SEARCH FOR OPTIMUM CONDITIONS TO PRODUCE EXCESS HEAT FROM THE ELECTROLYSIS OF HEAVY WATER WITH A PALLADIUM CATHODE

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control cell: \( \text{H}_2\text{O} + \text{H}_2\text{SO}_4 = 20:1 \) by volume

experimental cell: \( \text{D}_2\text{O} + \text{H}_2\text{SO}_4 = 20:3 \) by volume

Control cell: Pt foil electrodes

Pyrex Berzelius beaker (200 ml)

Experimental cell: Pd cathode, Pt anode.
Figure 13. AFM images of a) Pd foil surface after cold rolling (the vertical lines resulted from contact with the steel rolls); b) Pd cathode surface after electrolysis for 12 minutes; c) and d) are enlargements of surface pit in (b) to show the rounded and faceted features.
Figure 15. a) A bowl-shaped cavity in Pd cathode, illustrated a) in the height-mode b) in the force-mode, showing striations that converge into its center, and c) contour of the crater. The crater drops > 280 nm vertically from its rim.
Figure 22. An AFM force-mode image a) of the palladium cathode side facing away from the anode, electrolyzed for a total of 105 seconds. The asperity seen here appears to be from melting and recrystallization. The angles of the facets suggest that these are traces of \{111\} planes. The section analysis b) indicates that this feature rises about 1 \(\mu\)m above the surrounding surface.
Figure 29. SIMS is a procedure that bombards a small area of the Pd surface with a primary beam (Cs133). Surface atomic layers are sputtered off, and the mass of the ions from the resulting sputtered particles are analyzed using a mass spectrometer to provide elemental and isotopic identification.
### RELATIVE ABUNDANCES AND WEIGHTS OF NATURALLY OCCURRING ISOTOPES

<table>
<thead>
<tr>
<th>Elem.</th>
<th>AMU</th>
<th>Isotopic Comp. (at. %)</th>
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<tbody>
<tr>
<td>Pd$^{102}$</td>
<td>101.905634</td>
<td>1.020</td>
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<tr>
<td>Pd$^{104}$</td>
<td>103.904029</td>
<td>11.14</td>
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<td>Pd$^{105}$</td>
<td>104.905079</td>
<td>22.33</td>
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<td>Pd$^{106}$</td>
<td>105.903478</td>
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<td>Pd$^{107}$</td>
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<td>Pd$^{110}$</td>
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<td>Ag$^{107}$</td>
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<td>Ag$^{109}$</td>
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<td>Cd$^{106}$</td>
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<td>Cd$^{108}$</td>
<td>107.904176</td>
<td>0.89</td>
</tr>
<tr>
<td>Cd$^{110}$</td>
<td>109.903005</td>
<td>12.49</td>
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</table>
Figure 1. SIMS profile of the six palladium isotopes for a region of the palladium sample not electrolyzed (top), and a region of the six minute heavy water electrolyzed sample (bottom). The latter shows isotopic inversions of Pd$^{108}$ with Pd$^{106}$, which merge after ~65 minutes sputtering. Also Pd$^{110}$ and Pd$^{104}$ are inverted.
Figure 5.20. Schematic representation of an energy-dispersive spectrometer and its associated electronics.
Pd cathodes 0.35mm thick, after electrolysis for about 400 hours

H - electrolyzed in H₂O – H₂SO₄
D – electrolyzed in D₂O – H₂SO₄

0.1 to 0.2 watts excess power produced by D₂O cell compared with H₂O cell during first 300 hours of operation

0.1 to 0.2 watts excess power produced by H₂O cell compared with D₂O cell during final 100 hours of operation
Fig. 2. Enlargement of lower right corner of H$_2$O cathode in Fig. 1.

The electrolyte where it occurs due to slow dissolution of the Pt anode. Au, however, is not expected to arise from a pure Pt anode. Nor is it expected to occur inhomogeneously as an impurity in Pd because Au and Pd are completely miscible in the solid state.$^3$

Fig. 3. EDS spectrum from region A of the H$_2$O cathode shown in Fig. 2.

