The cathodes used in the previous study of comparative heat measurements were examined for the nuclear transmutation (NT). This study involved electrolysis from two cells in series with the same electrolyte (0.06 mol fraction H_2SO_4) one in H_2O and another in D_2O, and both containing the above mentioned Pd cathode and Pt anode. A recombination catalyst was used in both cells. Excess heat was observed from the D_2O cell for the first 300 hours of operation, after which excess heat was observed from the H_2O cell for the final 100 hours of operation.

After about 400 hours of electrolysis, the original rectangular cross sections of the cathodes became oval and the original rectangular longitudinal shapes became tapered and bent concave toward the anodes. The original smooth, shiny surfaces changed to a dull, corrugated topography. Dark spots were present on the lower ends of both cathodes where the shape changes were greatest. EDS spectra of both Pd cathodes in light water (H_2O) and in heavy water (D_2O) showed an appreciable amount of Pt and Au.

a) Pd cathode in H_2O. Several regions on the concave side of the Pd cathode, which appeared darker and rougher with more contrast, gave EDS spectra which showed an appreciable amount of Pt and Au, in addition to Pd. It was likely that Pt was plated from the electrolyte where it occurred due to slow dissolution of the Pt anode.

b) Pd cathode in D_2O. Similar analysis of the bottom of the heavy-water Pd cathode on the concave side also revealed Au in localized regions. The concentration of Au on the heavy-water cathode appeared to be greater than on the light-water cathode. For example, analysis of an active area of 10^{-3} mm^2 on the heavy-water cathode gave 6 percent Au compared with 3 percent Au for an active area of the same size on the light-water cathode.

The authors suggested that the origin of the detected Au on the cathodes was nuclear transmutation by neutrons generated in the sample by some nuclear reactions. This point will be discussed at the end of this section.

Experiment B with Pd foil of 0.055 mm thick and without recombination catalyst.

The same cells used in Experiment A were used in series with the same electrolytes (0.06 mol fraction H_2SO_4) but without the recombination catalyst. The two identical open electrolytic cells were run in series, using 0.03 mm Pt foil anodes and 0.055 mm Pd foil cathodes. The electrodes were made from the same lots used for the electrodes in Experiment A.

Electrolysis was performed for five hours and then the power was turned off. The palladium cathodes were washed with deionized water and then cleaned ultasonically in acetone prior to being examined and photographed with a light microscope and with the SEM. The average temperature of light water (H) or heavy water (D) cell was obtained averaging the four water-jacket temperatures in each cell. The result of the difference in power input and the difference in temperature between the H and D cells during the experiment were shown in their paper). A positive value for the average D – H temperature and a negative value for the difference (D – H) in power input is clearly evident. This indicated that the D cell was producing more heat than the H cell per unit of power input.

The observed change in surface morphology suggested that localized melting and chemical reaction with sulfate in the electrolyte had occurred during electrolysis. Using an EDS attached to an SEM, the chemical composition was determined in regions which had topography suggestive of localized melting. A peak for Pt was present in addition to a strong peak at 2.84 keV for Pd. The intensities of the Pt and Pd peaks suggested that the average surface composition of the entire area of the cathode was about 85% Pd and 15% Pt. In spectra from several points of the cathode, there are a predominant peak at 2.98 keV corresponding to Ag.

From the description given above, we guess that the amount of Ag in the surface layer is less than 0.1% and we use $Pd_{0.85}Pt_{0.15}Ag_x$ ($x \leq 0.001$) for the composition of the surface layer in the analysis in the next section.

A possible mechanism for the occurrence of Ag in the area inspected is, by the authors' opinion[6], transmutation caused by neutrons. They inferred the origin of the neutrons as the neutrons released in nuclear fusion resulting from the observed excess heat.

We have to give a comment here on the authors' explanation of the experimental data given in the paper[6], where they determined the NT's were from Pt to Au and from Pd to Ag. Their explanation is right in its essence, but their origin of the participating neutrons is not appropriate because the nuclear reactions between charged particles are impossible in solids if there is no acceleration mechanism.

