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Simultaneous Measurement Device of Heat and Neutron of Heavy Water Electrolysis with Palladium Cathode.

Y. ASAOKA, T. ICHIJI, T. FUJITA and T. MATSUMURA
CRIEPI, Central Research Institute of Electric Power Industry
2-11-1, Iwato-kita, Komae, Tokyo 201, JAPAN

Abstract

An experimental device of cold fusion phenomena has been developed. Feature of the device is precise calorimetry and simultaneous measurement of excess heat, neutron and gamma-ray emitted from the electrolysis cell. The deuterium loading ratio of the palladium cathode can be measured simultaneously.

The galvanostatic electrolysis of heavy water with Pd cathode and Pt anode has been carried out in a closed cell with recombination catalyst. For precise excess heat measurement, the flow calorimetry method were adopted. Obtained accuracy of the calorimetry system was ±0.2W at up to 10W of applied power. The electrolysis cell was set in shielding and neutron emission was detected by an NE-213 liquid scintillation counter and a He-3 proportional detector. Gamma-ray emission was measured with the Ge(Li) semiconductor detector. Electric resistance of the palladium cathode and pressure of the gas phase in the electrolytic cell were measured simultaneously to evaluate the deuterium loading ratio. D/Pd ratio evaluated by each method has reached approximately 0.87.

With these in-situ measurements of heat, neutron and gamma-ray, no remarkable cold fusion phenomena have been observed up to the present time.

1. Introduction

To reproduce the cold fusion phenomena, high loading ratio of deuterium in palladium cathode, that is considered to be one of the most important factors, is required[1,2]. Simultaneous and precise measurements of excess heat and nuclear products, such as neutron, tritium, helium and gamma-ray, are required to obtain the relationship of them in the investigation of the cold fusion phenomena.

An experimental device of cold fusion phenomena has been developed under consideration of these requirements. Objectives of the experimental device are reproducing cold fusion phenomena with attention to the deuterium loading ratio and measuring excess heat, neutron and gamma-ray simultaneously.

In the present study, characterization of the device was performed and preliminary results of the experiments are also discussed.

2. Experimental Methods

Galvanostatic electrolysis of D_2O-LiOD solution with Pd cathode and Pt anode has been carried out in a closed cell with recombination catalyst. Palladium cathode materials obtained from Tanaka Kikinzoku Kogyo(TKK) was cut to sheets of 12mm × 12mm × 1mm or rods of 3mm ϕ × 15mm. Platinum anode wire is rolled round the cathode as in the device of Takahashi et al.[3] for the sheet-shaped cathode; and mesh type anode is used for the rod-shaped cathode. A stainless steel electrolysis cell has volume of 140cm^3,which is coated by Teflon in inner wall. The cell includes a cathode, an anode, a resistance heater, a thermocouple, about 70cm^3 electrolyte and recombination catalyst. The pressure of the electrolysis cell is monitored by pressure transmitter located near the top of cell.

Cross section of the calorimeter and the electrolysis cell is shown in Fig. 1. For precise excess power measurement, flow calorimetry method was adopted. The calorimeter is consists of a water bath, thermal insulation, and a Dewar bottle. Flow rate of coolant is controlled to be constant in about 14g/min. Calibration was done with an internal resistance heater before and after electrolysis. Temperatures were measured at five points, near the top of the water bath, near the bottom of the bath, at the water inlet tube, at the outlet tube and in the electrolyte. The difference between the inlet and outlet temperatures is used to calculate the output power.

Fig.2 shows top view of the neutron and gamma detectors together with shielding. The electrolysis cell was set in the shielding which consists of polyethylene, cadmium and low background (Co-60 free) iron. Neutron emission was detected by an NE-213 liquid scintillation counter and a He-3 proportional detector. Gamma-ray emission was measured with a Ge(Li) semiconductor detector. The radiation measurement system is able to monitor back ground neutron count rate simultaneously with another He-3 detector set out of the shielding, measure continuously for two weeks and identify the energy of neutron and gamma ray. The detection efficiency for each detector was measured with a neutron source of Cf-252 and gamma-ray sources of Cs-137, Co-60, Na-22 and K-40. Back ground count rate decreased about 30% for the He-3 proportional counter, about 35% for the NE-213 liquid scintillation counter, and about 65% for the Ge(Li) semiconductor detector with shielding. The performance of the radiation measurement system is shown in table 1.

