Skepticism Grows Over Cold Fusion

The difficulty of reproducing a claim of room-temperature fusion has caused some scientists to dismiss it; chemists and physicists are tending to line up on different sides of the issue

SOME WERE CALLING IT the "Woodstock of chemistry." In a large arena at the Dallas Convention Center, more than 7000 chemists got firsthand details of what—if it is true—would be perhaps the greatest discovery of the century: cold fusion. Codiscoverer Stanley Pons, an electrochemist at the University of Utah, stood before his peers and explained the procedure that he says produces fusion at room temperature. It was the first time that a large group of scientists has had a chance to grill Pons on his work, and the tone of the questions indicated that many of the chemists there were beginning to accept the results.

On the other hand, many scientists in other fields remain skeptical, and that skepticism is growing as all but a few of the attempts at verification produce negative results. In general, it seems that physicists are much less convinced of the reality of Pons' results than are chemists, and fusion physicists are not convinced at all.

The U-1 Utah tokamak. *Fusion in a test tube?*

University of Utah

The fusion furor began 23 March when Pons and Martin Fleischmann of the University of Southampton, England, claimed they had produced a sustained fusion reaction in a simple electrochemical cell consisting of little more than a palladium and a platinum electrode placed in a glass test tube filled with heavy water. A voltage applied across the electrodes splits the water into oxygen and deuterium—a heavy isotope of hydrogen—and the deuterium is absorbed into the palladium electrode. There, Pons and Fleischmann say, it undergoes fusion. As proof, they offer measurements of heat generated by the cell as well as the observation of a few neutrons, which are by-products of fusion.

At first sight, the experiments seem unbelievable, yet Pons and Fleischmann are well-respected electrochemists, and there have been a few tentative reports of confirmation. One of the more embarrassing episodes in the fusion saga came when Georgia Tech researchers announced on 10 April that they had detected neutrons from fusion cells, then retracted the claim three days later. It seems that their neutron counters had a previously unnoticed sensitivity to heat, and the "neutron measurements" were little more than temperature readings.

Researchers in Hungary, Russia, and at Texas A&M University have all seen some of the same effects claimed by the Utah scientists. Something unusual does seem to be happening inside the cells, but it is still not clear whether it is fusion or some unexpected chemical effect.

The chemists at the ACS session seemed willing to accept that it might indeed be fusion, and they were tickled pink it was chemists who discovered it. When ACS president Clayton Callis introduced the session, he enthused over the tremendous potential of fusion as an energy source and detailed the problems physicists have had achieving it. "Now it appears that chemists may have come to the rescue," he said, and the arena broke into applause and laughter. Some chemists have pointed out that it was two chemists, Otto Hahn and Fritz Strassmann, who discovered nuclear fission after physicist Enrico Fermi made the initial observations but could not explain them.

Harold Furth, the token nuclear physicist at the ACS session, said he is not convinced fusion is producing the heat Pons has seen. "Certain experiments really need to be done," said Furth, director of the Princeton Plasma Physics Laboratory. "That's the only thing that will galvanize the nuclear physicists of this nation to look into it."

Many physicists, however, do seem willing to believe that a small amount of fusion is taking place in the palladium electrode, especially in light of independent experiments done by Steven Jones at Brigham Young University. Jones has performed careful measurements of neutrons produced in cells similar to those of Pons and Fleischmann and concludes that there is a tiny amount of fusion. Such a little bit of fusion is not too difficult to fit in with current understanding of what might go on inside a metal, but it cannot account for the observed heat.

George Chapline, a theoretical physicist at Lawrence Livermore National Laboratory, said he and two colleagues have a theory that explains the observed production of neutrons (see box), but it is up to chemists to explain the heat. "The ball is back in the chemistry ball park," he said. "The neutron observations are not indicative that something revolutionary is going on."

The different postures of physicists and chemists about the fusion claims reflect their differing areas of expertise. The attitude of many fusion physicists seems to be: "We know what fusion looks like, we know what it takes to produce fusion, and this isn't it. If something is there, it must be a chemical reaction." Fusing two deuterium atoms generally requires a great deal of energy to overcome the mutual repulsion between their nuclei, and it is difficult to see where this energy is coming from. Further, deuterium fusion generally produces neutrons and other by-products, and although neutrons have been detected in some experiments, the number is one-billionth of what would be expected given all the heat that Pons and Fleischmann claim to have measured.

The chemistry side of the debate is: "We know what chemical reactions look like, and there is no possible chemical reaction that could be producing this much heat. It must be fusion." Pons told the Dallas audience that one cell which has run for hundreds of hours has produced 50 megajoules of heat—several orders of magnitude more than could be produced by any known chemical reaction, he said, even if all of the matter in the cell were consumed by the reaction, which it is not. Allen J. Bard, an electrochemist at the University of Texas who also spoke at the session, said, "The lesson that more heat is produced than can be accounted for by burning all the setup is starting to get through to me. The effects are starting to add up to a fairly strong case."

