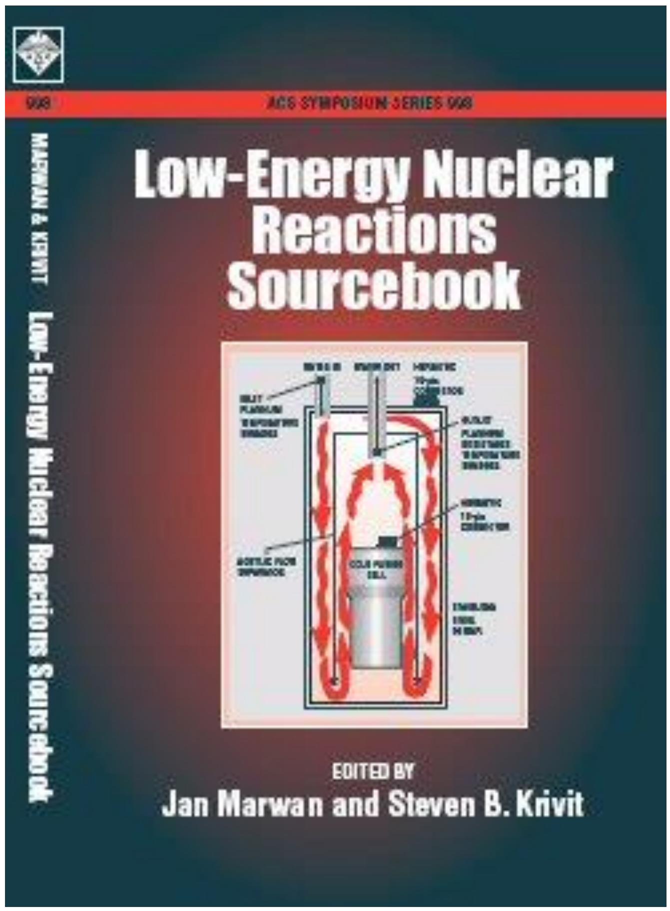
March 8, 2023

Retrospective on "*[Chapter 1 Low Energy Nuclear Reactions: The Emergence of Condensed Matter Nuclear Science](#)*," Published in *Low-Energy Nuclear Reactions Sourcebook (Vol. 1)* , Jan Marwan, Steven B. Krivit, editors, American Chemical Society/Oxford University Press, Washington, D.C., ISBN 978-0-8412-6966-8



Summary

I submitted this chapter to Oxford University Press in December 2007. The book published nine months later, in August 2008. In retrospect, parts of this chapter remain helpful; parts do not.

2008 was a turning point for me. That's the year I stopped calling the research "cold fusion" and instead referred to it as low-energy nuclear reactions, LENRs. On Aug. 20, 2008, the same month that the book published, I spoke at the American Chemical Society national conference. In my talk, I identified eight experimental facts that conflicted with the hypothesis of “cold fusion.”

The "Cold Fusion" Hypothesis

According to the "cold fusion" hypothesis, two deuterium nuclei, each having positive charges, overcome their electrostatic repulsion (Coulomb barrier) at room-temperature, with sufficient energy to allow the strong force to draw the nuclei together and fuse the two deuterium nuclei into one helium-4 nucleus. This reaction is represented by the equation ***D+D —> 4He + 24 MeV / 4He***. It postulates that, for every 24 MeV of heat produced, one helium-4 atom is produced.

In the 2008 ACS conference, I reported that the nuclear products observed in LENRs, as well as their pairings, energies, and probabilities, were inconsistent with the nuclear products, their pairings, energies, and probabilities observed in thermonuclear fusion. The experimental evidence nevertheless showed that unfamiliar nuclear reactions were taking place in LENRs.

Some researchers in the field were also using the term Condensed Matter Nuclear Science. It's a good term, but it is not a direct replacement, in many cases, for LENRs.

