Experimental Investigation of the Electrochemically Induced Nuclear Fusion

Hideo KOZIMA, Sumio ŌE*, Kunihiko HASEGAWA**,
Hideo SUGANUMA**, Masaharu FUJII, Takami ONOJIMA.
Kunio SEKIDO and Masaharu YASUDA

Department of Physics. Department of Chemistry and*
*Radiochemistry Research Laboratory***
Shizuoka University, Shizuoka 422

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Synopsis

Preliminary results of experiments on the electrochemically induced nuclear fusion are reported. An electrolysis of $D_2O + LiOH \cdot H_2O$ solution was used is the experiment with Pd plate cathode and Pt wire anode. To detect neutrons liberated in a reaction

$$d + d \rightarrow {}^3He + n.$$

A Neutron Dose Rate Meter 2202D was used. Observed amount of neutrons ($\sim 6 \times 10^{-3}\ cm^{-3}s^{-1}$) is comparable to the data ($\sim 6 \times 10^{-3}\ cm^{-3}s^{-1}$ for titanium) reported by Jones et al.[1]

1. Introduction

Since sensational news of the electrochemically induced nuclear fusion of deuterons in palladium or titanium metal by Jones et al.[1] and Fleischmann and Pons,[2] many experiments have been performed to confirm the outstanding results on this line. On the other hand, A. De Ninno et al.[3] performed an experiment in which various metals that absorb hydrogen were made contact with deuterium gas changing the thermodynamic properties of the system. They observed neutron emission appearing in bunches. It was reported that their results were reconfirmed by an experiment in Los Alamos.[4]

The event of neutron production seems stochastic according to the positive results cited above, not saying negative experiments which we will not cite here.

Several theoretical investigations of nuclear fusion other than the thermonuclear one

were presented hitherto. The μ meson catalyzed fusion was proved to occur as predicted by a theory.[5] The piezonuclear fusion[6] is on the same line of it making feasible the fusion by raising kinetic energy to overwhelm Coulomb repulsion in terms of the confinement of space available for a deuteron according to the uncertainty principle. One of the proposed mechanism[7] of the electrochemically induced fusion is on the line of the above mechanism assuming a large electron mass which combines two deuterons to form a molecule-like pair. Another type of the mechanism[8] is dynamical one in which a deuteron absorbed into a metal collides with another one occluded in it beforehand. In the process, the screening of the repulsive Coulomb potential was assumed to make the fusion easier for two deuterons colliding with a relatively low mutual energy supplied in the process of electrolysis from the applied electric voltage. Fusion probability is estimated as a function of the screening constant and the mutual energy. Considering only the screening effect by mutual electrons, Kondo[9] estimated an output of fusion which is much less to compare with the experimental data.[1]

Because of a-diversity of data in the experimental conditions of positive experiments reported by now, it is difficult to discuss reality of these proposed models. It should be desirable to accumulate more experimental data and to make possible more concrete models on them.

We will explain experimental condition and results which show a reality of the cold nuclear fusion in or on a palladium plate cathode in a process of electrolysis of D_2O with such a low voltage as 10 V.

2. Experimental

Considering perplexing situation of the experiments on the cold fusion with or without electrolysis, it is desirable to accumulate experimental data with definite experimental conditioins. Though the available apparatuses are limited, we have made experiments with finest care and report here a positive result on the deuteron-deuteron fusion at room temperature and pressure during low-voltage electrolysis of a heavy water with a metallic palladium plate electrode.

As a neutron counter, the Neutron Dose Rate Meter 2202D has been used to detect neutrons liberated in a reaction

$$d + d \rightarrow {}^3He + n. \qquad (1)$$

The neutron sensitivity of the counter is 0.4 count per neutron/cm^2•s for an energy of $\sim$2 Mev. i. e. the efficiency is 0.4 at $\sim$2 Mev (where the efficiency becomes highest and then sharply drops in the low energy side). The counter is very senisitve to humidity of the ambient air. To stabilize the counter and lower the background, the counter was sealed in a polyethylene bag with a dessicant. With this care, the average background count became as low as one count/hour.

Refering to the work by Jones et al.[1] we chose the electrolytic system as follows. The

electrolyte is typically a mixture of ~60 ml D_2O plus 0.03 g $LiOH \cdot H_2O$. The cathode is a palladium plate of thickness 0.2 mm with a size 50×50 mm^2. The plate was bent in arch to fit with the glass cup 10 cm high and 4 cm in diameter used as a vessel for the cell. The anode is a platinum wire of 0.5 mmϕ with length 150 cm wound in a shape of a coil with diameter 10 mmϕ. The anode was placed equidistant from the cathode plate. The palladium plate were sometimes reused with or without heat treatment to dehydrate them. A direct-current power supply provided voltages of 2-20 volts between the electrodes at currents of up to 600 mA. In the voltage range used, 8~13 volts were optimum ones for the neutron gain. Experiments with $H_2O + LiOH \cdot H_2O$ were performed to check the effect of deuterium.