Fig. 4. EDS spectrum from region B of the H$_2$O cathode shown in Fig. 2.
Assume that the following fusion reaction occurs:

\[ \text{D}^+ + \text{D} \rightarrow ^3\text{He} \ (0.82 \text{ MeV}) + \text{n} \ (2.45 \text{ MeV}) \]

Subsequently, the neutron produced in this reaction is absorbed by a Pt atom on the surface of the Pd electrode. The energy of the neutron is converted to heat, and the Pt atom decays to Au by the following reaction:

\[ ^{196}\text{Pt} + \text{n} = ^{197}\text{Pt} = ^{197}\text{Au} \]

$^{197}\text{Pt}$ is an unstable isotope, with a half life of 80 min. It yields an orbital electron, thus becoming $^{197}\text{Au}$ (stable).
Characteristic Peaks for Pd, Ag, and Cd

La - most intense

Lb - about one-half La intensity
A: Spectrum from area of photograph in Figure 3
B: Spot 1, Figure 4
C: Spot 2, Figure 4
D: Spot 3, Figure 4
E: Spot 4, Figure 4
Figure: Circuit diagram. A Single-pole-double-switch (SPDT) switch was used to switch the voltmeter reading between the two experimental cells. ‘ ’ Represents a K-type thermocouple used for temperature measurement. All thermocouples were attached to a STP-36CJC-102-02A board manufactured by Kiethley. The board was connected to a computer which was used to read and paste temperature values in a MS Excel worksheet.
Equations for excess heat

At steady state:

\[ \text{Power IN} = \text{Power OUT} - \text{Anomalous power} \]

\[ IV_1 = k(T_1 - T_A) + \frac{dH_1}{dt} \]

\[ IV_2 = k(T_2 - T_A) + \frac{dH_2}{dt} - \frac{dH_{xs}}{dt} \]

I = constant current

\( V_1 \) = control cell voltage

\( V_2 \) = experimental cell voltage

k = a constant

\( T_1 \) = control cell temperature

\( T_2 \) = experimental cell temperature

\( T_A \) = ambient temperature

\( \frac{dH_1}{dt} \) = power lost from control cell due to evaporation

\( \frac{dH_2}{dt} \) = power lost from experimental cell due to evaporation

\( \frac{dH_{xs}}{dt} \) = excess thermal power
Excess power data for 2 cells with Pd cathodes and heavy water electrolyte in comparison with a control cell which had a Pt cathode and light water electrolyte. Current = 3A, Current density = 0.48 A/cm-sq. Precision of measurement is estimated at +/- 0.1W
Fig. 5. Changes in morphology and EDS spectra of the features in the square shown in Fig. 4a. These changes occurred during storage at room temperature with no further electrolysis.
Palladium Lβ/Lα = 0.4  ➜ Elemental Silver = 0%
Palladium Lβ/Lα = 0.6  ➔ Elemental Silver = 7%
Palladium Lβ/Lα = 0.74  ➞ Elemental Silver = 10%
Excess thermal power output versus experimental cell temperature. Current density was about 0.5A/cm² for all three experiments. Pd cathode thickness was 0.05mm.
Pd-0.05mm-8mm-36mm Sample

1. Image

Fig. 1.1 Image of sample Pd-0.05mm-8mm-36mm (small magnification)

Fig. 1.2 Image of sample Pd-0.05mm-8mm-36mm (big magnification)
2. Spectrums

EDS of Pd-0.05mm-8mm-36mm convex, area s11, which has largest silver concentration, 4.02% (Pd Lb/La=0.63)

EDS of Pd-0.05mm-8mm-36mm convex, area s14, which has silver concentration, 1.9% (Pd Lb/La=0.73)

EDS of Pd-0.05mm-8mm-36mm concave, area s10, which has largest silver concentration, 9.56% (Pd Lb/La=0.78)

Figure: EDS of sample Pd-0.05mm-8mm-36mm
3. Concentrations

Figure: All concentrations of sample Pd-0.05mm-8mm-36mm

Figure: Ag concentrations of sample Pd-0.05mm-8mm-36mm

Figure: Pd concentrations of sample Pd-0.05mm-8mm-36mm