From about 2000 to 2010, LENR scientists who believed in the hypothesis of "cold fusion" had asserted that Michael McKubre and his team at SRI International had produced experimental proof of "cold fusion." Two years later, in 2010, I found that McKubre had fabricated the specific portion of that experiment that purportedly proved LENRs were fusion. However, his group's actual measurements of excess heat and helium-4 production appear to be valid and confirmatory of a new nuclear phenomena.

Introduction

On Page 4, I wrote, "Two general groups of reactions exist in the field. In addition to the heat-producing reaction discovered by Fleischmann and Pons, the field encompasses a set of experiments that demonstrate transmutation with heavy elements that are not all fusion reactions." I learned this bifurcation from the first-generation LENR researchers who believed in the "cold fusion" hypothesis. I later learned that it was an artificial separation.

By the year 2000, thanks to experiments from Yasuhiro Iwamura at Mitsubishi Heavy Industries, LENR experiments revealing heavy-element transmutation results could no longer be ignored by scientists who believed in the "cold fusion" idea. They could no longer brush off the transmutation results as mistakes and delusions, as they had done years earlier with John Bockris, George Miley, and Tadahiko Mizuno.

Some of the first-generation LENR researchers who believed in "cold fusion" went so far as to engage in character assassination, telling me unflattering things about Bockris and his work.

The heavy-element transmutation results were one of several data sets that conflicted with the hypothesis of "cold fusion." So rather than admit the obvious, scientists who believed in the idea of "cold fusion" created the idea that the experiments which showed heavy-element transmutations were caused by one nuclear process and that experiments which showed excess heat were caused by "cold fusion."

Department of Energy 1989 Cold Fusion Review

On Page 4 of this chapter, I wrote about the 1989 Department of Energy "Cold Fusion" review. Although information that I wrote is accurate, this section is contextually obsolete because I later obtained thousands of pages of deeply buried internal documents used for that review. Nobody, including me, had an accurate depiction of this history until 2014, when I obtained these documents from Richard Garwin, a member of that review panel. My book *Fusion Fiasco* is exclusively about this first year in "cold fusion" history.

I wrote, "The members of the panel either failed to recognize or failed to communicate the possibility that some other novel nuclear process may have been at work." In fact, panel members chose not to recognize the evidence they had in their possession that indicated a novel nuclear process.

Fleischmann-Pons Excess Heat

On Page 5, I wrote about the public confusion about the fundamental discovery of electrochemists Martin Fleischmann and Stanley Pons: an inexplicable thermal phenomenon producing heat at rates far beyond what is possible from ordinary chemistry.

I did not write much about excess heat in my 2016 books. My focus was on direct nuclear products. The section in this 2008 chapter, however, beginning with the heading "Public Confusion" provides an accurate, concise review of the concept of excess heat, the measured excess heat that validated the Fleischmann-Pons experiments, and basic concepts of calorimetry.

Dominant Products

On Page 7, in the section "What Is Known," I wrote that "the dominant byproducts of the palladium-deuterium experiments are excess energy, in the form of heat, and helium-4. Eight months later, I had enough information to indicate that that statement was not accurate. That statement, specifically the claim of dominant products, is a reflection of the "cold fusion" hypothesis, which LENR scientists like Michael McKubre and Edmund Storms had repeated often. The only person I know who openly challenged them was Eugene Mallove, the former editor of *Infinite Energy* magazine.

Without a complete assay of all nuclear products and effects in a LENR experimental system, determining which nuclear products are dominant in LENRs is not possible. Therefore, this section in the 2008 chapter is invalid and irrelevant:

> Half a dozen independent reports show a very close correlation between the excess heat and the evolution of helium-4. This correlation matches the energy that would be expected as a release from the fusion of two deuterons.

McKubre's M4 experiment was identified by first-generation LENR researchers as the best of those reports — until I reported how McKubre had fabricated the alleged quantitative correlation. Mallove had warned me that such claims were "on thin ice" but he did not know that McKubre had actually fabricated the correlation.

This sentence in the 2008 chapter is also invalid and irrelevant:

> Remaining discrepancies between the expected amount of helium-4 and the observed amount are accounted for by the expected absorption of helium into the palladium in the experiments.