The description of the experimental conditions is sufficient to analyze their data except for the exact sizes of the Pd sheet and the foil cathodes, which are necessary to analyze using the TNCF model. In the analysis given in the next section, we inferred them from the descriptions given in the paper [6] as the volume $V = 1.6 \times 10^{-2}$ cm^3, the surface area $S = 4.7 \times 10^{-1}$ cm^2 and then $S/V = 57$ cm^{-1} for the Pd sheet and $V = 2.8 \times 10^{-5}$ cm^3, $S = 5.1 \times 10^{-3}$ cm^2 and $S/V = 364$ cm^{-1} for the Pd foil, with an ambiguity factor of one order of magnitude for both.

This values $S = 5.1 \times 10^{-3}$ cm^2 = $(0.71$ mm$)^2$ for experiment B, which seems too small to use for electrode. The

value of concentration of Ag calculated by Dash et al.[6] is 0.4%. If we substitute 0.004% instead of this 0.4% in the calculation, the volume of the electrode V and the surface area S is estimated at $V = 2.8 \times 10^{-3}$ cm^3 and $S = 5.1 \times 10^{-1}$ cm^2, respectively. This surface area S is similar to that used in experiment A and may be reasonable. The concentration 0.004% of Ag is more consistent with the value 0.6% of Au concentration in experiment A because the duration of experiment B is about 2 orders shorter than that of experiment A. Thus we use the latter values of the volume and the surface area of the cathode calculated using 0.004% instead of 0.4% in the analysis given in the next section.

3. Theoretical Analysis

The basic idea is to analyze the data introduced in the preceding section. The first premise of the TNCF model assumes the existence of trapped neutrons with a density n_n in cold fusion materials (Pd cathodes in this case). It is clear that Dast et al. observed the excess heat and NT in both H and D cells and that the proton-proton fusion is more difficult than the deuteron-deuteron fusion in solids at room temperature, as critiques have discussed. Therefore, Dash's explanation fails in that the excess heat was produced in some nuclear reactions which at the same time generated neutrons which induced NT's from Pt to Au and from Pd to Ag.

3.1 Analysis of Experiment A

A more consistent explanation should be as follows with a the assumption[4] of the trapped neutrons. The trapped thermal neutrons with a density n_n can fuse with ^{A}Pt and $^{A'}$Pd to form isotopes $^{A+1}$Pt and $^{A'+1}$Pd and they transmute into $^{A+1}$Au and $^{A'+1}$Ag via a decay with beta emission. For example, in the system where Au was observed, the following neutron capture reactions could be taken up for the analysis:

$$n + {}^{190}_{78}\mathrm{Pt} = {}^{191}_{78}\mathrm{Pt} + \gamma(6.43\ \mathrm{MeV}), \quad (1)$$

$${}^{191}_{78}\mathrm{Pt} + e^- = {}^{191}_{79}\mathrm{Ir} + 1.02\ \mathrm{MeV}, \quad (2)$$

$$n + {}^{192}_{78}\mathrm{Pt} = {}^{193}_{78}\mathrm{Pt} + \gamma(6.25\ \mathrm{MeV}), \quad (3)$$

$${}^{193}_{78}\mathrm{Pt} + e^- = {}^{193}_{79}\mathrm{Ir} + 0.06\ \mathrm{MeV}, \quad (4)$$

$$n + {}^{194}_{78}\mathrm{Pt} = {}^{195}_{78}\mathrm{Pt} + \gamma(6.10\ \mathrm{MeV}), \quad (5)$$

$$n + {}^{195}_{78}\mathrm{Pt} = {}^{196}_{78}\mathrm{Pt} + \gamma(7.92\ \mathrm{MeV}), \quad (6)$$

$$n + {}^{196}_{78}\mathrm{Pt} = {}^{197}_{78}\mathrm{Pt} + \gamma(5.84\ \mathrm{MeV}), \quad (7)$$

$${}^{197}_{78}\mathrm{Pt} = {}^{197}_{79}\mathrm{Au} + e^- + \nu_e + 1.70\ \mathrm{MeV}, \quad (8)$$

$$n + {}^{198}_{78}\mathrm{Pt} = {}^{199}_{78}\mathrm{Pt} + \gamma(5.55\ \mathrm{MeV}), \quad (9)$$

$${}^{199}_{78}\mathrm{Pt} = {}^{199}_{79}\mathrm{Au} + e^- + \nu e + 1.70\ \mathrm{MeV}, \quad (10)$$

$${}^{199}_{78}\mathrm{Au} = {}^{199}_{79}\mathrm{Hg} + e^- + \nu e + 0.45\ \mathrm{MeV}, \quad (11)$$

The natural abundances of Pt isotopes in these fusion reactions are 0.013, 0.78, 32.9, 33.81 25.3 and 7.21%, respectively, and the cross sections for a thermal neutron are 150, 8, 1.2, 28, 0.6 and 3.6 b, respectively.

