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On the Explosion in a Deuterium/Palladium Electrolytic System*

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Abstract

An explosion in a D/Pd electrolytic system is analyzed; it is not a chemical explosion but a cold fusion reaction. A possible mechanism of cold fusion is presented.

Keywords: explosion; cold fusion; Deuterium/Palladium electrolytic system.

1. Introduction

Since the announcement of cold fusion by Fleischmann and Pons [1], there have been a lot of research worldwide on the D/Pd system; some explosions in D/Pd systems especially in D/Pd electrolytic systems have happened, the accident at SRI International [2] was a famous one. It was suggested that explosion in the D/Pd system is caused by Oxygen/Deuterium recombination [2]. In our D/Pd electrolytic experiments, three explosions occurred in April 1991. After examining the remains of one of the explosions, we concluded that it was caused by cold fusion in a Pd tube.

2. Electrolytic cell and explosion case

The electrolytic system included a glass measuring cylinder ($\phi_{\text{out}} 25.5 \times \phi_{\text{in}} 23 \times 186$ mm, ~ 80 ml), heavy water (~ 39 ml), Pd tube ($\phi_{\text{out}} 1.67 \times \phi_{\text{in}} 0.67 \times 80$ mm) cathode and spire Pt wire anode, a rubber plug of round platform ($\phi_{\text{top}} 27 \times \phi_{\text{bottom}} 21 \times 22$ mm, ~ 15.5 g) stretched in the measuring cylinder about 12 mm and sealed the cell top except for a blowhole ($\sim \phi 3$ mm, allowing gas to escape, as shown in Fig. 1). The volume of gas in the headspace above the heavy water in the cylinder was about 33.3 cm^3 . The cell was placed in a water bath (~ 530 ml light water).

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There were three explosions in these D/Pd electrolytic systems in April 1991. In two explosions, the rubber plug with Pd tube and Pt wire flew off about 1.5 ~ 2 meters away, and the bottom of cell was blown out; D₂O in cell had been mixed with H₂O in the bath. Because no one was present at the scene of explosion, direct observation was impossible. But the temperature of the water in the bath was measured within a half hour after one explosion, and it was found to have risen by 5°C. The electrolysis had continued about 50 hours with 7.5 V of cell voltage and 0.26 A of electrolytic current before the explosion.

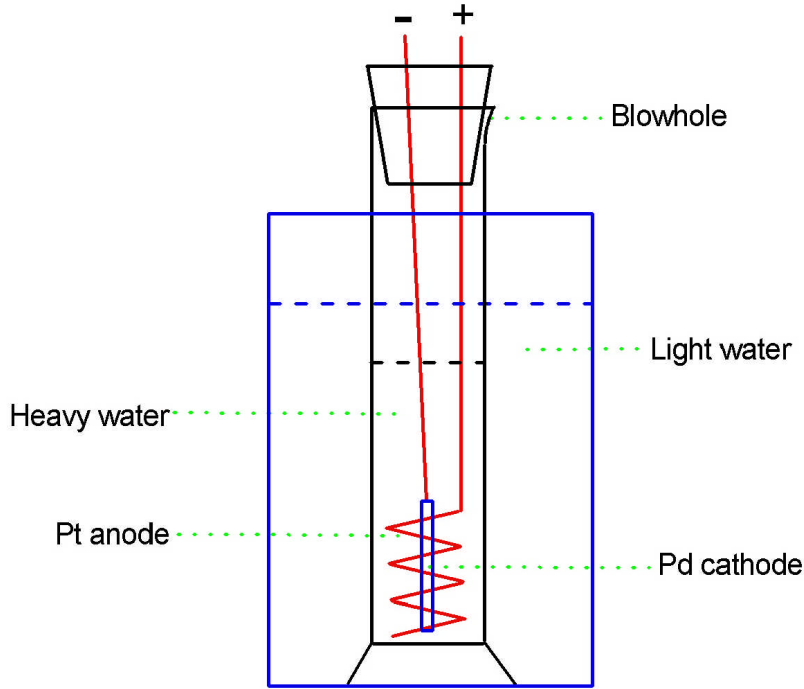


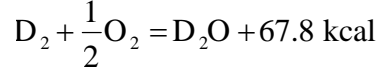
Fig. 1. Schematic of experimental set-up

3. Explosion analysis

Firstly, a 5°C temperature rise of 530 ml water need absorb heat: $\Delta Q = 1.1 \times 10^4$ J at least (heat dissipation after explosion is neglected).

Secondly, as a result of a simulation test, 2.1 kg of force is needed to cause the plug to fly off, corresponding to excess pressure $\Delta P = 5.1 \times 10^4$ Pa. That is to say, the minimum pressure in gas cylinder of cell is 1.5×10^5 Pa. Because the electrolytic cell is an open system, the D₂ and O₂ gases produced in electrolysis can escape through the blowhole easily and the excess gas in cell cannot accumulate, as a general rule. The only situation is that a lot of gas is produced in short time (τ) and high pressure is formed in cell. Therefore the gas cannot escape through the small hole efficiently and the rubber plug is pushed out and flying off, the bottom of cell is blown out in the resulting rocket action. Two possible situations can lead to this result:

<1> D₂+O₂ recombination causes chemical explosion. Volume of gas above electrolyte in the cell is 33.3 cm³, the heat production Q can be calculated using the optimal D₂/O₂ mixing ratio:



$Q = 281 \text{ J}$. This is much less than the actual heat.

