

Anomalous Silver on the Cathode Surface after Aqueous Electrolysis

J. Dash, Q. Wang

Eugene F. Mallove Laboratory for New Energy Research, Portland State University, Portland, OR 97207

E-mail: dashj@pdx.edu

Abstract. The presence of localized concentrations of anomalous elements (gold and silver) on the surfaces of palladium cathodes after electrolysis in either light water or heavy water electrolyte was first reported in 1994 [1]. Similarly, anomalous elements in surface pits were reported for titanium cathodes after electrolysis in heavy water electrolyte [2]. More recently, off-the-shelf battery fluid (Sp.G. 1.26) was substituted for analytical-grade H_2SO_4 (Sp.G. 1.84) in the electrolyte. Silver was found in localized concentrations on palladium cathodes after electrolysis. These results are consistent with a thermal neutron mechanism proposed previously [1].

1. Introduction

A demonstration of our excess heat experiment was performed in Salt Lake City (SLC) at an American Chemical Society conference on March 23, 2009, the 20th anniversary of the announcement by Fleischmann and Pons that they had achieved nuclear fusion in a bottle. The apparatus for this demonstration was shipped from our Portland State University (PSU) laboratory. The electrolyte, containing sulfuric acid, a hazardous chemical, was to be shipped separately, with required precautions. However, the electrolyte did not arrive in SLC in time for the demonstration. Rather than cancelling the demonstration, commercial battery fluid was substituted for our electrolyte.

2. Experimental methods and Results

The battery fluid contained dilute sulfuric acid (Sp.G. 1.265). This was further diluted with tap water. Therefore, the diluted electrolyte contained no heavy water. This was the electrolyte for the control cell (C cell). This cell contained a Pt foil anode, a Pd foil cathode, and hydrogen and sulfate ions in the electrolyte. The experimental cell (E cell) was identical except that it contained the same commercial battery fluid diluted with heavy water instead of tap water. This cell also contained a Pt foil anode and a Pd foil cathode, but the electrolyte contained both hydrogen ions and deuterium ions, in addition to sulfate ions. The cell components are given in Table 1.

The two cells were connected in series to a direct current power supply which supplied constant current to both cells at almost the same voltage. Thus, the power input was almost identical for the two cells (about 14 watts), but the power output was at least one watt higher for the C cell compared with the E cell. This result was totally unexpected. The experiment in SLC was repeated, and the result was the same, i.e. the C cell produced more than one watt greater thermal power than the E cell.

Our previous experiments used deionized water and pure sulfuric acid (Sp.G. 1.84) for the C cell electrolyte, and pure heavy water and the same sulfuric acid for the E cell electrolyte. A typical excess heat result was about 0.8 watt higher power output from the E cell. This was the result which we demonstrated at ICCF10 in Cambridge, MA in 2003.

After electrolysis for about two hours, the demonstration was stopped, the electrolyte was removed, and the apparatus was shipped back to PSU. The C cell cathode was removed from the cell and examined. Whereas it originally was a flat, silvery foil, it is now black and bent lengthwise to a curved surface which was concave to the anode during electrolysis. It was then examined with a scanning electron microscope (SEM) equipped with an energy dispersive spectrometer (EDS). Fig. 1 shows the pitted topography on the concave side of a Pd cathode after electrolysis for about two hours in light water electrolyte. A characteristic x-ray spectrum was taken by scanning the electron beam over the entire area of Fig. 1. The only elements detected in this spectrum were C, O, Al, Pd, and Pt. The origin of C is not known, O, Al, and Pt are thought to result from the $Pt-Al_2O_3$ recombination catalyst suspended above the electrolyte. Pt could also be produced by electroplating Pt dissolved from the anode.

Table 1. Cell components for experiment on 3-23-09 in SLC.

	E-cell	C-cell
	50ml D2O (99.9%, 151882-250g, Aldrich)	75ml H2O (tap water)
	50ml H2SO4 (Battery Fluid, S.G. 1.265, UN2796)	25ml H2SO4 (Battery Fluid, S.G. 1.265, UN2796)
Anode	Pt=1.2798g (25mm*24mm*0.1mm)	Pt=1.3503g(25mm*24mm*0.1mm)
	Stock #11509 Lot # C25Q28	Stock #11509 Lot # C25Q28
Cathode	Pd=0.5355g cold rolled (29mm*8mm*0.2mm)	Pd=0.6167g cold rolled (29mm*8mm*0.2mm)
	Stock #11514 Lot # IO5S014	Stock #11514 Lot # IO5S014
Catalyst	20ml	20ml
	Alfa Aesar 0.5% Pt on alumina	Alfa Aesar 0.5% Pt on alumina

In Fig. 1 the gray areas contain mostly Pd, the white areas contain mostly electroplated Pt, and the black holes contain mostly Pd with statistically significant Ag. The ratio Ag/Pd averages 0.06 for 9 black holes. This Pd/Ag ratio for each of these nine black holes is given in Table 2.