The electrolytic cell was placed beside the neutron counter as shown in Fig. 1. The solid angle which the center of the cell spanned for the counter was $\sim 0.2 \times 4\pi$, i. e. the geometrical factor of the counter for this experiment is ~5. During the experiment, electrolyte was stirred with a stirrer beneath the cell. The temperature of the electrolyte was about 40°C at room temperatures of about 25~30°C and humidity of 75 ~85%.

3. Results and Discussion

Figure 2 shows experimental results of the neutron counts as a function of time. As seen from this figure, experimental points are outside of the standard deviation of the background. If the H_2O was used instead of D_2O in the electrolyte, the response of the counter was almost the same as the case with no electrolysis. Therefore, it is confirmed that there is a neutron production in the process of electrolysis of D_2O with a cathode of

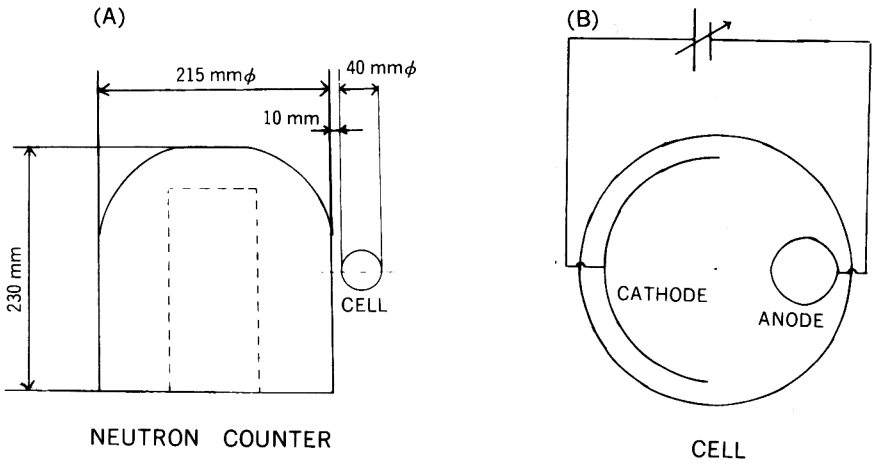

Fig. 1. Experimental apparatus. (A) Relative position of the neutron counter and the electrolytic cell. (B) The electrolytic cell with electrodes.

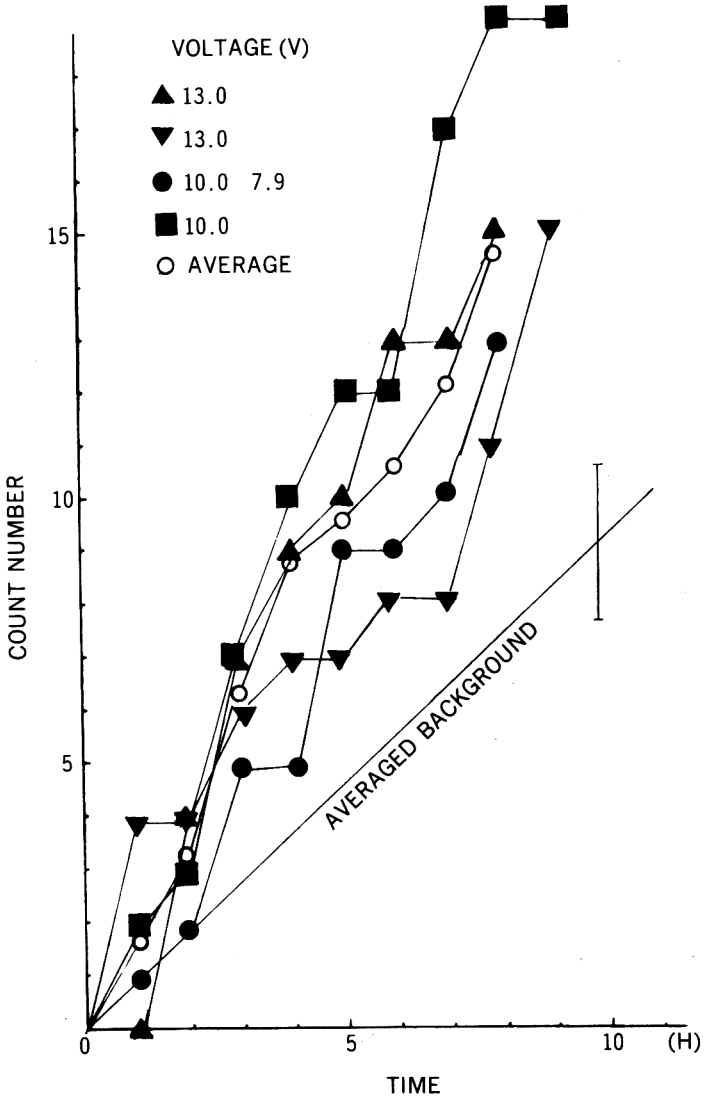

Fig. 2. Neutron count numder vs. time in hour. Background count is measured many times for 999 minutes and averaged to plot in this figure. To obtain the average number of the neutron counts during the electrolysis, experimental data for voltages of 8 to 13 V were averaged irrespective of the voltage.