We consider another extreme situation, the space above electrolyte in cell is filled with O_2 gas and it combines with D_2 gas released from Pd tube in short time and forms water, the corresponding heat is 843 J, it is only 1/13 of the actual heat and this kind of heat cannot heat up electrolyte efficiently, so the real explosion cannot be caused by chemical reaction.

<2> Heat burst is caused by cold fusion in Pd tube. Lots of heat released makes the temperature of Pd tube rise to thousands of degrees and the heavy water around it vaporizes rapidly, the heavy water vapor raises the pressure in the cell rapidly, and the explosion occurs.

We can estimate the upper limit of τ .

$$\tau = \frac{L}{V_{\text{eff}}} = L \sqrt{\frac{\rho_0 \left(\frac{\phi}{\phi_1}\right)^2}{\Delta P}}$$

where $L = 8 \text{ cm}$ (height of gas cylinder), $\Delta P = 5.1 \times 10^4 \text{ Pa}$, $\phi = 2.3 \text{ cm}$ (inner diameter of the cell), $\phi_1 = 0.3 \text{ cm}$ (effective diameter of blowhole), $\rho_0 = 0.0009 \text{ g/cm}^3$ (density of heavy water vapor at 1 atm). The result is $\tau = 0.058 \text{ s}$.

The energy production rate is:

$$P \geq P_{\text{min}} = \frac{\Delta Q}{\tau V} = 1.1 \times 10^6 \text{ W/cm}^3 \text{ Pd}$$

$V = 0.147 \text{ cm}^3$, is volume of Pd tube. The heat burst in the explosion reached MW per $\text{cm}^3 \text{ Pd}$.

There was also an explosion in a D/Pd electrolytic system at SRI International on January 2, 1992. Because it was a closed system and the parameters are complex, we cannot reach a clear conclusion on it as here, but it is possible that it was also a cold nuclear fusion explosion.

4. A proposal for mechanism of cold fusion

Where such large excess heat comes from? Why the heat mismatches nuclear products? It is puzzle for us and very difficult to explain within the domain of the physical and chemical knowledge now available, it is possible that new physics appears in it. Two years ago, the first author of this paper provided a hypothesis as below [3].

A small part of the rest energy Mc^2 connected with the rest mass M of deuterium can be transformed directly into utilizable energy, this process named as RDTME can be written in the form of

$$D_1 + D_2 \rightarrow D_3 + D_4 + \varphi \quad (1)$$

in which D_i ($i = 1 \sim 4$) represents deuterons with rest M_i , and

$$M_3 = M_1 - \Delta M_1, \quad M_4 = M_2 - \Delta M_2 \quad (2)$$

$\varphi = (\Delta M_1 + \Delta M_2)c^2 > 0$ is the energy which can be released as the kinetic energy of electron, deuterons and/or the energy of photon. It seems that the value of φ mainly distributes from order of 1 eV to 20 keV.

The reaction mentioned above takes place only under certain specific artificial circumstances with, especially, some kind of electronic screening. The condition under which F-P's cold fusion occurs is one of these specific artificial conditions.

Furthermore, we suggest a possible mechanism of excess heat released in RDTME model.

In PdD_x, TiD_x or other Deuterium/Metal system, when a free electron transits to a specific state in which the electron can screen the coulomb repulsive force between two D nuclei, i.e. the electron comes into a bound state, the photon may be emitted. Due to some possible yet unknown relation between the electromagnetic interaction and the strong interaction, D nuclei may provide energy ΔMc^2 connecting with its rest mass M_D to the electron, then, the electron can get back to the initial state and emit photon again. This process may repeat several times under certain specific conditions, as a result, the excess heat is released continuously.

We divide the screen state involving electrons into two kinds: weak screen (w-s) and strong screen (s-s). When the electrons transit to w-s state, only lower energy photons are emitted without any traditional light nucleus fusion taking place. When the electrons transit to s-s state, besides the energetic photons being emitted, various fusions of deuterium may sometimes be ignited. Obviously, the probability that the electrons get into w-s state is much greater than that the electrons get into s-s state, so the production of excess heat is much greater than that of the nuclear particles. Therefore the puzzle of the huge mismatch between the excess heat and the nuclear products is solved naturally. At the same time, we may understand the possible correlation existing between the branching ratio of cold fusion and the temperature, pressure and other environment parameters in the PdD_x or other Deuterium/Metal Systems.

The screening effect existing between two deuterons caused by the mobile electrons and deuterium ions D⁺ in the lattice of PdD_x etc. have been discussed in many papers. This effect can make the coulomb barrier weaker, and then may enhance, perhaps greatly, the probability of fusion taking place between the low energy deuterons. But the screening mechanism has not yet explained the mismatch between the excess heat and the fusion products as well as such large fusion rate obtained in the experiments.

Similarly to the reaction in Eq. (1), the fusion reaction between protons and between proton and deuteron can take place too. That is to say, the light-water-electrolysis can also generate the excess heat in spite of small quantity.

References

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