Consistent Explanation of Experimental Data obtained from SRI International and EPRI

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Abstract

Experimental data on the isotope ratio changes (^{10}B and ^{105}Pd) in a PdD_x/Li cathode which produced the excess heat were analyzed on the TNCF model. A quantitative changes of the isotope ^{10}B and the amount of the excess heat generated in the cathode were consistently explained using a single adjustable parameter *nn*, density of the trapped thermal neutron, the value of which was determined as ~ 10^9 cm^{-3} when the experimental time was assumed to be a week (6×10^5 s).

1. Introduction

A Pd cathode with a total surface area 60 cm² and a thickness 25 μm (with a weight 0.9 g) used in an experiment with an electrolytic solution D_2O + 1.0 M LiOD + 200 ppm Al producing the excess heat of 0.56 MJ was subjected upon comparing measurements of the prompt gamma activation analysis (PGAA) using thermal neutrons in beams from research reactors. A result showed an ~ 18% reduction in the boron impurity ^{10}B. The author (T.O.Passell) had tried to interpret the result on the hypothesis that some reaction other than D + D was the likely heat and helium-4 producing nuclear reaction and took up a reaction

$$^{10}B + d \rightarrow {}^{4}He + {}^{8}Be$$

This assumed reaction is compatible with the absence of gamma, the author's most troubling experimental fact, but is equally difficult to understand to occur in solid as D + D fusion reaction without an energetic deuteron or a boron.

We will give a consistent explanation of these experimental results by the conventional physics on the TNCF model[2-4].

2. Analysis of the Experimental Results

The fundamental postulates of the TNCF model[2-4] are the existence of the stable trapped thermal neutron with a density n_n, which is an adjustable parameter to be determined by the experimental data and of its fusion reactions with another nucleus causing a large perturbation on the trapped neutron itself.

To analyze the experimental data[1] of the excess heat generation (in SRI International) and the nuclear transmutation (NT) of ^{10}B (in EPRI), we will take up only the following reactions caused by a thermal neutron for simplicity:

$$n + {}^6\mathrm{Li} = {}^4\mathrm{He} + t + Q_1 \qquad (1)$$

$$n + {}^{10}\mathrm{B} = {}^7\mathrm{Li} + {}^4\mathrm{He} + Q_2 \qquad (2)$$

where $Q_1 = 4.8$ MeV and $Q_2 = 2.8$ MeV.

Our assumptions in the TNCF model are (a) the observed excess heat Q of 0.56 MJ was generated by the reaction (1) in the surface layer of the PdLi alloy with a width $\ell_0 \sim 1$ μm where the abundance of the isotope ^{6}Li was assumed as the same as the natural one and also by the reaction (2) in the PdD_x cathode with a volume V, and (b) the change of the isotope ^{10}B was caused by the reaction (2) in the sample.

From the observed value $Q = 0.56$ MJ and the relative density of the impurity ^{10}B of 100 ppm, we can evaluate $n_n\tau$ using a following relation where τ is a time of the electrolysis experiment:

$$Q = 0.35 n_n v_n (n_{Li6} l_0 S \sigma_{n-Li6} Q_1 + n_B V \sigma_{n-B} Q_2)\tau \qquad (3)$$

In this relation, $0.35 n_n v_n$ is the thermal neutron flux per unit area and unit time, S is the surface area of the cathode, σ's are the fusion cross sections; $s_{n\text{-}Li6} = 9.4 \times 10^2$ and $\sigma_{n-B} = 3.8 \times 10^3$ barns. The main part of the excess heat was produced by the first term in the above relation as we can see by the numerical evaluation. From our point of view, there remains a possibility that the reactions (1) ~ (2) last after the electrolysis experiment in the sample and the excess heat measured only in the experiment had been underestimated compared with the NT. This point should be reminded in comparison with the experimental data.

