Nuclear Transmutation by Fission in Cold Fusion Experiments Analyzed Using the TNCF Model

H. Kozima, H. Kudoh and K. Yoshimoto
Department of Physics
Shizuoka University
Shizuoka 422, Japan

Abstract

Experimental data of the excess heat generation and the nuclear transmutation obtained in gas-loading Pd/D and Pd/H systems were analyzed using the TNCF model. An apparent difficulty in interpretation of the data, showing generation of zinc in palladium wire loaded with protium, is solved by the model. The arbitrary parameter in the model - the density n_n of the trapped neutrons - was determined as 1.6×10^{12} (Pd/D) and 9.9×10^{8} (Pd/H) cm^{-3}, which are in the range of values determined in previous works analyzing more than 40 experimental data of the cold fusion phenomenon.

1. Introduction

After its discovery[1] in 1989, there have appeared various anomalous events of the cold fusion phenomenon difficult to understand from conventional physics point of view. One of the most curious in these is the nuclear transmutation with large shifts of mass numbers[2]. A quantitative data of this type of the nuclear transmutation[3] in Pd/H system together with the excess heat[4] in Pd/D system were obtained in a simple gas loading system.These data are analyzed in this paper by the TNCF model proposed[5] by one of the present authors (H.K.).

The TNCF model has been used to analyze experimental data[6] of neutron generation in a gas loading system TiDx giving a consistent result with other more than 40 results of analyses[7,8] performed hitherto. The model is a phenomenological one using an adjustable parameter n_n, supposed to express the density of the trapped thermal neutrons in cold fusion materials, satisfying necessary conditions for the trapping. It is assumed that the necessary conditions are realized through stochastic atomic processes in the material. The cause of the poor reproducibility of the cold fusion phenomenon is so explained using the TNCF model as a result of those uncontrollable factors which produce the phenomenon. The value of a model, of cause, is determined by its applicability to events and success in the application. In this point, the TNCF model seems showing its effectiveness by the consistent explanation of various events in the cold fusion[7,8] reaction.

To verify and test the ability of the model further, a clear data of the excess heat[4] and the nuclear transmutation with large shift of mass numbers[3] in gas-loading Pd/D and Pd/H systems are taken up in this paper.

2. Experimental Results

The experiment on the Pd/D. and Pd/H. systems[3,4] were performed in a stainless steel Dewar with a piece of incandescent tungsten filament in it. The vacuum annealed palladium wire (900 °C in a pressure of 10^{-3} Pa for 3 hours) was sealed in the Dewar and hydrogen gas with a pressure of less than 1 atm was filled.

2.1 Excess Heat

The excess heat measurement was performed with a twin system of Dewars one with D_2 and another with H_2 gas. In the experiments the tungsten wires in both systems are connected in series such that the electrical current I_w (to heat the bottles) is same in both tungsten wires. From the temperature difference of both bottles, they could determine the excess heat generated in PdD_x sample with original weight of 2.846 g, as tabulated in Table I (from Table 2 of Reference 4). The analysis of these data will be given in Section 3.1.

2.2 Nuclear Transmutation by Fission

After one year of the loading and de-loading process, the resistance of the palladium wire increased to 5.5 ohms from the initial value of 2.7 ohms, meaning that the atomic loading ratio, H/Pd, should be close to 0.74.

An electron probe and an energy dispersive spectrometer were used for the analysis of the elemental composition in the Pd wires. The elemental composition was measured at six points from the surface (Point 1) to the center (Point 6) of the Pd wire with a diameter of 3.4×10^{-2} cm.

Comparison of the elemental composition after and before the experiment showed a remarkable increase of Zn and weak increase of Pb and Fe in points near the surface of the Pd wire. The composition changed little along the length of the wire. Two tables (Tables 1 and 2 of Reference 3) showing changes of the element composition are reproduced in Tables 2 and 3. The large change of elemental composition of Pd and Zn, if it correlates, could only be explained by fission reactions, i.e. nuclear transmutation by fission (NTF), in the surface region of the sample. We will give an explanation of this event in Section 3.2.