Deuterium loading ratio was evaluated with the electric resistance of palladium cathode measured by means of the 4 lead method and

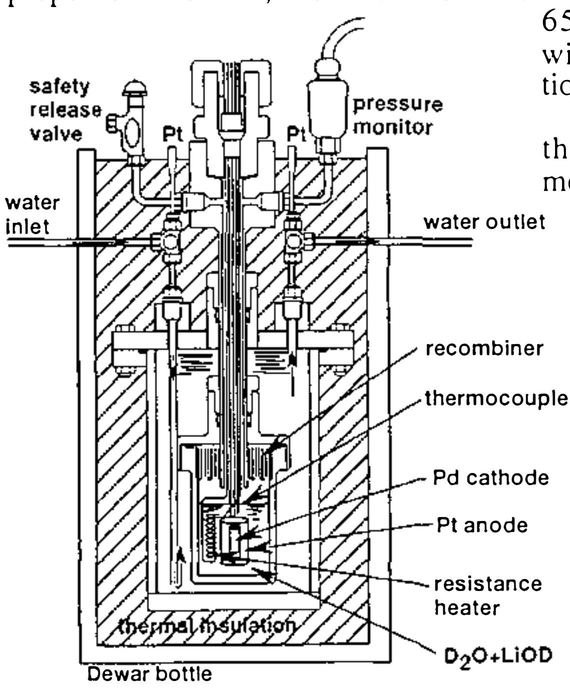

Fig. 1 Cross section of the electrolytic cell and calorimeter.

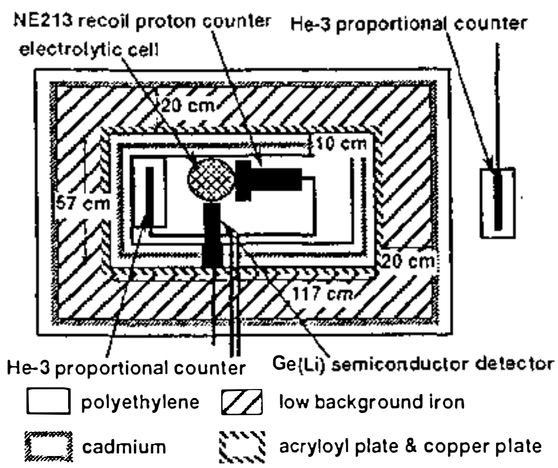

Fig. 2 Top view of the neutron and gamma detectors together with shielding.

Table 1. The performance of the radiation measurement system.

detectors	detection efficiency (%)	back ground count rate (s^{-1})	minimum detectable count rate (s^{-1})
He-3 proportional counter	0.89	1.5×10^{-2}	1.01×10^{-2}
NE-213 liquid scintillation counter	0.32	6.38×10^{-2}	1.94×10^{-2}
Ge(Li) semiconductor detector			
5.49MeV	0.027	2.60×10^{-2}	1.29×10^{-2}
6.26MeV	0.026	2.60×10^{-2}	1.29×10^{-2}
23.8MeV	0.014	4.56×10^{-1}	4.97×10^{-2}

the calibration curve of the R/Ro-D/Pd relationship[4]. D/Pd ratio was also evaluated with monitored pressure of the gas phase in the Pd cathode electrolysis cell compared with that of the reference experiments of Pt cathode electrolysis.

3. Results and Discussion

Fig. 3 shows the typical results of energy balance of heavy water electrolysis with a sheet-shaped palladium cathode and resistance heater calibration. The ordinate represents the difference between the calibrated value with the resistance heater before and after the electrolysis. The output power was calculated with the inlet and outlet temperatures and flow rate of coolant. The period of 0 to 75 hours and that of 700 to 800 hours represent the energy balance of heater calibration. The calibration curve was determined with these data. The period of the 75 to 700hours is for electrolysis. Input power changed several times from 1W to 9W, according to the electrolysis current was changed from 300mA to 900mA. The energy balance of the electrolysis seems to be almost zero except the sharp peaks due to step wise change of input power, that means the output power is always equivalent to the calibrated value calculated from the input power. From the data of non-excess heat electrolysis, the accuracy for the

