Further Evidence for Cold Fusion

A REPORT ON THE THIRD INTERNATIONAL CONFERENCE

Since March 1989 when Professors Stanley Pons and Martin Fleischmann made their dramatic announcement regarding the production of excess heat from their heavy water electrolysis experiments, using a palladium cathode and platinum anode in a simple calorimeter (1–3), there have been numerous attempts to repeat their work in laboratories throughout the world. Many of these attempts have failed, or produced ambiguous results, but some have appeared to be successful. The Third International Conference on Cold Fusion, held in Nagoya, Japan, from 21st to 25th October, 1992, was attended by some 350 participants from sixteen countries, and provided an ideal opportunity to review the present status of work on this topic.

Fleischmann and Pons postulated a nuclear fusion explanation to account for their results, presumably involving deuterons, and research work has been devoted both towards verifying the excess heat effects and to identifying nuclear particles produced by these systems. As a result of the adverse publicity given to the early work, most of the later work has been underfunded or performed in investigators' spare time, and as a result sometimes lacks thoroughness. There have been some notable exceptions, however, and some of the presentations at this conference represented work which had been very carefully executed. Results described included evidence for excess heat, and for nuclear particle and helium production.

Excess Enthalpy Measurements

The conference opened with a description of thorough work carried out by M. C. H. McKubre's group at the Stanford Research Institute in California, which is funded by the Electric Power Research Institute. Closed cells which were sealed and pressurised were used. Seventeen electrochemical variables were carefully controlled and the reaction parameters recorded on-line. The results indicate that one criterion for the observation of excess power is the formation of highly loaded compositions in the ß-phase of the palladium-deuterium system; that is PdD_x with x larger than approximately 0.9, taken as an average over the entire cathode. In addition, it is apparent that the satisfaction of other criteria is involved, although these latter factors are currently less well characterised.

Appropriate cell design and close attention to the electrochemical aspects of the loading process were advocated by McKubre. In addition, it is desirable that the deuterium loading be monitored closely in-situ during the electrochemical experiment. Only in this way may the instantaneous value of the apparent excess power be related directly to the average cathode loading. Using this technique, baseline excess power in the range 2 to 50 per cent of power-in was sometimes observed with occasional bursts of 350 to 500 per cent of input power.

A. Takahashi and co-workers, of Osaka University in Japan, described their experiments using a palladium plate cathode, and the application of low current and high current alternately, from which they had recorded output power levels of 1.7 times the input power; that is 70 per cent excess heat. Some subsequent experiments had, however, given lower excess power levels and attempts to reproduce the Takahashi method by F. Celani (INFN Laboratory, Frascati, Italy) were successful but produced only 25 per cent excess power.

Work carried out in collaboration with E. Storms at the Los Alamos National Laboratory in New Mexico, was reported by T. Claytor. Two pieces of palladium sheet, similar to those used by Takahashi, were loaded with deuterium in a Fleischmann/Pons type electrolytic cell. One sheet produced a steady increase in excess power that reached 7.5 watts (20 per cent of input power) at a deuterium:palladium loading ratio of 0.82; but the other did not, possibly as a result of achieving a maximum loading ratio of only 0.75.

An electrolytic cell pressurised by deuterium gas in which the deuterium loading ratio in the palladium cathode can be determined in-situ, has been developed by K. Kunimatsu of IMRA Japan. It was found that excess heat generation of up to 35 per cent became evident at deuterium:palladium loading ratios of about 0.85.

S. Pons, now of IMRA SA, France, first reviewed some of the Utah work, carried out in collaboration with Fleischmann, in which both steady state excess enthalpy and bursts of heat had been observed, using the published protocol of an initial period of charging at low current density, followed by raising the current density to observe excess enthalpy effects. He then demonstrated how time-lapse video recordings were used in recent experiments which were run into the region of the boiling point and/or to boiling, using both palladium and palladium alloy electrodes. The rates of excess enthalpy generation could be calculated using the enthalpy inputs, and the rates and latent heats of evaporation of deuterium oxide. These experiments illustrate three important aspects of excess enthalpy generation in these systems: that it is feasible to generate excess enthalpy in the region of the boiling point, that very high rates of excess enthalpy generation can be achieved (> 1 kW/cm^3) and that the effects of changes in the experimental protocols can be measured directly.

Nuclear Products

The meeting was reminded by S. E. Jones, Brigham Young University, Utah, of the results from work on deuterium charged metals where he has evidence for anomalous nuclear reactions occurring in the laboratory as well as naturally in the earth (4). Jones is currently working in the Provo Canyon Laboratory, Utah, and in collaboration with the University of Tokyo in another underground laboratory. Small steady emissions of neutrons have been recorded. Other conference papers such as those by A. Takahashi (Osaka) and by D. Gozzi and colleagues (Rome) included reports of emissions of neutrons from electrolysis experiments, coincident with excess heat production, those recorded by Gozzi coming in big bursts.

