Using a Thin Pd Wire Cathode for Excess Heat Generation

Hideo Kozima, Masayuki Ohta
Masahiro Nomura, Katsuhiko Hiroe
Shizuoka University
836 Oya
Shizuoka 422, Japan

Abstract

Experimental data on the excess heat generation in thin and long PdD./Li cathodes obtained by Celani et al. were analyzed using the TNCF model. A quantitative measurement of the amount of the excess heat generated in the cathodes was used to determine the single adjustable parameter n_n, the density of the trapped thermal neutrons, the maximum value of which was determined as 1.0×10^{12} cm^{-3}.

1. Introduction

An Italian group in Frascati made an excellent experiment[1] which generated excess heat with a high degree of qualitative reproducibility. They used long, thin pure Pd wires (mainly 100 µm x 160 cm) wound around a cylinder (with a diameter 4 cmø) as a cathode for both high voltage DC electrolysis and high power-high frequency electrolysis (peak currents up to 25 A, peak voltages up to 270 V, pulse width $2 \times 10^2 \sim 5 \times 10^4$ ns, repetition rate $10^2 \sim 5 \times 10^4$ Hz) in a dilute solution 0.25 mN LiOD - D_2O (LiOH - H_2O). The anode was a Pt wire (1 mmø) wound around a cylinder with a diameter 2 cmø coaxial to the cathode.

The excess heat was measured by a flow calorimeter. They detected the excess heat with a high degree of reproducibility. The average excess heat was ~ 20% (D_2O) and ~ 10% (H_2O) of the input energy. The maximum excess heat in the case of D_2O was 70 W (200 %).

On the other hand, a bundle of thin Pd was used as a cathode in the experiment[2] where the excess heat, ^{4}He and X-rays were measured. In this work the cathode was a bundle of Pd wires (each wire was with a dimension 250 µmø x 40 mm). This data has already been analyzed using the TNCF model[3] to give a consistent explanation of the data.

In this paper we will give an analysis of the data[4] using the TNCF model and show the effectiveness of fine particles, thin wire and thin plates to realiably produce the cold fusion phenomenon.

2. Analysis of the Experimental Results

According to the TNCF model[3-5] scenario the trigger reaction in the electrolytic system with the LiOD (LiOH) electrolyte is assumed as a neutron-^{6}Li fusion reaction in the PdLi alloy layer (with a thickness l_o taken as 1 μm) on the Pd cathode surface:

$$n + {}^6\text{Li} = {}^4\text{He}\,(2.1\ \text{MeV}) + t\,(2.7\text{MeV}). \quad (1)$$

If all the liberated energy is thermalized in the system the excess heat of this reaction is Q = 4.8 MeV.

Then, the excess heat Q in time t is expressed as follows:

$$Q = 0.35 n_n v_n n_{Li6} l_o S \sigma_{n\text{-}Li6} Q_l \tau. \quad (2)$$

In this relation $0.35 n_n v_n$ is the thermal neutron flux in the sample per unit area and unit time S is the surface area of the cathode and σ is the fusion cross section; $\sigma_{n\text{-}Li6} = 9.4 \times 10^2$ barns.

Putting into this relation values obtained in the experiments and we knew from experience, $v_n = 2.2 \times 10^5$ cm/s, $n_{Li} = 3.4 \times 10^{22}$ cm^{-3}, assuming the PdLi alloy has the same lattice parameter as Pd metal, the isotope ratio of ^{6}Li = 7.4% (the natural abundance), S= 5.0 cm^2 and 1J = 6.25 x 10^{12} MeV, we obtain the density of the trapped thermal neutrons n_n as follows;

$$n_n = 1.0 \times 10^{12}\ \text{cm}^{-3}.$$

The result in the case of H_2O generating about 10% excess energy shows the similar effect observed with light water[6-8]. The difference between the D_2O and H_2O cases might be attributed to the following breeding and trigger reactions expected only in the D_2O system:

$$t\,(2.7\ \text{MeV}) + d = {}^4\text{He}\,(3.5\ \text{MeV}) + n(14.1\ \text{MeV}) + 2.7\ \text{MeV}, \quad (3)$$

$$n\,(14.1\ \text{MeV}) + d = n'\,(\varepsilon) + d'\,(\varepsilon'), \quad (4)$$

$$n\,(14.1\ \text{MeV}) + d = n'\,(\varepsilon) + p\,(\varepsilon') + d'\,(\varepsilon''), \quad (5)$$

$$n + d = t + \gamma + 6.25\ \text{MeV}. \quad (6)$$

3. Conclusion

The TNCF model[3-5] has consistently explained a series of data obtained in the cold fusion experiments. Especially, the riddles of the cold fusion phenomenon, the qualitative reproducibility, the huge excess heat, the large N/N_n ratio, the generation of ^{4}He, nuclear transmutation and the cold fusion in metal-hydrogen system had been solved[9,10] which were impossible to explain just by following simple fusion reactions between light nuclei themselves, even if they occurred with a high probability:

$$d + d = t + p, \quad (7)$$

$$= {}^3\text{He} + n, \quad (8)$$

$$= {}^4\text{He} + \gamma. \quad (9)$$

The result of analyses is tabulated in Table 1 given before[9,10], including new data obtained in the last two works[3,14], together with in the present one.

