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Amoco Production Company

Research Department

**COLD FUSION: REPORT ON A RECENT AMOCO
EXPERIMENT**

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SUMMARY

This report will discuss briefly some of the early calorimetric experiments on cold fusion and in more detail, a single experiment just concluded.

A closed cell electrolytic experiment has been conducted using a palladium cathode and platinum anode with accurate (± 0.001 watt) calorimetric measurements. Results indicate a positive energy output of approximately 50 Kjoules more than was input to the experiment through electrolysis current and heater current. The heat output was observed both as short term bursts of energy and as long term sustained production. Colorimetric calibration with an internal heat source showed essentially identical data before and after the electrolysis experiment. Material balance for palladium, water and lithium showed essentially no material had been consumed during the experiment. Tritium levels measured before and after electrolysis showed a factor of 3 increase that cannot be accounted for by concentration effects.

It is important to note that if this experiment had been terminated after only one month the results would have shown no positive energy production.

These data support the claims of several experimenters that anomalous heat and tritium are produced during electrolytic experiments using a hydrogen absorbing cathode. Further experiments are in progress to determine reproducibility and better define experimental parameters.

BRIEF HISTORY

Cold fusion burst upon the scene with great fanfare and little hard information with a press conference in March 1989, when Pons and Fleischmann (1) announced they had found anomalous energy associated with an electrochemical cell. Before there were any actual reports in the literature, circulation of the preprints was commonplace. There were several claims of confirmation over the following few months from diverse groups located worldwide (2-9). At the same time there were many statements that "cold fusion", at best, was the result of experimental error (10-19). Since many "experts" have come out saying that there is nothing to cold fusion, the public perception at this time is that cold fusion has mostly faded away.

AMOCO HISTORY

In April 1989, a "garage experiment" on cold fusion was set up by Ted Lautzenhiser of Amoco and Melvin Eisner of the University of Houston on the basis of a common interest in a scientific curiosity. This experiment yielded a 30% energy gain over the life of the experiment (two months). The calculation of the energy gain depended upon assigning an energy to the dissociation of heavy water into its components, deuterium and oxygen. This is in common with most of the published experiment, although a platinum surface had been provided for the catalysis of the gases back to heavy water. The surface area of the catalyst had proven to be insufficient and the volume of the electrolyte had been diminished by the electrolysis. Concurrent with this experiment an idea for a possible commercially valuable process was mutually conceived. At this point the work was disclosed to Amoco TRC management and support was given to continue the investigation of cold fusion as an Amoco project.

In June 1989, the first experimental modification was to the catalyst after the experiment was moved from Houston to the Amoco TRC laboratories. This catalyst consisted of platinum powder packed into a glass tube with the gases evolved from the electrolytic cell being forced through the tube. This catalyst appeared to work effectively and the experiment was again yielding about 30% excess energy until the catalyst became water logged and channeling of the gases through the platinum powder caused the catalyst to fail. However, the energy gain without "bookkeeping" had been shown, although only briefly.

In August 1989, a new catalyst was constructed using platinum powder ground into a fiberglass matrix. This unit allowed the water formed to drip back into the electrolytic cell. Because the catalyst was now bigger than envisioned at the beginning of the experiment the calorimetric chamber had to be modified to allow for the electrolytic cell and catalytic unit to be enclosed. The energy gain during this experiment was 10%, but it was felt that the modifications to the calorimetric chamber had introduced an error such that the energy gain determined was conservative. It should be noted that all of these experiments used the same palladium ingot purchased by Lautzenhiser and Eisner in Houston. At this time a new calorimetric cell was built and the following experiment was begun.

DETAILED EXPERIMENT

CALORIMETRIC CELL

The determination of the energy balance was accomplished through a calorimetric cell. This cell, shown in Figure C1 (90080ART0182), consisted of a thick walled aluminum cylindrical chamber (1) connected to an aluminum plate (2) with 3 brass bolts (3) passing through 2 inches of insulation (4). This assembly is placed inside an insulated chamber (5) which is surrounded on all sides except the bottom by a water jacket (6). This is set upon another inch layer of insulation. The water jacket has a forced circulation of water maintained to within $\pm 0.0005^{\circ}\text{C}$. This water jacket is surrounded by an inch layer of insulation (7). A thermistor probe (8) was inserted through a tee at the water outlet (9).

In operation, the inner aluminum chamber is maintained at a constant temperature difference above that of the aluminum plate to which it attached with the brass bolts. These bolts serve as the primary thermal . . .

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. . . The cell over a period of less than 2 hours began to produce power at about 90 mw versus the 40 mw it had built up to over the previous week. This transition event occurred over about a two hour span.

Then as shown in Figure R6 (90079ART0305), there was another spontaneous transition event and the power production from the cell fell to approximately 60 mw rate. Here the power level remained till December 7, when the current was shut off.

