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Neutron Evolution from a Palladium Electrode by Alternate Absorption Treatment of Deuterium and Hydrogen

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We observed neutron emissions from palladium after it absorbed deuterium from heavy water followed by hydrogen from light water. The neutron count, the duration of the release and the time of the release after electrolysis was initiated all fluctuated considerably. Neutron emissions were observed in five out of ten test cases. In all previous experiments reported, only heavy water was used, and light water was absorbed only in accidental contamination. Compared to these deuterium results, the neutron count is orders of magnitude higher, and reproducibility is much improved.

KEYWORDS: neutron emission, electrolysis, deuterium absorption, hydrogen absorption

It has been reported that palladium electrolyzed in heavy water produces excess heat.[1)] However, the mechanism remains unknown because research is hampered by poor reproducibility and lack of control. The very existence of the reaction is often called into question. On the other hand, based on several reliable reports of neutrons and other fusion products, many researchers assume that the mechanism involves nuclear fusion; however, many problems remain with this assumption.[2–5)]

The authors have examined many of the reports available to date of neutrons and heat, and have reached the following conclusions. First, when neutrons and excess heat are observed, they usually appear after electrolysis has continued for a long time. Second, many instances have been reported in which these effects occur after the cell is replenished with new electrolyte. Third, it is known that when electrolysis is used to absorb deuterium into palladium, at first, the electrolyte contains almost pure heavy water but later, it becomes mixed with light water.[6)] This substitution occurs because heavy water is hydrophilic, and light water permeates even a nominally closed cell at some stage during the process, gradually diluting the heavy water.

Based on these observations, we conclude that this reaction must require something more than the absorption of deuterium. In particular, after electrolysis has continued for a long time and the heavy water has been replenished, light water is likely to be mixed in the electrolyte. Also, after electrolysis loading has reached a certain point, any hydrogen present in the cell will migrate to the cathode and block the absorption of additional deuterium. In view of these facts, we predict that the reaction cannot occur with deuterium absorption alone, and that it requires certain triggering events.

Palladium wire, 99.9% purity, 1 mm in diameter and 3 cm in length, was used as the cathode. Tungsten lead wire, 1.5 mm diameter and 150 mm in length, was welded with the sample electrode. The electrolyte was composed of 100% pure heavy water from Acros Organics, and K_2CO_3 reagent from Kanto Kagaku Corp., which was 99.5% pure, and was adjusted to 0.2 M concentration. The reagent was heated to 300°C in an electric furnace to evaporate all water in it. The palladium sample was placed in a quartz glass cell containing 100 g of heavy water electrolyte. It was surrounded by a platinum mesh that served as the anode. Electrolysis was performed for three hours. Immediately after that, the palladium cathode was transferred to a light water cell where light hydrogen absorption was performed. At this stage, voltage was 10 V, and current was about 2 A. The light water cell was made of Pyrex, and it was 10 cm diameter and 20 cm high, with a silicon rubber lid. The palladium was introduced through a hole in the lid. The cell was also equipped with a platinum mesh anode in a configuration similar to the heavy water cell. In this phase, voltage was 40 V and current reached a maximum of 8 A; however, because the electrolyte temperature rose rapidly toward its boiling point, current was reduced to 1 A.

Neutrons were measured with three He3 detectors placed 50 cm above and apart from the cell. The detectors were calibrated with a standard Cf252 neutron source (2.58×10^4 decay/s). The background count was 0.008 ± 0.003 c/s. The efficiency of the detectors was set at 4×10^{-5} by calibration measurement. To reduce noise, the detectors were covered by an electromagnetic shield. After calibration, neutrons and noise were distinguished by covering one of the detectors with a 0.5-mm-thick Cd film. Neutron emission could be detected by the coincidence method with two of the detectors and the anti-coincidence method with one detector that was covered by the Cd film.

The experiment was performed ten times. A typical result of neutron emission is shown in Fig. 1. This shows the neutron count rate as well as the input voltage, current, and electrolyte temperature during the run. In this example, voltage was raised to 85 V at 3000 s, and immediately after that, 1 and 2 count rates were observed by the detectors that were not covered by the Cd film. As shown in Fig. 1, 25,800 neutrons were observed to emit from the cathode, with the count rate of 1 c/s. Neutron production peaked when voltage was raised, and 200 s after that, fell to the background level again. During this period, the total neutron count was estimated as

Table I. Changes of the factors and neutron emission for various measurements.

Sample No.	Cell Temp. (°C)	Starting Voltage	Ending Voltage	Duration of boost (s)	Voltage Boost (V)	Voltage change (V/s)	Peak Count	Total counts	Duration of Burst (s)	Count rate (c/s)	Total neutron burst
No. 1	40	0	40	15	40	2.67	7.70	17	50	0.17	438600
No. 2	26	0	30	10	30	3.00	3.08	5	2.6	1.92	129000
No. 3	40	0	25	5	25	5.00	0	0		0	0
No. 4	90	30	83	20	53	2.65	1.54	61	200	0.305	1573800
No. 5	95	50	90	40	40	1.00	0.05	3	100	0.03	77400
No. 6	90	40	90	20	50	2.50	0	0		0	0
No. 7	90	70	90	15	20	1.33	0	0		0	0
No. 8	90	20	90	40	70	1.75	0.910	5	135	0.037	129000
No. 9	60	0	0	200	0	0	0.025	5	200	0.025	129000
No. 10	80	72	92	15	20	1.33	0.460	1	195	0.005	25800