The experimental data[1,2] obtained using thin Pd wire shows several characteristics of the cold fusion phenomenon which occurs in fine particles11, thin wires and thin films[8,12]. (1) They show high qualitative reproducibility, if not quantitative. (2) The relative excess heat to input energy is fairly high as 100 to 200%. (3) Sometimes the excess heat accompanies ^4He[2,11] or the nuclear transmutation (NT)[7,12].

Experimentally, those cathodes have a common character of the large surface area vs. volume ratio. On the other hand, from the point of view on the TNCF model[6,7], they show high densities of the trapped thermal neutrons $n_n = 10^{11} \sim 10^{12}$ cm^{-3}.

These characteristics of the cathodes seem to express a necessary condition for the cold fusion apparatus based on the electrolyte D_2O + LiOD to generate excess heat with high efficiency. (a) The qualitative reproducibility of the phenomenon necessitates having a large number of cell units where a Pd cathode with a large surface vs. volume ratio produces the excess heat. The average of the output over all cells guarantees the stable output as a whole. (b) The nuclear reactions occurring in the cell produce some radioactive nuclei and it is necessary to protect surroundings from them. Possible reactions are as follows in addition to those above:

$$n + \mathrm{p} = \mathrm{d} + \gamma + 2.2\ \mathrm{MeV}, \qquad (10)$$

$$n + {}^7\mathrm{Li} = {}^8\mathrm{Be} = 2\,{}^4\mathrm{He} + e^- + \nu_e + 16.2\ \mathrm{MeV}, \qquad (11)$$

$$n + {}^A\mathrm{M} = {}^{A+1}\mathrm{M}' + e^- + \nu_e. \qquad (12)$$

The authors would like to express their thanks to Dr. F. Celani for the discussion of their results at the conference.

References

(1) F. Celani, A. Spallone, P. Tripodi, D. Di Giacchino, S. Pace, P. Marini, V. Di Stefano, M. Diocianiuti and A. Mancini, " High Power μs Pulsed Electrolysis Using Long and Thin Pd Wires in Very Dilute LiOD-D_2O Solution: Observation of Anomalous Excess Heat," *Proc. CCF6 (1996)*, Hokkaido, Japan) (to be published).

(2) F. Cellucci, P.L. Cignini, G. Gigli, D. Cozzi, E. Cisbani, S. Frullani, F. Galibaldi, M. Jodice, and G.M. Urciuoli, "X-ray, Heat Excess and 4He in the Electrochemical Confinement of Deuterium in Palladium," *Proc. ICCF6(1996)* (to be published).

(3) H. Kozima, H. Hiroe, M. Nomura and M. Ohta, "Explanation of Experimental Data of X-ray, Heat Excess and 4He in PdD./Li Systems," *Cold Fusion* **22**, 54 1997.

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

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

(6) S. Focardi, R. Habel and F. Piontelli, "Anomalous Heat Production in Ni-H Systems, *Il Nuevo* Cimento **107A**, 163 (1994).

(7) R. Bush and R. Eagleton, "Evidence for Electrolytically Induced Transmutation and Radioactivity Correlated with Excess Heat in Electrolytic Cells with Light Water Rubidium Salt Electrolytes," *Trans. of Fusion Technol.* **26**, 344 (1994).

(8) D. Cravens, "Flowing Electrolyte Calorimetry," *Cold Fusion*, **11**, 15 (1995) and also *Proc. ICCF-5*, 79 (1995); V. Lapuszynski, "The Patterson Power Cell," *Cold Fusion*, 7, 1 (1995); B. Klein, "Project: Cold Fusion Testing at Clean Energy Technologies Inc.," *Cold Fusion*, **9**, 21 (1995).

(9) H. Kozima, "An Analysis of Experimental Data Using the TNCF Model," *Cold Fusion* **18**, 30 (1994).

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

(11) Y. Arata and Y.C. Zhang, "Achievement of Solid-State Plasma Fusion ('Cold Fusion')," *Proc. Jpn Acad.*, **71B** 304 (1995); "A New Energy caused by 'Spillover-Deuterium,'" *Proc. Japan Acad.*, **70B** 106 (1994)

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