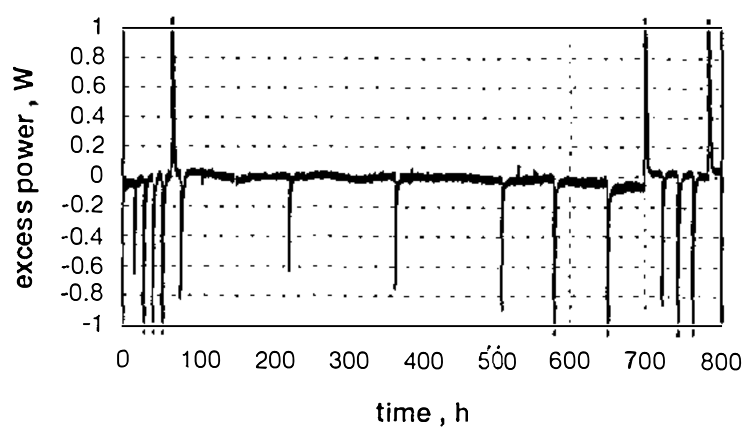

Fig. 3 Energy balance for heavy water electrolysis.

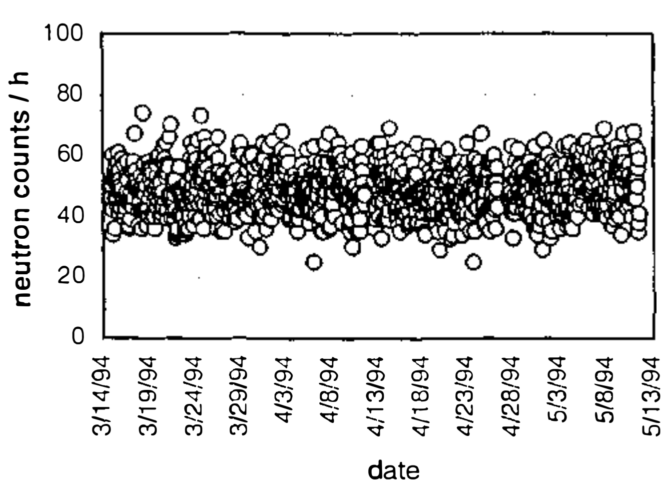

Fig. 4 Neutron count rate of He-3 counter in the shielding.

excess power measurement of the system was obtained to be ±0.2W at up to 10W of applied power.

Fig. 4 shows the count rate of the He-3 proportional counters in the shielding. The count rate seems to be almost constant during the electrolysis. No anomalous counts was observed for the other experiments. The data of the NE-213 counter and those of the Ge(Li) detector showed similar results.

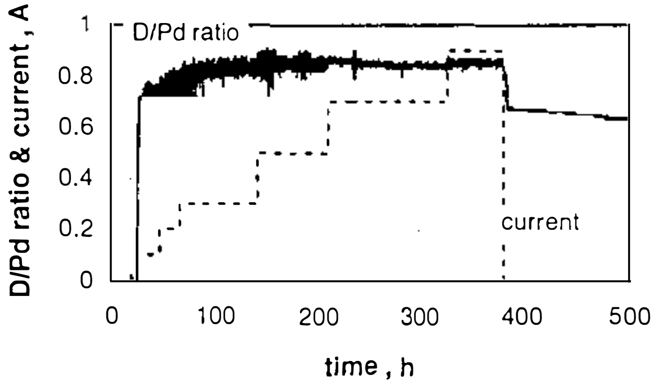

Fig. 5 Deuterium loading ratio in palladium cahtode.

D/Pd ratio of rod-shaped palladium cathode evaluated by the electric resistance together with the electrolysis current is shown in Fig. 5. When the electrolysis started, the loading ratio increased immediately and reached saturation in a day. Maximum D/Pd ratio was seems to reach 0.87. D/Pd ratio determined with cell pressure showed the similar results.

The performance of developed device was enough to detect the reported cold fusion phenomena. However, the results of all experiments showed no excess heat and no excess neutron and gamma-ray. One of the reasons for undetectable cold fusion phenomena is considered that the D/Pd ratio is not high enough for the phenomena.

4. Summary

Simultaneous measurement device of heat, neutron and gamma-ray of heavy water electrolysis with palladium cathode was developed. The device is able to monitor the deuterium loading ratio in palladium cathode simultaneously. As the result of the characterization of the developed device, the performance was enough for detection of the reported cold fusion phenomena.

With these in-situ measurements of heat, neutron, gamma-ray, no remarkable cold fusion phenomena, as excess heat or higher neutron count rate than back ground have not observed up to the present time. One of the reasons for undetectable cold fusion phenomena is considered to be low deuterium loading ratio.

Reproduction of the cold fusion phenomena with various cathode materials with attention to the D/Pd ratio, simultaneous measurement of heat, neutron, gamma-ray, helium and deuterium loading ratio, analysis of the palladium cathode are to be conducted.

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