From the amount of Au (6%) found in the surface layer (1 μm thick) of Pt on the Pd cathode plated in the experiment, we can determine the parameter n_n by a relation

$$n_{Au} = 0.35 n_n v_n n_{Pt} V_0 \sigma_{n\text{-}Pt}. \quad (12)$$

In this equation, V_0 is the volume of the

reaction region (surface area S x thickness of the surface layer l) and is 4.7 x 10^{-5} cm^3.

Taking only the most effective reactions (7) and (8) involving ^{196}Pt with a large natural abundance and a fusion cross section for the Au production, and using above values for parameters, we obtain a value of the parameter n_n as follows:

$$n_n = 3.81 \times 10^{12}\ cm^{-3}.$$

Using this value of n_n we can calculate expectation value of the excess heat Q_{th} by a following relation, if we assume that the energies liberated in these reactions were thermalized completely in the system:

$$Q = 0.35 n_n v_n n_{Pd} V_s (\Sigma_i P_i \sigma_i Q_i) \tau \xi. \quad (13)$$

In this equation, $0.35 n_n v_n$ is the flux of trapped neutrons per unit area and time, P_i, σ_i and Q_i are the natural abundance, neutron absorption cross section and liberated energy of the reaction for the isotope i of Pd (numbered according to the mass number, for instance). τ is the duration of experiment and ξ is a parameter depending on the stability of the trapped neutrons in the reaction volume V_s (surface layer with a thickness 1 μm in this case).

When the gamma's emitted in these reactions were not thermalized in the system, i.e. they did not have any contribution to the excess heat, the value of n_n calculated above gives

$$Q_{th} = 2.4 \times 10^6\ J,$$

compared with the experimental value Q_{exp} = 6.4 x 10^5 J. This difference of factor 4 is in the opposite direction of the general difference of factors 3 ~ 5 higher for the excess heat obtained in previous analyses[1,9] of ordinary nuclear products. This data seems to show a peculiarity of NT suggesting a lot of reactions exist which transmute elements without thermal energy production.

3.2 Analysis of Experiment B

The average composition of the surface layer is assumed as $Pd_{0.85}Pt_{0.15}Ag_x$ ($x \leq 0.001$), as explained in the previous section. To treat the generation of Ag from the Pd cathode we use following reactions between a trapped neutron and Pd isotopes in the surface layer in addition to the reactions (I) ~ (II):

$$n + {}^{102}_{46}Pd = {}^{103}_{46}Pd + \gamma(7.62\ MeV), \quad (14)$$

$${}^{103}_{46}Pd + e^- = {}^{103}_{47}Rh + \gamma(0.543\ MeV), \quad (15)$$

$$n + {}^{104}Pd = {}^{105}Pd + \gamma(7.09\ MeV), \quad (16)$$

$$n + {}^{105}Pd = {}^{106}Pd + \gamma(9.56\ MeV), \quad (17)$$

$$n + {}^{106}Pd = {}^{107}Pd + \gamma + (6.53\ MeV), \quad (18)$$

$${}^{107}Pd = {}^{107}Ag + e^- + \nu_e + 0.033\ MeV, \quad (19)$$

$$n + {}^{108}Pd = {}_{109}Pd + \gamma(6.15\ MeV), \quad (20)$$

$${}^{109}Pd = {}^{109}Ag + e^- + \nu_e + 1.166\ MeV), \quad (21)$$

$$n + {}^{110}Pd = {}^{111}Pd + \gamma(5.75\ MeV), \quad (22)$$

$${}^{111}Pd = {}^{111}Ag + e^- + \nu_e + 2.19\ MeV, \quad (23)$$

$${}^{111}Ag = {}^{111}Cd + e^- + \nu_e + 1.04\ MeV. \quad (24)$$

The natural abundance of these isotopes of Pd is 0.96, 10.97, 22.3, 27.33, 26.71 and 11.81%, respectively. The re-

action cross sections of these neutron absorption reactionsare 3.2, 0.52, 22, 0.29, 8.69 and 0.73 b, respectively.