Among the most significant papers in this section were those which had positively identified helium-4 emissions from deuterated palladium. E. Yamaguchi and T. Nishioka of Nippon Telegraph and Telephone Corporation Basic Research Laboratories, Tokyo, used a deuterium loaded palladium plate with gold deposited on one side and manganese oxide on the other in a vacuum system. In an early stage of the study they observed gigantic neutron bursts, explosive gas release, uniform biaxial bending of the sample caused by plastic deformation, and excess heat evolution, all at the same time. Using an ultra-high resolution mass spectroscopy system they have recently found a signal attributable to He^4 during the excess heat evolution period.

M. F. Miles and B. F. Bush, China Lake, California, have repeatedly been able to correlate positive identification of He^4 with emission of excess heat from their electrochemical experiments, but have had problems reproducing the excess heat effect, and are currently examining the variables in their experiments.

The production of massive quantities of tritium at a palladium electrode, accompanied by the production of He^4, was reported by J. O'M. Bockris, Texas A and M University. This He^4 has been positively identified by thermal expulsion and mass spectroscopy by N. Hoffman of the Rockwell International Corporation; no He^3 was found, but He^4 was measured in nine specimens out of the ten examined. The amounts measured corresponded to 2–300 times background, and no helium was detected in the material prior to its use in the tritium production experiments. A logarithmic relation between the rate of tritium production and the overpotential of the electrode reaction was established.

Materials Aspects

In his paper Bockris referred to the fact that examination of palladium electrodes used in his experiments had identified deposition of numerous metals and silicates. These results are in agreement with those reported at the conference by D. T. Thompson from work performed at the Johnson Matthey Technology Centre by D. R. Coupland, M. L. Doyle, J. W. Jenkins, J. H. F.

Notton and R. J. Potter, on rods returned by Fleischmann and Pons from their Utah laboratory. The results showed that a number of elements including platinum, silicon and lithium had been deposited on the surface of the palladium during the electrolysis in heavy water. The unique role which could be played by lithium in these experiments was indicated both by temperature programmed hydrogen absorption/desorption profile measurements and by electrochemical investigations, together with a time of flight SIMS experiment which indicated a possible reduction in the Li^6:Li^7 ratio found on the surface of an active rod (5).

The production of 30 per cent excess heat from experiments using a palladium cathode and a palladium anode, thus avoiding the possibility of platinum deposition on the cathode, were reported by A. De Ninno and co-workers from ENEA, Frascati, Italy.

With regard to the key factor of achieving the maximum deuterium:palladium ratio, interesting results were reported by T. Sano, T. Terasawa, T. Ohi, and S. Nezu of IMRA Material R and D, Kariya, Japan. These results showed that alloying with silver or cerium markedly reduced hydrogen:palladium loading ratios, but neither annealing nor swaging of pure palladium samples produced a significant effect.

Conclusions

The production of He^4, neutrons and tritium from cold fusion experiments indicates the nuclear origin of the phenomena. The size and reproducibility of the excess enthalpy effect continue to be under study in laboratories in many parts of the world, and the focus of the current effort is in Japan. One key requirement for the observation of the excess heat effect, that is a high deuterium:palladium loading ratio has been proposed and supported by experimental results. This is not the only significant variable, however, and many others are under investigation, and the effect cannot yet be reliably reproduced on demand. The mechanisms producing these effects are as yet poorly understood, although many theories were advanced at this conference, and the reason for the disparity between the quantity of nuclear particles and the excess heat recorded seems to indicate that the results of more than one effect are being observed. However, significant progress should soon be made now that increased funding is available in Japan. D.T.T.

References

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3 Anon., *Platinum Metals Rev.*, 1989, **33**, (2), 54

4 S. E. Jones, E. P. Palmer and J. B. Carr, *Nature*, 1989, **338**, 737

5 D. T. Thompson, *Platinum Metals Rev.*, 1990, **34**, (3), 136

Platinum-Aluminide Coatings

The improvement in environmental resistance that platinum-aluminide coatings can impart to some of the nickel-base superalloys used by the gas turbine industry has resulted in much interest in combinations of these materials. Now a further paper by investigators at the King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, and at Rolls-Royce, Bristol, England, reports on the effect of substrate composition on the oxidation behaviour of selected platinum-aluminised nickel-base superalloys, with particular emphasis on the thermal stability of the coating and on microstructural features of the surface scale (H. M. Tawancy, N. M. Abbas and T. N. Rhys-Jones, *Surf. Coat. Technol.*, 1992, **54/55**, (1–3), 1–7).

Platinum-aluminide coatings were applied to polycrystalline, directionally solidified and single-crystal superalloy rods before they were oxidised in still air at temperatures of 1000 and 1100°C. The microstructures were characterised by analytical electron microscopy, scanning electron microscopy and X-ray diffraction. Interdiffusion between the surface coatings and the substrates occurred at both temperatures. Variations in the protective nature of the coatings were believed to result from the outward diffusion of elements from the substrate. Refractory and reactive elements appeared to have the most significant effects. The beneficial and adverse effects of these elements are discussed. It is concluded that although the refractory elements tend to degrade the protective nature of the scale developed on the coating, the presence of the reactive elements can outweigh these adverse effects.