

Using a Thin Pd Wire Cathode for Excess Heat Generation

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Abstract

Experimental data on the excess heat generation in thin and long Pd/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 $1.0 \times 10^{12} \text{ cm}^{-3}$.

1. Introduction

An Italian group in Frascati made an excellent experiment¹ which generated excess heat with a high degree of qualitative reproducibility. They used long, thin pure Pd wires (mainly $100 \mu\text{m} \times 160 \text{ cm}$) wound around a cylinder (with a diameter 4 cm) 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 $2 \times 10^2 \sim 5 \times 10^4 \text{ ns}$, repetition rate

$10^2 \sim 5 \times 10^4 \text{ Hz}$) in a dilute solution $0.25 \text{ mN LiOD} - \text{D}_2\text{O}$ ($\text{LiOH} - \text{H}_2\text{O}$). The anode was a Pt wire (1 mm) wound around a cylinder with a diameter 2 cm 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 $\sim 20\%$ (D_2O) and $\sim 10\%$ (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 experiment² where the excess heat, ^4He and X-rays were measured. In this work the cathode was a bundle of Pd wires (each wire was with a dimension $250 \mu\text{m} \times 40 \text{ mm}$). This data has already been analyzed using the TNCF model³ to give a consistent explanation of the data.

In this paper we will give an analysis of the data⁴ using the TNCF model and show the effectiveness of fine particles, thin wire and thin plates to reliably produce the cold fusion phenomenon.

2. Analysis of the Experimental Results

According to the TNCF model³⁻⁵ scenario the trigger reaction in the electrolytic system with the LiOD (LiOH) electrolyte is assumed as a neutron-⁶Li fusion reaction in the PdLi alloy layer (with a thickness l_0 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 $Q = 4.8 \text{ MeV}$.

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

$$Q = 0.35 n_n v_n n_{\text{Li}^6} l_0 S \sigma_{n\text{-Li}^6} Q_1 \tau. \quad (2)$$

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; $\sigma_{n\text{-Li}^6} = 9.4 \times 10^2$ barns.

Putting into this relation values obtained in the experiments and we knew from experience, $v_n = 2.2 \times 10^5$ cm/s, $n_{\text{Li}^6} = 3.4 \times 10^{22}$ cm⁻³, assuming the PdLi alloy has the same lattice parameter as Pd metal, the isotope ratio of ⁶Li = 7.4% (the natural abundance), $S = 5.0$ cm² and $1J = 6.25 \times 10^{12}$ 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 H₂O generating about 10% excess energy shows the similar effect observed with light water⁴⁻⁸. The difference between the D₂O and H₂O cases might be attributed to the following breeding and trigger

reactions expected only in the D₂O system:

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

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

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

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

3. Conclusion

The TNCF model³⁻⁵ 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 ⁴He, 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:

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

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

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

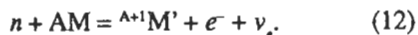
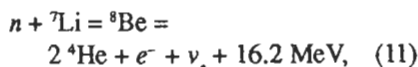
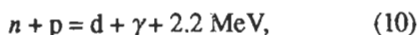
The result of analyses is tabulated in Table 1 given before^{9,10}, including new data obtained in the last two works^{3,14}, together with in the present one.

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 ${}^4\text{He}^{2+}$ 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 $n_n = 10^{11} \sim 10^{12} \text{ cm}^{-3}$.

These characteristics of the cathodes seem to express a necessary condition for the cold fusion apparatus based on the electrolyte $\text{D}_2\text{O} + \text{LiOD}$ 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:



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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 $\text{LiOD-D}_2\text{O}$ Solution: Observation of Anomalous Excess Heat," *Proc. ICCF6 (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 Pd/D.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 Nuovo 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)*,