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May 13, 1991

Dr. Joseph Santucci
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Re: RP-3170 Review Meeting Report

Dear Joe:

Enclosed is my report on the review meeting last March. I am really sorry for the delay but I was waiting to receive the view graphs and these came just as I was leaving on several trips which were followed by the end of the semester here with the usual exam and grading activities. Let me also note that a few of the key view graphs, specifically those comparing and summarizing the results of all the calorimetric experiments, were missing.

I hope you find this review suitable. Please call me if you would like any additional comments or would like to discuss this further.

With best wishes,

Sincerely,

Alan J. Bard

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enclosures: report
invoice

Comments on SRI RP-3170 Review Meeting (25-26 March 1991)

Allen J. Bard

The following is a summary of impressions and some recommendations based on the overview of electrolysis, calorimetry, and other experiments discussed at the review meeting. I also studied my notes from the meeting and reviewed the viewgraphs supplied later. However I must emphasize that it is quite difficult to understand and appreciate all of the details of the different studies described In a relatively short meeting.

1. Pd/D Loading Studies.

A rather large effort has been made in the use of Pd resistance measurements (R/R°) to determine the loading of D into the Pd. Since high loading is thought to be a necessary condition for the observation of anomalous heat effects, an independent measurement of D-loadlng, that can be made in operating cells, is a very good idea.

However the calibration of R/R° as a function of Pd/D seems to be largely based on earlier data by Baranowski (on H/Pd) and an extrapolation of the data of Lewis from a region of lower loading (D/Pd < 0.7). We weren't shown any other results to confirm the R/R° values for higher D/Pd ratios. In light of the importance of loading, and the fact that the relation between D/Pd and R/R° is not monotonic, perhaps some additional independent calibrations at high loading should be made. A second effect that might be important, especially if small amounts of H_2O can contaminate the cell, is the relative loading with H and D. It has been reported that small amounts of H can severely decrease D loading, and that almost no loading of D is possible in the presence of appreciable levels of H_2O In the D_2O. The effects of surface films from additives and impurities on loading and resistance also seems to be an important issue.

2. Excess Heat Effects

It is difficult to give a detailed analysis of the calorimetric results because of the obvious complexities of these experiments.

As everyone recognizes, these are very difficult experiments that involve calorimetry under conditions of continual input of energy and measurements over long time periods. The experiments described are certainly among the best that I have seen in this field. The use of closed cells with recombination of evolved gases, flow calorimetry, redundancy in temperature measurements, and careful consideration of the calorimeter model, design features, and systematic errors, lends confidence to the results reported. However, subtleties in design and possible small artifacts are sometimes difficult to discern (especially from a brief examination). Thus, continued efforts to demonstrate reproducibility, as well as numerous control experiments are desirable. For example, I think it would be useful to replace the electrodes in the cell with a calibrating heater of the same size and configuration, and test the accuracy, over a reasonable period of time, with this configuration.

The concept of an “oxygen-free” (high-pressure) cell is a very good one, although more difficult to use than the closed "D_2-O_2" cell. As far as I can discern from my notes, an appreciable excess heat effect has not yet been demonstrated in such a cell.

Controls and blanks, e.g., with H_2O or other metal cathodes, are important. From my notes I found only one independent H_2O control experiment. Given the total number of experiments and the number of cells that clearly show an excess heat effect, more control experiments are necessary. These should be arranged so that the experimental conditions and the input energy and output heat are as close as possible to those in the actual experiments (e.g., by adjustment of cell ohmic drop). Running controls is a boring exercise, but they need to be carried out in numbers and for durations similar to those for the Pd-D experiments.

3. Question of Reproducibility and Magnitude

Reproducibility remains a key consideration. Although it is felt that the excess heat effect will appear whenever certain key conditions (high D-loading. sufficient loading duration, and high current density) are met, I'm not sure that there have been sufficient number of independent cells tried to convince an external observer that appreciable excess heat effects can be generated “on demand.” One still has the impression that the effect turns on and turns off in a non-controlled way.

The overall effect observed, in terms of excess output energy integrated over the duration of the experiment, remains a rather modest one (~2 %), even when rather large power bursts are seen. Thus, from a practical point of view (in terms of eventual applications) it is important to extrapolate to conditions where sustained, greater than break even, energy can be obtained. Unfortunately there was not much time available at the meeting to discuss scale-up. I don't think a large effort should be made in scaled-up experiments until the smaller scale experiments of the type being carried out (e.g., in small high pressure cells) allow one to have confidence that the system is totally under control and the important known variables have been established. These small-scale experiments should then allow an estimation of expected effects in larger cells and whether break-even operation will be attainable.

4. Materials Considerations

Additives that lead to controlled film formation on the cathode that governs reactivity of D and hence D-loading are thought to be important factors. Contamination of the cathode by adventitious impurities from the cell (e.g., Si) and anode (e.g.. Pt) also occurs. So far materials characterization, e.g., of the cathode after excess heat effects compared to a cathode in a cell that never showed excess heat, have been meager. Once the system is thought to be "under control,” detailed analysis of electrode surfaces should be undertaken. Alternative cell materials (e.g., Teflon) and anode materials (in recombination cell) (e.g., dimensionally stable anodes, SnO_2, RuO_2> might be considered.

5. Mechanism and Products

Given the state of this field, the scientific community will probably not be convinced about the reality of these effects unless there is some understand of the mechanism of the process and products are detected at levels consistent with the observed heat effects. If the process is a nuclear one, there must be some signature. If the process is a chemical one, e.g.. some chemical

charge/discharge cycle, it would, of course, be much less important from an energy viewpoint, but would still be interesting to understand.

The product detection experiments carried out so far do not yet provide convincing evidence. The autoradlography experiment is clouded by the possibility of chemical effects of hydrogen and the X-ray detection experiments are not unambiguous. It would, of course, be best if detection experiments could be carried out under conditions where excess heat effects could be measured simultaneously. This clearly complicates the apparatus for both calorimetry and product detection, but would lead to the highest confidence in the measurements.

In conclusion, the work at SRI to detect and understand excess heat effects during electrolysis with Pd cathodes has been carried out carefully and has shown some excess heat effects that cannot readily be attributed to artifacts or errors. The number of different cells and controls do not seem to be sufficient at this stage to convince an outsider that these are completely unambiguous. The detection of nuclear products at levels consistent with the excess heat levels has not yet been accomplished. Such detection is necessary before a convincing case can be made for a process involving a nuclear reaction.