After current shut off, the cell continued to produce power for about a week. This power in large part was probably due to the release of the deuterium from the palladium and the subsequent catalytic recombination with oxygen. However, the energy released after the current shutoff was greater than the 25 KJ that had apparently been used to charge the cell at the beginning of the experiment.

In Figure R7 (900079ART0306), the period starting at 1000 on December 17 is shown. This is about a week after the electrolyzing current has been shut off. The net power in has again returned to the 2.486 watt line as during the calibration period. It might be noticed that it is actually a little above 2.486 watts indicating perhaps the extent of the drift of the calorimeter system or perhaps indicating that during the original calibration there had been a background power release from the cell due to a chemical reaction. This effect would make calculation of the energy produced pessimistic by about 20 Kjoules.

TRITIUM

The electrolyte was analyzed for tritium activity before and after the experiment. Prior to starting the experiment the electrolyte had a value of 2.5 ± 1.0 pcurie/mL. After the experiment was completed, a sample of the electrolyte was counted again and was found to have 7.4 ± 1.1 pcurie/mL. While not a large increase in tritium, this increase is significant.

The system was not closed to restrict gas flow in or out of the cell. But, no concentration of activity could have occurred from the isotope effect because the internal catalyst converted any excess deuterium and oxygen gas produced back into water which remained in the cell. The measured water volume before and after the experiment (80 ml) shows that no concentration of tritium occurred due to losses past the catalyst from possible catalytic inefficiency. Also, gas flow was measured from the catalyst and flow could only be detected during times of rapid charging or discharging of the palladium electrode when stoichiometric volumes of gases were not present.

Thus, the tritium production in this experiment, although small, is real and significant. Three factors make the amount of tritium produced appear less significant. The volume of electrolyte in the cell is large compared to published experiments producing tritium (20). Also, this experiment was run on an electrode of much larger volume than those published (21). The charging time for this experiment was a large part of the total experimental time. The experiment was terminated to recalibrate soon after excess heat was observed which would have not given much time for tritium production.

PALLADIUM ELECTRODE

The machined electrode surfaces were not visibly different after the experiment. The surfaces were still the same color and texture as when the experiment was started. The surface left as cast was noticeably smoothed after the experiment. Surface analysis by X-ray fluorescence did not indicate the presence of lithium, platinum or other metals. The electrode was rinsed with water and vacuum dried before analysis. Surface analysis studies of palladium electrodes from similar experiments (22) indicate the surface may be coated with lithium which is rapidly converted to

LiOD with no current or an exposure to atmosphere. It is likely that any lithium on the palladium was removed by washing before the analysis.

The electrode was also tested for radioactivity by placing it on radiographic film for 72 hours. No darkening of the film could be detected. However, it is likely that any stored tritium would have been removed during vacuum baking, but this test should have also detected unstable isotopes of the metal if they were formed.

LITHIUM

The electrolyte was analyzed for lithium concentration after the experiment was completed. Analysis by ICP indicated a lithium concentration equivalent to 2.87 M LiOD. This is in good agreement with the 3 M LiOD that was originally used, although the original measurements (22 gm Li in one liter of heavy water) are not of the same accuracy as the post measurement. These numbers are considered in good agreement and indicate that at most very little lithium was consumed during the experiment.

DISCUSSION

The calorimetry conclusively shows excess energy was produced within the electrolytic cell over the period of the experiment. This amount, 50 kilojoules, is such that any chemical reaction would have had to be in near molar amounts to have produced the energy. Chemical analysis shows clearly that no such chemical reactions occurred. The tritium results show that some form of nuclear reactions occurred during the experiment. The tritium produced was not nearly enough to account for the excess energy. The expected nuclear processes would have been on the order of 4 Mev per event. 10^{17} such reactions would have been required to produce 50 Kjouies of energy. Our measurement of tritium shows an excess of 5×10^8 atoms. In other words, tritium production would only account for about 5×10^{-9} of the observed excess energy. The main point of the tritium in this experiment is then that there are some nuclear processes

involved. Some competing process must be highly favored. A candidate at this time is the Phillips-Oppenheimer type of deuterium-palladium reaction which would, through beta decay, yield silver and hydrogen. Isotopic measurements of the palladium to show the resulting silver would not be possible using known technology, although an experiment run significantly longer at the measured excess power rates would make the possible silver measurable. We hope to test this hypothesis in the near future.

ACKNOWLEDGEMENTS

This is to acknowledge the efforts Tim Stanley, Jim Wirtz, Tony Hambrick and Ralph Wiley put into this effort. Tim Stanley provided valuable insights into some of the metallurgical and electrolytic aspects. Jim Wirtz programmed the data collection system and provided the printouts and plotting of the data for our analysis. Tony Hambrick helped design and built many of the mechanical devices such as the calorimeter and electrolytic cell accessories. Ralph Wiley helped us monitor for possible harmful radiation which was not detected during the period of the experiment.

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