Media accounts have emphasized the simplicity of the experimental setup, and from this perspective it may seem strange that scientists have such a hard time understanding what happens inside the electrode. In fact, a palladium electrode with deuterium diffused through it is a much more complicated environment than a high-temperature, high-pressure plasma. No one really knows what is going on.

One of the most intriguing comments at the ACS session came when Pons was asked why he has not reported results of control experiments done with water instead of heavy water. "A baseline reaction run with water is not necessarily a good baseline reaction," he said. When asked to elaborate, Pons intimated he had performed the experiment with water and had seen fusion. "We do not get the expected baseline experiment," he said. "We do not get the total blank experiment we expected."

To many, Pons' oblique reference to fusion taking place in normal water suggested that perhaps something other than fusion is causing the heat. As *Science* went to press, however, a report from the University of Washington claimed to have seen signs of fusion in deuterium cells and not in water cells. Physics graduate students Van Eden and Wei Liu used a mass spectrometer to detect tritium, a by-product of fusion, and said they detected tritium when heavy water was used but not with regular water.

Whatever is going on, it has the chemistry community worked up like nothing in recent memory. Talk in the halls during the ACS meeting invariably turned to fusion, and scientists were comparing the fusion frenzy to the excitement around the discovery of high-temperature superconductivity 2 years ago, when 3500 physicists at an American Physical Society meeting turned a hastily scheduled session on superconductivity into the "Woodstock of physics."

Pons summed up the different approaches of chemists and physicists with a single slide. In an earlier presentation Furth had shown a slide of Princeton's tokamak, a mammoth machine covered with pipes and wires that is still a couple of years away from a break-even fusion reaction. Pons in turn flashed a picture of his own—a simple jury-rigged device in a plastic dishpan that supposedly creates a sustained energy-producing fusion reaction. "This is," he deadpanned, "the U-1 Utah tokamak," and the chemists loved it.

■ ROBERT POOL

Fusion Theories Pro and Con

In the third week after the announcement of cold fusion claims by Stanley Pons and Martin Fleischmann, theories proposed to explain the "fusion in a jar" were propagating faster than a runaway nuclear reaction. At the same time, it seemed that even more theories were being suggested to explain why the claims are wrong.

The most publicized theoretical explanations came from the Massachusetts Institute of Technology, which announced that it has filed patent applications in connection with theories proposed by physicist Peter Hagelstein. Although theories themselves cannot be patented, they may lead to practical applications that can be. As quoted in the *Washington Post*, Hagelstein argues that deuterons fuse inside palladium to form helium-4 plus a great deal of energy, but few neutrons—a suggestion that has been made by several other scientists who have not filed for patents.

Birgitta Whaley of the University of California at Berkeley has proposed a "boson screening" theory to explain how deuterons (deuterium nuclei) inside a palladium electrode can get close enough together to fuse. Deuterons are bosons, a class of particles that interact with one another in a special way. In particular, Whaley suggests that the deuterons in the electrode undergo "boson condensation," a process in which all the deuterons assume their lowest possible energy level. Then, Whaley hypothesizes, the energy of repulsion between the deuterons is mostly screened out so that "the particles can get on top of each other despite the repulsion." Whaley's fusion theory manuscript is one of several submitted to *Science*.

At least as popular as theories to explain cold fusion are theories to explain how the results come from something besides fusion. Several scientists have suggested that a recombination of deuterium and oxygen is creating the heat in the "fusion cells." The electrolysis taking place in the cells separates heavy water into deuterium molecules and oxygen molecules, which can come back together and give off heat. It is hard to believe, however, that such good electrochemists as Pons and Fleischmann could have mistaken something as elementary as the heat of recombination for an entirely new physical process.

Another popular explanation is that the cells are acting as batteries, storing energy and releasing it. Since Pons and Fleischmann run current through the cells for weeks or months before they begin producing heat, the argument is that the cells still have not been shown to produce more total energy than has been inserted into them. Pons says the cells turn out too much heat for this to be a possibility.

Three physicists at Lawrence Livermore National Laboratory have submitted a paper to *Physical Review Letters* suggesting that the small amount of neutron production observed in the cells is caused by cosmic ray muons that become embedded in the palladium electrode. It is well known that muons will help deuterons to fuse at a slow rate, and the researchers suggest that the fusion cells enhance the fusion rate enough that muon-catalyzed fusion becomes observable.

Lee Hansen of the chemical engineering department at Brigham Young University argues that the heat observed by Pons and Fleischmann could be produced by a number of ordinary, non-fusion processes that might be easily overlooked. There might be, for instance, chemical reactions that have not been accounted for. Or the wires carrying the current into the cells might also carry heat into them. A third possibility is that the heat is coming from a Peltier junction effect, in which a current flowing across a junction between two metals causes heat to flow between between them. "I'm really so certain that it will turn out to be one of the more mundane effects," he said, "that I haven't even set up the experiment myself." ■ R.P.