Fleischmann and Pons report new direction to cold fusion experiment

by Carol White

Because the cold fusion experiment has proven to be so extremely difficult to reproduce, there has been an unfortunate tendency for a good deal of research money to be allocated simply to establish irrefutable evidence that the phenomena exist. It is therefore extremely welcome news that cold fusion discoverers Martin Fleischmann and Stanley Pons are proceeding with a whole new series of experiments to establish precisely what the results are of running a palladium cell at the boiling point for a period of three months. This is in keeping with their experimental philosophy, always to push an experiment as far as possible to maintain extreme conditions over an extended period of time.

In the past, as they have frequently reported, they have observed large "bursts" in heat production, but they were always both episodic and unpredictable events. Furthermore, it is very difficult to accurately measure heat at temperatures near the boiling point. At the Third International Conference on Cold Fusion in Nagoya, Japan in December 1992, the two researchers showed videos of four cells in which the water rapidly boiled away. Fleischmann and Pons estimated then that they had produced almost 4 kilowatts/cm^3 of excess power in the 10-minute period of rapid boil-off. They did this on the basis of their calculations of how much heat would have been necessary to evaporate that much water from the cell over such a short time.

As they pointed out at the time, this was no substitute for accurate calorimetry, but it was as close as they could get at that time, to any reasonable estimate. Now, after more than a year-long effort to design a cell which would not boil out immediately and which would allow calorimetry at temperatures in the neighborhood of 100°C, they report an encouraging success. They have designed a cell which they hope to keep boiling for a three-month period, which can now function for more than four days at a time.

Getting a functioning distillation cell is the second step of an eight-stage program which the two experimenters have designed to run over a four-year period. (Stage one involved specifying a cell which provides reproducible excess heat at room temperature. As a point of comparison, normal laboratory hot fusion requires a temperature of well above 100 million degrees centigrade.) After this stage has proven successful, the next six will involve successive doubling of the size of the cell.

Such scale-ups are problematic because they introduce more strain on the material from which cracking can occur. Deuterium, which finds its way into such cracks, will normally leak back out into the environment without becoming active. Another obvious danger is the possibly explosive nature of unplanned heat bursts.

New cell design

Their new cell is designed so that water that is evaporated through boiling is then recondensed such that the latent heat of condensation can be measured as the vapor is re-liquefied. To do this, they needed to totally redesign the configuration of their cell. They have stayed away from the kind of closed cell design used at Stanford Research Institute, because of dangers inherent in stresses to which they are deliberately subjecting the system. Therefore, they do not need to deal with the problems of recombining hydrogen and oxygen, which are dissociated during electrolysis, and they can regularly refill the cell with fresh water.

In the past, Fleischmann and Pons have used a Pyrex glass cell, which lost heat to the environment through radiation; in this instance they have designed an aluminum cell, and heat loss occurs for the most part through simple conduction. In order to diagnose what is occurring throughout the experiment, they have two calorimeters in the cell, rather than one. One is a normal setup which allows them to record the temperature within the cell and calibrate it in order to determine the amount of heat gain or loss; the other is specially designed to measure just the latent heat of condensation.

Again they are using a very small calorimeter, with a volume of approximately .04 cm^3. Because the design is so new and tricky, it is impossible for them to assert how much excess heat they may really be producing, but the indications are that the range of excess heat production is as high as 50% over more than four days.

There are many reasons why it is important to be able to operate a cold fusion cell at temperatures over the boiling point: One is that the higher the temperature of the cell, the more efficient is the heat transfer necessary for any future application of the process of cold fusion as an energy-producing technology. This follows simply from the Carnot cycle.

But there are more profound, scientific questions involved.