3. Analysis of the Experimental Results and Discussion

We analyzed the experimental results of the excess heat and the nuclear transmutationusing the TNCF model[5-8].

3.1 Data of the Excess Heat

We can cal culate the parameter n_n for the sample at $I_w = 0.801$ A generating the excess heat of 0.821 W using following relations[6];

$$n + d = t\,(6.98\,\text{keV}) + \gamma\,(6.25\,\text{MeV}), \qquad (1)$$

$$N_Q = 0.35 n_n v_n n_d V \sigma_{nd} \xi \qquad (2)$$

I_w (A)	0.1?7	0.359	0.464	0.601	0.753	0.801
Q_{ex} (W)	0.009	0.065	0.115	0.227	0.450	0.821

Table I. Excess heat from D/Pd relative to H/Pd system.

In the second relation (2), N_Q is the number of events generating the excess heat (which is assumed as the excess heat divided by the energy of the photons emitted in the reaction (1), i.e. 6.25 MeV), $0.35 n_n v_n$ is the thermal neutron flux per second and cm^2, n_d is the density of deuterons in the sample with a volume V, σ_{nd} is the cross section of the reaction (1) and ξ is a parameter with a value of 0.01 in volume at room temperature and of 1 at high temperature and in the surface layer (according to our recipe[5]).

Using the data of the maximum excess heat generation of 0.821 W in Table 1 (where the current is maximum and we take 1 in this case), we could determine the parameter n_n as follows:

$$n_n = 1.6 \times 10^{12} \text{ cm}^{-3} \qquad (3)$$

The excess heat depends on the current I_w through the system (to heat the bottle) as seen in Table 1. This dependence may be explained by the temperature dependences of v_n, σ_{nd} and the parameter ξ in volume, $\xi(T)$, because the large I_w corresponds to a high temperature in the bottle. The main contribution may due to $\xi(T)$ because the product $v_n \sigma_{nd}$ is insensitive to the temperature. The behavior of $\xi(T)$ had been determined as follows[5]: In volume, ξ = 0.01 at room temperature (~300 K) and = 1 at 3000 K. If the parameter n_n can be taken the same for all I_w, the difference of two orders of magnitude in Q_{ex} (0.009 ~ 0.821 W) corresponds to the difference of the same order of magnitude in ξ (0.01 ~ 1).

	Atomic Concentration (%)		
Elements	Rim 1	Rim 2	Center
Pd	99.61	99.58	99.44
Zn	0.22	0.23	0.24
Pb	0.07	0.00	0.08
Fe	0.01	0.19	0.18
Cu	0.09	0.00	0.07
Sr	0.00	0.00	0.00

Table 2. Element composition of original palladium

The value of n_n in the Pd/D system given above has uncertainty of a factor 2 due to the ambiguity of experimental data of the excess heat, i.e. the neglect of the possible excess heat generation in the Pd/H system used as the standard. As is shown in the next section, the excess heat generation accompanied with the nuclear transmutation in the Pd/H system occurred.

3.2 Data of the Nuclear Transmutation by Fission

In the data of the nuclear transmutation tabulated in Table 3, we take up only that of zinc Zn and analyze it using the TNCF model, using the procedure outlined in a previous paper[2]. The probable reaction inducing the transmutation of Pd into Zn is written down as follows:

$$^{A}_{46}Pd + n \rightarrow {}^{A+1}_{46}Pd \rightarrow {}^{A'}_{30}Zn + {}^{A+1-A'}_{16}S \ldots.. (4)$$

with A = 102 – 110 and A' = 64 – 70 for stable isotopes and therefore

$$A + 1 - A' \equiv A'' \geq 32.$$

The cross section σ, for the absorption reaction in the above relation ranges from 0.2 to 20 barns[9]; σ = 3.36, 0.52, 20.25, 0.30, 8.50 and 0.23 b for A = 102, 104, 105, 106, 108 and 110, respectively. Assuming the intermediate nucleus $^{A+1}$Pd in the reaction (1) is unstable and decays by and by into Zn and S, we can calculate the number of Zn atoms N_{Zn} generated in a time t as a function of the density of the trapped neutrons nn by the following relation:

