Coming in from the cold

Cold fusion may have a bad reputation, but the materials system in which it was allegedly achieved has plenty still to recommend it.

Over the past 30 years, the term 'cold fusion' was seldom voiced without the hint of a sneer. It refers to the claim made in early 1989 by electrochemists Martin Fleischmann and Stanley Pons that they had achieved the fusion of deuterium nuclei in a test-tube, driven by nothing more than conventional electrolysis of (heavy) water with palladium electrodes. Working at the University of Utah, Fleischmann and Pons claimed to have seen their electrochemical cells sometimes produce more energy (heat, measured by calorimetry) than was put in to electrolyse the ionic solution. They also reported the detection of characteristic 'fingerprints' of fusion, such as emission of gamma rays and neutrons.

'Reported', that is, in the loosest of senses. Aside from a sketchy paper published in the *Journal of Electroanalytical Chemistry*[1], the Utah researchers released almost no details of their experiments or results beyond what they presented in their press conferences. This frustrated efforts to replicate the work, which began as soon as the news broke. Failures could be dismissed on the grounds that they had followed a different protocol. The frenzied attempts at replication worldwide testified to the magnitude of the goal. If nuclear fusion were possible with cheap benchtop equipment, rather than the vastly expensive plasma reactors such as tokamaks that had been failing to show net energy gain for decades, the urgent search for inexpensive and environmentally friendly energy generation would be over. It quickly became evident, however, not only that the Utah experiments could not be reliably repeated, but also that there were serious questions about what Pons and Fleischmann had really done — whether, for example, their 'fusion gamma rays' had the right energy, and whether they had run control experiments with ordinary rather than heavy water.

By the end of 1989, most scientists had decided that cold fusion was a mirage: that, regardless of what the Utah researchers (and some other groups) had allegedly seen, there was no reason to believe that fusion could be dependably or usefully produced this way. Cold fusion came to be seen as a classic example of what American chemist Irving Langmuir had dubbed 'pathological science': a striking but irreproducible claim on the borders of detectability.

Fleischmann and Pons at the time of their claimed cold fusion discovery. Credit: Bettmann/Getty

A few regarded this dismissal as premature. They remained convinced (or at least open to the idea) that the electrochemical studies had glimpsed an effect worth pursuing. Such studies of 'low-energy nuclear reactions', as the topic was rebranded, have largely been confined to the fringes. But a paper published in May in *Nature*[2] might bring them back into the mainstream.

Initiated by Matt Trevithick of Google in Mountain View, California (which supplied the funding), this project brings together teams led by Yet-Ming Chiang at the Massachusetts Institute of Technology, Curtis Berlinguette of the University of British Columbia, and Thomas Schenkel of the Lawrence Berkeley National Laboratory. They have revisited the electrochemical experiments and also explored a different approach to fusion that uses deuterium plasmas surrounding charged palladium wires.

At the core of the project is an undeniable truth: the palladium–hydrogen system involves some fascinating materials chemistry. Palladium has long known to be capable of absorbing large amounts of hydrogen, which sits at interstitial sites in the metal lattice. A favourite rationale for the original claims of cold fusion was that the loading of hydrogen in the electrodes, promoted by the electrochemical force, became great enough for the hydrogen (that is, deuterium) nuclei to overcome their Coulombic repulsion and fuse into helium. While this never seemed very plausible, it's true that palladium can host hydrogen at least up to a 1:1 stoichiometry and, in theory at least, perhaps twice as much as that if the hydrogens occupy tetrahedral rather than octahedral sites.

There are plenty of reasons to be interested in such behaviour, regardless of whether it can promote fusion. In particular, palladium hydride could be useful for hydrogen storage, needed, for example, in technologies such as fuel cells that would use hydrogen as a 'green' fuel. Further research might show how to attain the very highest hydrogen loadings theoretically feasible in the material. Metal hydrides have also recently drawn interest because of the possibility that they will support superconductivity at high temperatures[3,4]. Electrochemical manipulation of hydrogen, meanwhile, could be useful for chemistry. Berlinguette's team has already developed a palladium membrane system for electrocatalytical hydrogenation (and deuteration) of organic molecules[5].

Schenkel's experiments on plasmas, meanwhile, did produce evidence of nuclear fusion[6]. This is not entirely surprising: the very high electrical fields involved mean that deuterons from the surrounding plasma are accelerated towards the metal target, where they undergo high-energy collisions. The amount of fusion seen so far is minuscule, and nowhere near the level needed to be of practical value in energy generation. All the same, it exceeds theoretical predictions by two orders of magnitude, for reasons not yet understood.

Whether the link to 'cold fusion' in this project amounts to much more than an advertising gimmick can be debated; at any rate, the association with such a murky past could be a mixed blessing. But the new work shows that, whatever really happened in Utah 30 years ago, there is plenty still worth investigating in this unusual and potentially fertile field of metal hydrides. ❐

Published online: 23 October 2019
https://doi.org/10.1038/s41563-019-0530-1

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