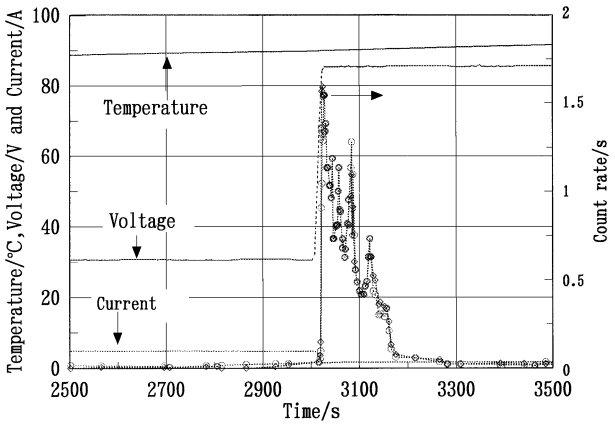

Fig. 1. Neutron counts after absorbing deuterium and hydrogen. After 3000 s, electrolysis voltage was raised to 80 V, and neutron emissions suddenly occurred. (Data from sample 4.).

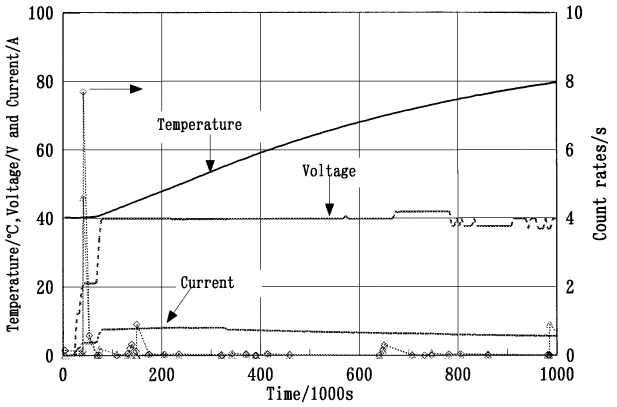

Fig. 2. Example in which neutron emissions began immediately after electrolysis commenced, and continued for 50 s. (Data from sample 1.).

1.57×10^6. In this example, electrolysis in light water continued for a considerable length of time and neutron emission was observed when voltage increased.

Another run is shown in Fig. 2. Here, neutron emissions were observed immediately after light water electrolysis commenced. Electrolyte temperature was 40°C and input voltage was 40 V. The maximum count rate was 7.7/s, the duration time 50 s and the total neutron count was estimated as 4.38×10^5.

Table I shows how differences in electrolysis conditions led to differences in neutron emissions. Column 1 shows sample number and column 2 is electrolyte temperature. When neutron emissions occur, they always occur after increase in voltage, either when electrolysis begins, or later on when voltage is increased to a higher level. Column 3 shows the voltage level before neutron emissions began. Voltage was zero for samples 1, 2, and 9, meaning they produced neutrons immediately after electrolysis began. Column 4 shows the ending voltage after emissions ceased, or with samples 6 and 7, after a boost failed to produce neutrons. (Sample 3 remained at 25 V during the entire run, with no boost, and failed to produce neutrons.) In some cases we tried raising voltage gradually while in others, we increased it abruptly. Column 5 shows how much time was taken for each sample. Column 6 shows the total voltage increase that trigged an event, or the boost increase that failed to trigger an event, and column 7 shows the rate of increase. For example, with sample 7, we raised voltage from 70 to 90 V over 15 s, a total of 20 V, at the rate of 1.33 V per second, but no emission was detected. Column 8 shows the peak count, column 9 the total counts, and column 10 the duration of the emission event. Column 11 shows the average count rate per second, and column 12 shows the total number of neutrons extrapolated from the count, based on the calibration with the Cf252 neutron source.

It is clear from this table that in five examples, over 100,000 neutrons are observed, which is deemed a significant count. Emission performance was neither predictable nor controllable: neutron counts varied by one order of magnitude, from 10^5 to 10^6, and continued for the duration ranging from 2 to 200 seconds. All emissions had a distinct pattern, namely a peak soon after the emission began, and a gradual decline. From the data in this table, we cannot yet establish a causal connection between neutron emissions and temperature, voltage, or other control parameters, but in samples that did produce neutrons; the degree of the total voltage increase does appear to correlate with the peak, average, and total neutron counts. Higher voltage correlates with higher neutron counts.

Neutron emissions during light water absorption following heavy water absorption are very difficult to explain by the models proposed heretofore, which involve *d-d* fusion reactions. These other models assume that neutron emissions occur when heavy water alone is absorbed, and the emissions must be accompanied by excess heat and tritium production.

The reaction we observed came about after alternating absorption of deuterium followed by hydrogen, and the reaction appeared to be highly reproducible, reliably generating high neutron emissions. We conclude that the models proposed heretofore based upon *d*-*d* reactions are inadequate to explain our present results, which involve hydrogen nuclear reactions.

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