The area shown in Fig. 1 was chosen for intensive study because it is highly pitted. One possible explanation for the pitting is that localized melting and vaporization occurred. Such events seem unlikely with only 14 watts input energy. Another possibility is that chemical dissolution occurred. If so, a more uniform topography would be expected instead of the pitted surface shown in Fig. 1. In previous research localized concentrations of anomalous elements were found on surface asperities [1] and in pits [2] The SEM electron beam, less than 1 μ m diameter, was focused on the asperity or pit. This resulted in the emission of characteristic x-rays from all of the elements present. The x-rays were detected and processed to produce a spectrum from each pit. Carbon, atomic number 6, and all elements of higher atomic numbers, could be detected and quantified by this method.

Table 2. Silver content at various locations in the black pits shown in Fig. 1. Statistically significant (>3 sigma) amounts of Ag were found in nine of 14 pits which were analyzed. The spectrum obtained by scanning the electron beam over the whole area of Fig. 1 (wa) did not contain Ag.

Atomic %-041409	Pd	Ag	Ag/Pd
Shu-SLC-C-Cell-Pd-CC-0.5k-wa		0.0	
Shu-SLC-C-Cell-Pd-CC-0.5k-s1	94.8	5.2	0.06
Shu-SLC-C-Cell-Pd-CC-0.5k-s2	95.3	4.7	0.05
Shu-SLC-C-Cell-Pd-CC-0.5k-s3	90.6	9.4	0.10
Shu-SLC-C-Cell-Pd-CC-0.5k-s4	92.7	7.3	0.08
Shu-SLC-C-Cell-Pd-CC-0.5k-s5	94.8	5.2	0.05
Shu-SLC-C-Cell-Pd-CC-0.5k-s7	95.8	4.2	0.04
Shu-SLC-C-Cell-Pd-CC-0.5k-s8	94.7	5.3	0.06
Shu-SLC-C-Cell-Pd-CC-0.5k-s10	95.4	4.6	0.05
Shu-SLC-C-Cell-Pd-CC-0.5k-s11	92.2	7.8	0.08

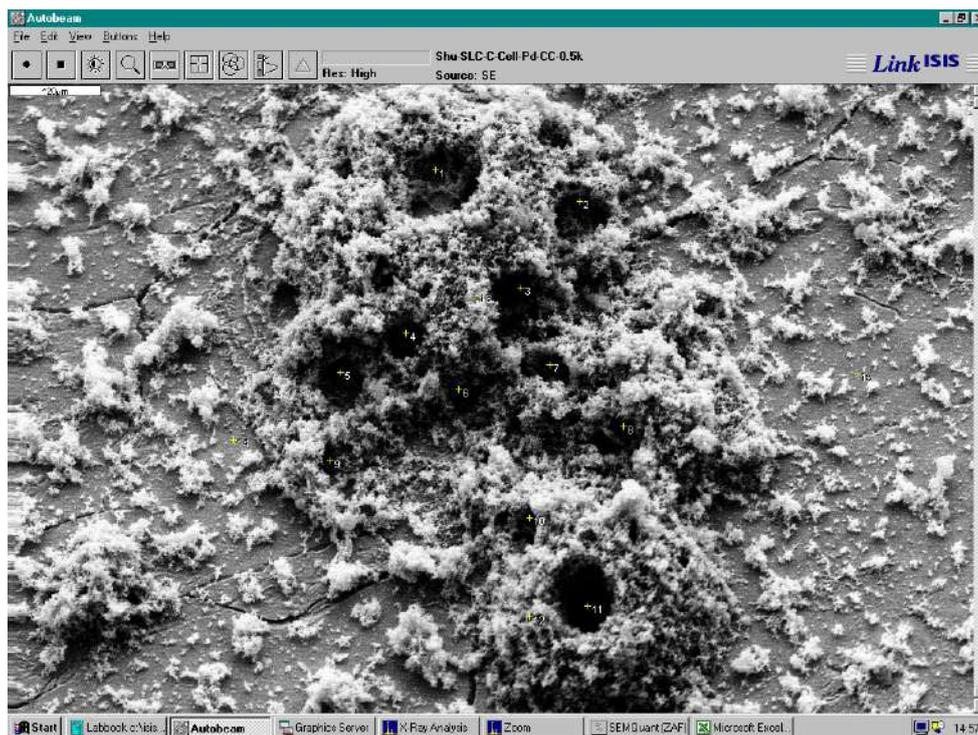


Fig. 1 - Micrograph of the concave side of the Pd cathode after about two hours electrolysis in light water electrolyte.