$$N_{Zn} = 0.35 n_n v_n n_{Pd} V \tau \Sigma P_A \sigma_A, \quad (5)$$

where v_n is the thermal velocity of the trapped neutron, n_{Pd} is the density of palladium, P_A (in %) is the natural abundance of a Pd isotope with mass number A , σ_A is the absorption cross section for the reaction (1) and V is the volume of the sample.

Using an average value N_{Zn} = 4.065 x $10^{-3} n_{Pd} V$ of the experimental values at Points 1 to 4 generated in τ = 1 year = 3.15 x 10^7 s) and therefore V = (1.7^2 - 1.3^2) x 10^{-4} cm^3 = 1.2 x 10^{-4} cm^3 per unit length of the Pd wire, we obtain the parameter n_n as follows;

$$n_n = 9.9 \times 10^8 \text{ cm}^{-3} \quad (6)$$

Many of the isotopes of sulphur (S) generated finally in the reaction (1) have β-decay modes and generate chlorine (Cl) and argon (Ar) which are gaseous and not expected to remain in the sample to be detected there. The excess heat which accompanied the fission generating Zn is estimated to take only the predominant modes in the reaction (4) and is ~ 0.5 W. Therefore, the calculation of n_n given in the previous subsection is valid by a factor 2 where we did not care about reactions in Pd/H system used as standard in the experiment of the excess heat measurement in Pd/D system.

Thus, the curious result of Zn generation from the heated Pd wire in the process of the loading and de-loading process has been explained as a result of nuclear fission reaction (4) triggered by the trapped neutrons assumed in the TNCF model. This may be called as the nuclear transmutation by fission, NT_F. Another typical example of NT_F has been measured by Miley et al.10 which will be analyzed similarly using the TNCF model.

4. Discussion

The two values of n_n determined in the preceding section ~ 10^{12} and ~ 10^9 cm^{-3} for Pd/D and Pd/H systems seems consistent with each other if we consider the latter is for an event of NT_F averaged over one year while the former is for an event of the excess heat generation measured in a single positive experiment. Another phase of the dif-

	Atomic Concentration (%)					
Elements	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Pd	57.66	58.24	58.62	59.38	99.14	98.96
Zn	41.40	40.84	40.49	39.85	0.42	0.71
Pb	0.82	0.90	0.83	0.75	0.12	0.05
Fe	0.06	0.03	0.07	0.02	0.16	0.19
Cu	0.04	0.00	0.00	0.00	0.08	0.09
Sr	0.00	0.00	0.00	0.00	0.08	0.00

Table 3. Element composition of reacted palladium (cross section)

ference may be in the difference of atomic processes of deuteron and proton migration in the palladium lattice. The latter is more mobile in the crystal and its distribution would be homogeneous. The difference of the distribution causes a difference of n_n by the trapping ability of the sample depending strongly on the distribution. In spite of this difference in n_n determined by the excess heat and the nuclear transmutation, it might be possible to say that the nuclear fission in the cold fusion materials is confirmed experimentally and theoretically by the analysis given in this paper.

A possibility of nuclear fission in such a solid as used in the cold fusion experiment has not been known before this phenomenon was noticed first as an effective heat source. As was discussed briefly in the previous paper[2], the TNCF model has presented a consistent explanation for the stabilization of neutrons and de-stabilization of matrix nuclei in the solid containing trapped neutrons. In short, the nuclear interaction between the trapped neutrons and the lattice nuclei might result in the effect of neutron stabilization and nuclear destabilization. The verification of this speculation of the physical principles is left as a challenge for physicists proposed by experimental facts and a phenomenological model.

The nature and origin of the adjustable parameter n_n in the model should also be a question to be solved in future although some speculation have been given in previous works[6-8].

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