palladium though the energy of neutrons counted was not determined.

The production rate of neutrons is calculated as follows. If the counter registers N counts, the production number in the cell will be

$N \times$ geometrical factor $\times$ (efficiency of the counter)$^{-1} = 12N$.

Using the count number 0.9 per hour for the system obtained in our experiment shown in Fig. 2, we obtain a neutron count number per cm^3 per second

$0.9 \times (3600)^{-1}$ counts/0.5 $cm^3 \cdot s = 5.0 \times 10^{-4}$ counts/$cm^3 \cdot s$.

Therefore, the fusion rate is equal to$\sim 6 \times 10^{-3}/cm^3 \cdot s$. This value is compared with a value of 10^{-23} fusions per deuteron pair per second ($\sim 6 \times 10^{-3}/cm^3 \cdot s$) for titanium obtained by Jones et al[1]

When the voltage between the electrodes was elevated up to 20 V, the neutron count number did not show excess above the background. This data suggest a voltage dependence of the nuclear fusion in the metal. A further experimental investigation will be performed with a variety of experimental condition.

The effect of aging of the cathode in the process of electrolysis observed by Jones et al[1] was also found in our experiments. When the same palladium plate was used as the cathode for the second time, the production of neutrons went generally down to the background level in contrast with the brand-new plate which showed excess neutron production. The effect of the heat treatment of the used palladium plate is not certain.

Fusion probability of two deuterons occluded in a palladium or titanium metal is very small according to the commonly accepted knowledge of matter[5~8] However, there are several experimental data including the present one which show exceptionally high production rate of neutrons in those metals saturated with deuteron. The process of neutron production seems to be stochastic if we consider the time evolution of neutron count number observed in those data. If the process is stochastic, the mechanism of the fusion will be very complicated one depending on the fluctuational variation of the force acting between the deuterons in the metal.

Though the speculation could be diverse, more and more concrete experimental data should be accumulated with various conditions. One essential factor should be the surface condition of the cathode.

References

1) JONES, S. E., PALMER, E. P., CZIRR, J. B., DECKER, D. L., JENSEN, G. L., THORNE, J. M. and TAYLOR, S. E. (1989) Observation of Cold Nuclear Fusion in Condensed Matter, *Nature,* **338**, 737-740.

2) FLEISCHMANN, M. and PONS, S. (1989) Electrochemically Induced Nuclear Fusion of Deuterium, *J. Electroanal. Chem.*, **261**, 301-309.

3) DE NINNO, A., FRATTELILLO, A., LOLLOBATTISTA, G., MARTINIO, L., MARTONE, M., MORI, L., PODDA, S. and SCARAMUZZI, F. (1989) Evidence of Emission of Neutrons

from a Titanium-Deuterium System, *Europhys. Lett.* **9**, 221-224.

4) Report of LANL presented at International Work Shop on Cold Fusion. Santa Fe. May 23-25. 1989.

5) BRACCI, L. and FLORENTINI, G. (1982) Mesonic Molecules and Muon Catalyzed Funion, *Phys. Reports,* **86**, 169-216.

6) DEW VAN SICLEN, C. and JONES, S. E. (1986) Piezonuclear Fusion in Isotopic Hydrogen Molecules, *J. Phys. G : Nucl. Phys.*, **12**, 213-221.

7) RAFELSKI, J., GAJDA, M., HARLEY, D. and JONES, S. E. "Theoretical Limits on Cold Fusion in Condenced Matter" (preprint).

8) KOZIMA, H. (1990) On a Mechanism of the Electrochemically Induced Nuclear Fusion, *Rep. Fac. Science. Shizuoka Univ.*, **24**, 19-21 (1990).
KOZIMA, H., HASEGAWA, K., SUGANUMA, H., ŌE, S., SEKIDO, K., FUJII, M., YASUDA, M. and ONOJIMA, T. (1990) On a Mechanism of the Electrochemically Induced Nuclear Fusion II, *ibid*, **24**, 23-28.

9) KONDO, J. (1989) Cold Fusion in Metals, *J. Phys. Soc. Japan,* **58**, 1869-1870.