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Excess Heat In Heavy Water--Pd/C Catalyst Cathode (Case-Type) Electrolysis At Temperatures Near The Boiling Point

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At high temperatures, the Pd/C catalyst cathode (Case-type) electrolysis in heavy water might produce more excess heat than at room temperature. While the “excess heat” in Case-type experiment was apparently confirmed at the higher temperature, the method raised new problems with electrolysis near boiling temperatures.

1. Introduction

Leslie Case repeated his famous Pd/C catalyst cathode electrolysis^[1] in 2002 and reported his results ICCF-9.^[2] The huge surface area in the activated carbon catalyst generates a lot of Pd thin film on its surface. There is about 1000 square meters surface area for each gram of palladium-coating activated-carbon catalyst, and 15 grams of catalyst were used in our experiments. It is believed that this huge area of Pd surface facilitates not only the repeatability these experiments, but also the loading of deuterium into the Pd thin film. Usually, we need not wait a week in order to observe the “excess heat”. We have observed the “excess power” is in the order of 0.15 W while the input electrical power is about 0.5-0.7 W, and the temperature of the electrolyte is about equal to room temperature.

In the present work, our goal was to enhance apparent excess power by raising the temperature of the electrolyte. We believe that at a higher temperature the deuterium flux may be enhanced. The correlation^[3] between the deuterium flux and the heat flow might produce greater excess power. Based on our observations of “heat after death” and “after heat” we expected to observe increased excess power at higher temperatures.

A thermostat was used to raise the temperature of the water bath close to the boiling point of heavy water. We ran the Case-type Pd/C catalyst cathode electrolysis for both heavy water and light water cells immersed in the water bath. We hoped to see anomalous “excess power” drive the heavy water to the boiling point while the light water shows no change.

We had to solve new problems related to the higher temperature electrolysis. Vaporization becomes so rapid that the water level drops, and changes the heat transfer coefficient. When we reduced the open area at the top of the cell to reduce the vaporization, the mixture of deuterium and oxygen became another problem. A diaphragm was used to separate the cathode and anode. Uneven temperature distribution inside the electrolysis cell became a problem at higher temperatures. Thus, our top priority was to demonstrate a reliable calibration for an inhomogeneous system. It is assumed that even if in an inhomogeneous system, there is still a constant heat transfer coefficient, provided that the inhomogeneous system keeps its linearity in response to the heating power. This assumption has been confirmed by the experimental data both in the light water cell and the heavy water cell.

In the preliminary operation, we have observed the “excess power” again at higher temperature. This “excess power” is higher than that in the room temperature.

2. Apparatus

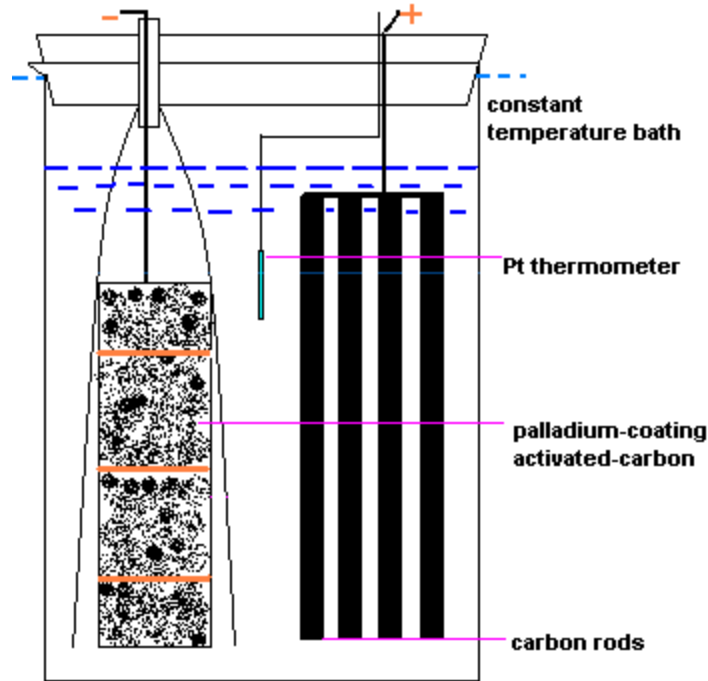


Fig 1 Schematic of the electrolytic cell in the thermostat water bath.

Fig.1 shows the electrolytic cell schematically. A glass beaker was used as the cell. A thick rubber block was plugged on the top of the glass beaker to reduce the heat exchange and decrease the vaporization of the electrolyte. The cathode was composed of Pd-coating activated-carbon catalyst which was contained in a copper basket. In order to separate the deuterium (hydrogen) gas from the oxygen, a plastic thin film was mantled on the cathode to guide the deuterium gas. The anode was composed by a set of graphite electrodes. A platinum thermistor (Pt-100) was fixed at the center of the electrolytic cell to measure the temperature of the electrolyte. The beaker was immersed in a thermostat water bath to raise the temperature of the electrolyte.

It was intended to raise the cell temperature to 95°C; then, the electrolysis in the light water cell might enhance the cell temperature to 99°C, and the electrolysis in the heavy water cell should bring the cell to boiling temperature due to the excess heat (if any). In reality, the thermostat was able to reach 91°C only when the beaker was immersed in the bath. If we increased the electrolytic power to enhance the cell temperature, the intensive gas bubbling became a problem even before reaching the boiling point. The bubbles and the foam spilled through the narrow passage in the rubber block. The experiment had to be redesigned to fix these problems.