On the other hand, the relative isotope change y of ^{10}B is related with n_n as follows:

$$y n_B = 0.35 n_n v_n n_B \sigma_{n-B} \tau \qquad (4)$$

where experimental value is $y = 0.18$ to be used in the evaluation. The fusion reaction of the trapped thermal neutron with the Pd nuclei is neglected in this calculation as had been in the analyses[3-7] of data where observed much excess heat or many nuclear products.

The relations (3) and (4) give us the values of $n_n\tau$ independently. Those values are 3.42×10^{14} and 6.7×10^{14} s cm^{-3}, respectively. The coincidence of these values in a factor 2 shows the reality of the TNCF model and the existence of the trapped thermal neutron.

Assuming the time of the electrolysis producing the excess heat of 0.56 MJ as 1 week (6×10^5 s), we obtain the density of the trapped thermal neutron as:

$n_n = 5.7 \times 10^9$ (Q) and 1.1×10^9 (NT) cm^{-3}

The difference in the densities of the trapped neutron determined by the excess heat (0.57×10^9) and by the NT of ^{10}B (1.1×10^9) might be a result of the aging of the sample[8] after the heat measurement until the NT measurement by PGAA as noticed above. (The larger τ in the relation (4) makes the smaller n_n for NT.)

3. Conclusion

The excellent experimental data on the changes of isotope concentrations in a cathode which produced the excess heat have shown the consistent scenario of the cold fusion phenomenon. The experimental results of the excess heat and the NT without observable gamma radiation was explained numerically by the TNCF model with a single adjustable parameter n_n, the density of the trapped thermal neutron. The values determined here from the different experimental data coincide very well showing consistency in itself supporting the TNCF mechanism of the cold fusion phenomenon from the excess heat production to nuclear transmutation.

The relative isotope change z of ^{105}Pd is related with n_n as follows:

$$z n_{Pd5} = 0.35 n_n v_n (n_{Pd4}\sigma_{n-Pd4} - n_{Pd5}\sigma_{n-Pd5}) (\ell_0/V)\tau \qquad (5)$$

where n_{Pd4} and n_{Pd5} are densities of ^{104}Pd and ^{105}Pd, respectively, and an experimental value $z = 0.03$, a value calculated from data given in Table 1 of the original paper[1] assuming that the cathode material was 3 times the mass of the virgin material. On an assumption that the stable neutron fused with ^{104}Pd and ^{105}Pd in the surface layer of PdLi alloy where the perturbation on the trapped neutron is large, we obtain an expected relative change of ^{105}Pd as 6.3×10^{-7} putting values $\sigma_{n-Pd4} = 5.23 \times 10^{-1}$ and $\sigma_{n-Pd5} = 2.03 \times 10$ barns and $n_n\tau = 5.1 \times 10^{14}$ cm^{-3} ($n_n = 0.85 \times 10^{9}$cm^{-3}) into the relation (5).

This value is too small to explain the experimental value $z = 0.03$ and verifies my presumption[1] that the difference of the density of ^{105}Pd was due to the inhomogeneity of the material. This is also consistent with our former treatment where the reaction of the trapped thermal neutron with the Pd nuclei has been used to be neglected in the analyses[2-4] of data where much excess heat or a lot of nuclear products were observed.

The value of n_n determined in this paper can be compared with other data[4]. The values of n_n determined by various experimental data spread from 10^3 to 10^{12} cm^{-3}, the value in this analysis drops into a part of the spectrum.

The PGAA, a method used in the experiment[1] to determine isotope concentration, uses a beam of neutrons with an energy of the order of the thermal one. It is necessary to note that the trapped thermal neutron and the beam used in PGAA have the same energy, but completely different characteristics. The trapped thermal neutron is expressed by a Bloch wave interacting with lattice nuclei. On the other hand, the neutron beam with the thermal en ergy is expressed by a plane wave with a definite propagation vector interacting with the individual nucleus on the path. The former can be imagined as a standing wave and the latter a travelling. Stability of the former is a result of many-body interaction with the lattice nuclei which is independent of the latter.