The palladium-hydrogen system has been studied intensively for over 50 years. This follows from the need to understand problems which emerge from hydrogen corrosion, for example, in nuclear reactors; from interest in studying processes for separating light water (H_2O) from heavy water (D_2O), in which the heavy hydrogen isotope, deuterium, substitutes for ordinary hydrogen; and from a number of allied technical studies. Thus the behavior of palladium- (and deuterium-) hydrides is apparently well-known; yet this is not so in the regimes at which the phenomena associated with cold fusion occur. Furthermore, the bulk of the studies have been carried out in conditions in which gas is directly introduced to the cell rather than through electrolysis, where the interface between the electrolyte and the electrode plays an important role.

For example, for cold fusion to occur repeatably, it is desirable to reach a ratio of 100% between the deuterium and palladium atoms as closely as possible, which is known as the loading ratio. Fleischmann and Pons have also postulated that increasing the temperature at which the experiment occurs may actually increase the rate of production of excess heat. This is a thoroughly heretical assumption, within the framework of what is known about the system, because the reaction is believed to be exothermic.

In an exothermic reaction, heat is given out as the hydrogen forms chemical bonds with palladium. Conversely, if the palladium-hydride is then heated, it will tend to release hydrogen back into the environment. In an endothermic reaction, heat is needed to further a chemical reaction, and that reaction is reversed when the temperature is lowered. It could be the case, under certain circumstances, that in an electrolysis experiment, even though it occurs exothermically, deloading is inhibited at high temperatures; however, it may be that a phase transition can be induced at high temperatures at high loadings, so that the reaction now becomes endothermic.

The answer is yet to be determined, but it is of enormous importance, because if that is the case, then it should eventually be possible to operate the cells at higher temperatures, at still greater efficiencies. It is also possible that the appearance of an endothermic phase shift occurring is deceptive. Fleischmann and Pons think not, but they are not prepared to rule out other explanations.

One explanation might be that at high temperatures, in particular, various chemicals which are normally imbedded in the walls of the cell will be released into the electrolyte, and then onto the electrodes. In an aluminum cell, such as the new one that Fleischmann and Pons are using, alumina would collect, whereas, in silicon cells, it would be silicate. It is conceivable—though unlikely—that such a coating would help to seal in the hydrogen or deuterium at high temperatures, even though the palladium-hydride was still being formed exothermically. It is also possible that the cell is operating exothermically, but that high loadings are achieved because this is an electrolysis rather than gas-loading experiment.

The existence of such a phase transition, if true, might help to explain some of the anomalies which make it so difficult to understand what actually may be occurring in the experiment, not only because it would be endothermic, but also because it seems likely that something like a phase transition must be occurring to account for the very ability of the deuterium nuclei in the palladium to come close enough to allow them to penetrate each other. As it is, the probability of fusion occurring under room temperature by ordinary calculations, in the normally observed face-centered cubic palladium lattice, is extremely low: 10^{-45}.

Cold fusion and hot fusion

The low rate of production of tritium and even lower incidence of the release of neutrons is one indication that cold fusion is very different from hot fusion.

In a cold fusion experiment, the measured heat is sometimes as much as a billion times too high in terms of the amount of fusion which can be identified by the production of either of these nuclear ashes—tritium or helium-3—which should be produced when two deuterium nuclei fuse together.

In the expected reaction, when the two nuclei fuse together, either an excess proton or an excess neutron would be sloughed off, so that the new nucleus would contain either one proton and two neutrons (tritium) or two protons and one neutron (helium). These would be formed in approximately equal amounts. In cold fusion, however, the ratio is overbalanced by more than a million times in favor of the production of tritium. This is useful in ensuring that the reaction will occur under favorable conditions, because it shields the surface of the palladium (the negative electrode, or cathode) from platinum, which might otherwise form on it from the positively charged platinum anode.

On May 31, ABC News's popular early morning broadcast "Good Morning America" featured an excellent eight-minute segment on cold fusion, including an interview with Drs. Fleischmann and Pons, and Eugene Mallove, editor of a new magazine *Cold Fusion*. During their interview, Fleischmann and Pons made public the news about their new experiment. However, as they emphasized on the broadcast, and repeated in a later conversation with this reporter, their results are still only tentative. There are many steps before they will be confidently able to confirm that these cells have actually produced excess heat and how much.