3. Preliminary Results

With these revised procedures, we ran the electrolysis at a temperature higher than room temperature, but less than the boiling point. The water bath heated the electrolyte, and the electrolyte transferred the thermal energy to the environment through the rubber block. In the meanwhile, the electrolytic power heated the electrolyte as well. The Joule heating power was:

$$P_J = I^*(U - U_{\text{neutral}}) \quad (1)$$

Here, I and U are the electrical current and voltage for the electrolytic cell. U_{neutral} is the thermoneutral potential, which is the necessary voltage to dissociate the water. We took U_{neutral} as 1.54 V. for the heavy water and 1.48 V. for the light water. Usually, we heat the electrolyte first using the water bath only until the cell temperature reached a steady state; then, the electrolysis power was switched on. The joule heating power would enhance the cell temperature further at the fixed environmental temperature. This cell temperature would reach a new steady state. The experiment was run in 4 different configurations: with positive and reverse polarity, and with heavy water and light water. For the 4 different cases the steady state might be quite different. With the light water electrolysis, the polarity of the electrolysis did not show much difference; however, with heavy water electrolysis, the polarity of electrolysis showed different temperature enhancements. When the electrolysis power was switched off, the cell temperature returned to its previous steady state. Figure 2 shows the temperature excursion in one of these experiments. The upper two curves use the left scale. When the water bath was fixed at about 91.5°C, the cell temperature was 88.3°C at first. Then, it was heated to 89°C by the Joule heating of electrolysis. After electrolytic power was switched off, the cell temperature fell back to 88.3°C again. The lower curve shows the room temperature (on the right scale), which was fixed at about 23°C.

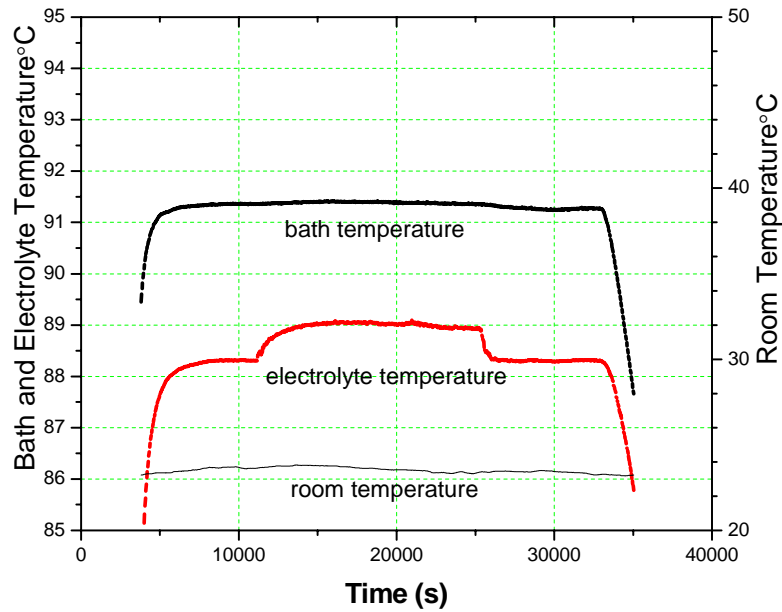


Fig. 2. Temperature excursion for one electrolysis run

Table 1, Cell temperature excursion for 4 different cases

Date	Category & Polarity	Before Electrolysis (°C)	During Electrolysis (°C)	After Electrolysis (°C)	Enhancement of Cell Temperature (°C)	Joule Heating Power (W)	Specific Heating (°C/W)
7-30	H ₂ O, Reverse	86.5	87.3	86.6	0.8	0.6	1.3
7-31	H ₂ O, Positive	-----	87.6	86.4	1.2	0.9	1.3
8-16	D ₂ O, Positive	86.6	87.1	85.6	0.5	0.2	2.5
8-17	D ₂ O, Reverse	87.0	87.4	86.9	0.5	0.65	0.77

Table 1 gives the experimental results for the 4 different cases. When the Pd-coating activated-carbon catalyst was used as the cathode, it was considered positive polarity. When the Pd-coating activated-carbon catalyst was used as the anode, it was considered reverse polarity. For the light water electrolysis, the cell temperature variation for positive polarity is same as that for the reverse polarity (Row 1 and Row 2 in Table 1). However, in the heavy water electrolysis the temperature variation for the positive polarity is very different from that for the reverse polarity (Row 3 and Row 4 in Table 1). When cathode was the Pd-coating activated carbon, the deuterium gas was fed into the Pd thin layer. In that case, we need only a little joule heating power to maintain the cell temperature. This might indicate there is anomalous excess heating power in the Pd-coating activated carbon catalyst.

4. Discussion

- (1) Apparent excess heating power is greater at the higher electrolysis temperature. In 2002, the same experiment was done near room temperature. The excess power recorded was about 0.15 W. In 2003, the cell temperature was elevated to 87°C, the excess power is about 0.45 W. This implies that at the higher temperature the higher flux might cause more “excess power” in the D/Pd system.
- (2) In order to run the electrolysis near the boiling temperature, we have to solve the problems with bubbles and the foam. We may replace the water bath fluid with oil to increase the bath temperature. Then, only a little power will be needed to raise the cell temperature close to the boiling point. This might reduce the electrolysis current, and reduce the bubbles and foam.
- (3) Fig. 2 shows that the precision of the temperature measurement is better than 0.1°C, and the accuracy of the temperature of the thermostat water bath is also in the order of 0.1°C. The apparent excess heat effect is obviously beyond this uncertainty.

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