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References

(1) T.O. Passell, "Search for Nuclear Reaction Products in Heat-Producing Palladium," Preprint to be published in *Proc. ICCF6* (1996).

(2) H. Kozima, "Trapped Neutron Catalyzed Fusion of Deuterons and Protons in Inhomogeneous Solids," *Trans. Fusion Technol.* **26**, 508 (1994).

(3) H. Kozima and S. Watanabe, "Nuclear Processes in the Trapped Neutron Catalyzed Model for Cold Fusion," *Proc. ICCF5* **1**, 347 (1995) and *Cold Fusion* **10**, 2 (1995).

(4) H. Kozima, "On the Existence of the Trapped Thermal Neutron in Cold Fusion Materials," Preprint to be published in *Proc. ICCF6* (1996).

(5) H. Kozima, H. Hiroe, M. Nomura and M. Ohta, "Analysis of the Electrolytic Cold Fusion Experiment on TNCF Model," Preprint to be published in *Proc. ICCF6* (1996).

(6) H. Kozima, M. Nomura K. Hiroe and M. Ohta, "Nuclear Transmutation in Cold Fusion Experiments," Preprint to be published in *Proc. ICCF6* (1996).
(7) H. Kozima, M. Ohta, M. Nomura and K. Hiroe, "Analysis of Nickel-Hydrogen Isotope System on TNCF Model," Preprint to be published in *Proc. ICCF6* (1996).
(8) M. Srinivasan, K.K. Rout, S.C. Mistra, M. Lai, A. Shyam, P.S. Rao and P.K. Iyengar, "Observation of High Tritium Levels in Aged Deuterated Titanium Targets as Possible Evidence of Cold Fusion," *Fusion Technol.* 18, 88 (1990).

ICCF6 Report Part One

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The Sixth International Conference on Cold Fusion (ICCF-6) sponsored by NEDO (New Energy and Industrial Technology Development Organization) and supported by ANRE (Agency of Natural Resources and Energy) in MITI (Ministry of International Trade and Industry, Japan) was held October 14-17, 1996 in Hokkaido, Japan.

There were 177 participants from 16 countries and 98 papers were presented in oral, special and poster sessions. The number of participants were as follows: Japan (91), Italy (15), Russia (8), France (6), China (4), India (1), Spain (1), and others (14). All of the papers were presented at the poster session in the afternoon of the first two days. They were divided into three categories; Oral (39 papers), Special (7) and Poster (52).

The presentation of oral papers in front of the audience was limited to 10, 20 or 40 minutes. Special papers were limited to five minutes, and poster previews to two minutes.

The conference was very well organized, with the program and abstracts (one page each) being published in time for the October 13th reception. The papers to be published in the Proceedings of the Conference are to be submitted to the Organizing Committee by October 17th, with the publication projected for January 1997, at the latest.

2. Scientific

Several of the papers presented showed remarkable experimental results which confirmed the reality of the cold fusion phenomenon. Several confirmed the production of both excess heat and nuclear products with greater accuracy than previously has been available. These results will be examined in depth in future issues of this journal.

There are two major artificial barriers to cold fusion investigation: (1) conceptual, and (2) patent problems. Conceptually there is the persistence of the d–d fusion and the quantitative reproducibility which are barriers to cold fusion development. There is the belief that the d–d fusion occurs effectively at a high energy level of 200 keV. Thus the objection to the possibility of the cold fusion phenomenon when other possible ways of inducing nuclear reactions in solids are neglected. The same prejudice seems to persist in the cold fusion society in trying to explain nuclear products only by the d–d fusion reactions.

Reproducibility is a problem. The physical and chemical processes occurring in complex systems like cold fusion materials are inevitably stochastic, therefore a cause does not lead to an effect, but to several effects with definite probabilities — including excess