To treat NT generating Ag, we take only the reactions (20) and (21) involving ^{108}Pd for its large abundance and cross section. Then, the amount of Ag is expressed as follows:

$$N_{Ag} = 0.35 n_n v_n n_{108} V_s \sigma_{108} \tau \xi. \qquad (25)$$

Using the assumed Ag generation of 100 x % in the surface layer and assuming we determine the parameter nn to obtain a value

$$n_n \text{ - } 3.6 \times 10^{14} x \text{ cm}^{-3}. \qquad (26)$$

In this calculation, composition of the surface layer with a thickness 1 μm is assumed to be $Pd_{0.85}Pt_{0.15}Ag_x$.

Using the value of n_n determined above from NT, we can calculate the expectation value of the excess heat Q_{th} using the relation (13) and reactions (1) ~ (11) and (14) ~ (24)

$$Q_{th} = 1.7 \times 10^6 x \text{ J},$$

to be compared with the experimental value Q@p = 1.8 x 103 J.

Taking the value of x as 0.001, we obtain following values for the parameter n_n and the expectation value of the excess heat Q_{th}:

$$n_n = 3.6 \times 10^{11} \text{ cm}^{-3}.$$

$$Q_{th} = 1.7 \times 10^3 \text{ J}.$$

The agreement of the expectation and the experimental values of the excess heat in this case is very good, although the ambiguity in the value of x is large.

4. Discussion

The experimental data obtained by Dash et al.[6] clearly show the occurrence of the cold fusion phenomenon, generation of the excess heat and NT in the surface layer of the Pd cathode in this case, in deuterium and also protium systems. This is not a special case where the cold fusion phenomenon was observed in the protium system, but one of more than several tens. Its typical example is the Patterson's microsphere.

The values of the parameter n_n determined above of $10^{11} \sim 10^{12}$ cm^{-3} is in the highest region of the value $10^8 \sim 10^{13}$ cm^{-3} obtained hitherto by us. This is probably a result of effective formation of the surface layer of Pt on the Pd cathodes by electrolyte H_2SO_4 + $D(H)_2O$ which works to trap thermal neutrons, in our opinion.

Thus, the cold fusion phenomenon including such various events as the excess heat generation, nuclear transmutation, tritium and helium productions and neutron emission has been confirmed to occur not only in deuterium-transition metal systems but also protium-transition metal systems, not mentioning other materials containing hydrogen isotopes, provided there are background ambient neutrons. We have to take whole data into our consideration in research of new phenomenon like the cold fusion one.

The authors would like to express their thanks to Prof. J. Dash for sending preprints of their works and also other members of our laboratory who have worked together in clarification of complex events of the cold fusion phenomenon.

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(Editorial continued from page 15)

The Opportunity!

Art Bell dropped a bombshell on his millions of listeners on October 13th when he suddenly announced during the last five minues of his five-hour show that this would be his last broadcast. Ever. He cited threats to him and his family as the reason for his walking away from what has been by far the country's most popular nighttime talk show.

Since Art has stepped on a lot of very big toes with his show, his fans have been speculating as to which may have gotten to him to this extent.

He's had guests on who have described in detail the government's part in covering up their contact with aliens, their hiding of several downed UFOs which were stored at Area 51 in Nevada, and the integration of captured alien technology into new products such as transistors, integrated circuits, lasers, and night vision. These facts have been confirmed by a number of guests with excellent credentials.

He's also had guests such as Sean David Morton, who has a long string of amazingly accurate predictions of major events for his credentials. He has also discussed the incredible number of people who were in a position to embarrass the President who have died under strange circumstances or suddenly "committed suicide."

Morton has been predicting some dire events in the near future, as have Ed Dames, Nostradamus (via Dolores Cannon), Gordon Michael Scallion, Stan Diel, Richard Noone, Dannion Brinkley and several other Art Bell guests. If *any* of these are right, there's going to be a dramatic need for cold fusion powered energy sources, so we need to get more inventors working to develop practical and dependable home heat and power sources.

This is going to take money, so the more I can get on the air and talk about the potential for cold fusion, the more likely we are to start getting the needed funding. This could put more pressure on the Patent Office to start processing the many cold fusion patent applications which have been blocked. It might even

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