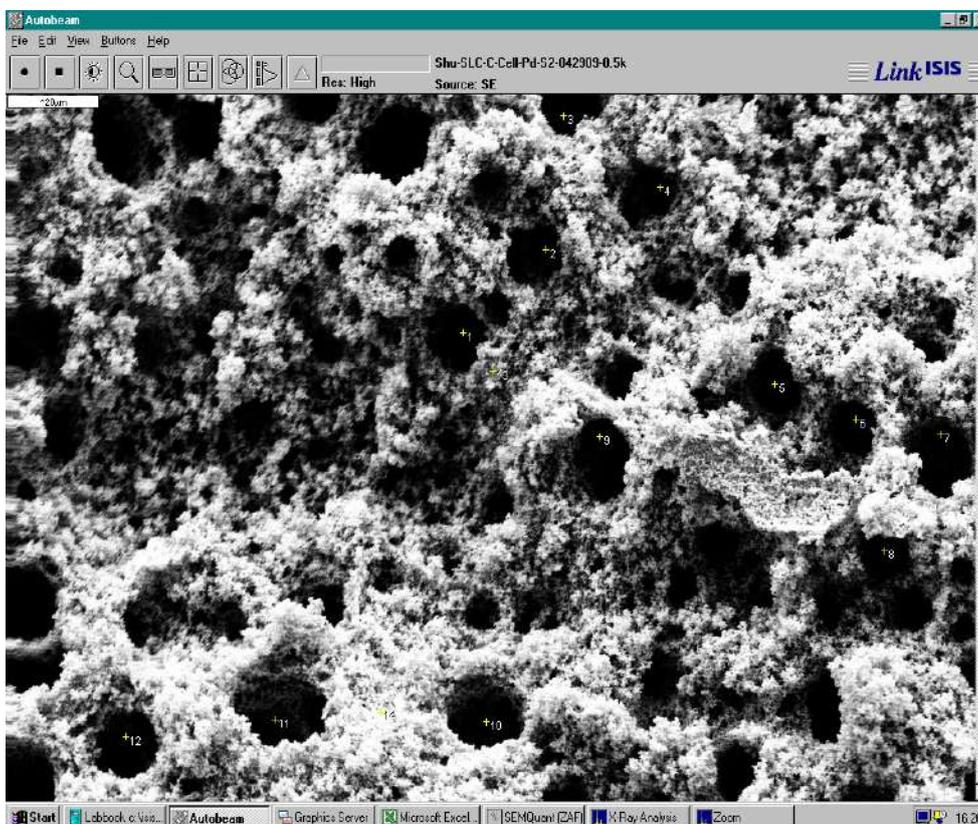


Fig. 2 - Topography of a hotspot on the convex side of a Pd cathode after electrolysis for about two hours in light water electrolyte, SLC 3-23-09. Twelve of 14 black holes contained statistically significant Ag (>3 sigma). The average ratio Ag/Pd was 0.09, and the range was 0.06 to 0.14.

3. Discussion

We now examine the possibility that the silver detected in the black holes originated from environmental contamination, such as impurities from the tap water. This seems unlikely because deposition occurs preferentially on asperities, not in pits. The black holes in figures 1 and 2 are rimmed with white particles which are almost pure platinum. We suggest that miniature explosions occurred, leaving behind pits containing Ag, which resulted from thermal neutrons absorbed by Pd. The unstable Pd isotopes then beta decayed to form Ag and heat sufficient to form a localized pit. Pt then electroplated from the electrolyte onto the rims, which were elevated above the original surface.

EDS measurements were also performed on the cathode from the E cell. Topography was similar to that found on the C cell cathode, and anomalous Ag was found in the pits. Our efforts were concentrated on the light water C cell cathode because it produced more heat than the heavy water E cell.

We are currently using secondary ion mass spectrometry (SIMS) before and after electrolysis to determine if there are changes in Pd isotopic abundance in our cathodes.

4. Conclusions

Excess heat was obtained from electrolysis with palladium cathodes in cells containing acidified H₂O electrolyte compared with cells containing palladium cathodes and acidified D₂O electrolyte.

Statistically significant, localized concentrations of silver were found in pits on the surfaces of palladium cathodes after electrolysis.

The results for the light water cells were obtained using commercial battery acid diluted with tap water, suggesting that highly purified chemicals are not necessary for LENR.

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5. References

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