This false belief was a component of McKubre's M4 fabrication. Helium-4 does not permeate through intact, defect-free metal at room temperature.

Required Threshold Parameters for Excess Heat

On Page 7, in the section "Required Threshold Parameters for Excess Heat," I wrote:

> Michael McKubre of SRI International was one of the first to identify three essential parameters that, when obtained, produce excess-heat reactions repeatedly.

I did not sufficiently emphasize in the section that, although people performing electrolysis-type experiments understood these three parametric requirements, they did not always understand how to create the physical conditions that would enable the attainment of the parametric requirements. Had these scientists known, they would have been able to repeat the excess-heat phenomenon on demand.

Normal Water Reactions
On Page 11, I prefaced the section called "Normal Water Reactions" with this qualifier:

> Many researchers in the field are skeptical of light-water excess-heat claims.

I included that qualifier because of the political pressure I received from some scientists in the field who did not want to concede that normal hydrogen produces LENR effects. This chapter, like all chapters in this book, was peer-reviewed. In my estimation, even though I was a co-editor of the book, I did not expect that this chapter would make it through peer-review without this qualifier. My co-editor handled the peer-reviews of the book. I handled the production.

Use of normal hydrogen as a reactant additionally disproves the "cold fusion" hypothesis. The thought leaders in the field had attempted to convince me that normal-hydrogen LENR experiments lacked credibility and they encouraged me to ignore such data. I recognized their behavior as pathological skepticism. Therefore, I thought it was all the more important to mention that normal-hydrogen experiments produced results in LENRs.

I put that qualifier in the paper to soften the blowback I would receive. Three years later, when Andrea Rossi made his fantastic (but fraudulent) claims of a commercial-scale "cold fusion" reactor using normal hydrogen as a reactant, the "cold fusion" proponents discarded their bias against normal hydrogen and welcomed Rossi with open arms.

Obsolete sections are highlighted

Chapter 1

Low Energy Nuclear Reactions: The Emergence of Condensed Matter Nuclear Science

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Introduction

It is helpful to begin with an introduction of relevant terminology. Low energy nuclear reactions (LENR) is the chosen term to describe the observations in the field of condensed matter nuclear science (CMNS).

Initially, the media labeled the field "cold fusion." However, that is a less-than-optimal name for this research. One of the primary reasons is that the term cold fusion implies that these reactions were just a "colder" form of conventional thermonuclear reactions, which they are not. This has resulted in significant confusion. As well, other nonfusion reactions have been clearly observed in addition to the possible fusion reaction.

The field is in its 19th year. It was introduced in 1989 by Martin Fleischmann and Stanley Pons at the University of Utah. The field evolved from their research, which used an electrolysis experiment with the elements palladium and deuterium.

Fleischmann and Pons' first significant experiment occurred in the spring of 1985, when they informally reported that, overnight, an experimental cell had exhibited significant anomalous behavior that included the melting and partial vaporization of the palladium cube used for their cathode. They also informally reported the partial destruction of their lab bench, a small hole in the concrete floor and damage to the fume hood.

The two electrochemists worked as quietly as possible for several years and, after using up their own research funds, applied to the Department of Energy for a grant. This led to the eventual public disclosure of their work at a press conference on March 23, 1989.

Fleischmann and Pons discovered an electrochemical method of generating nuclear energy, in the form of heat, in a way that was previously unrecognized by nuclear physicists. Much drama and unscientific reaction followed the announcement and the unexpectedness of their claim. The claim flew in the face of hot fusion research, which had yet to demonstrate a commercially viable product, and thus triggered no small amount of disbelief and hostility.

To the surprise of many people, the research in the field has shown consistently positive, coherent sets of results. Progress has been slow, but the research shows considerable promise.

Low energy nuclear reaction research composes a new field of science. It does not belong exclusively to chemistry, physics, or any other previous scientific discipline. Much is known about the science, but many significant facts remain unknown.

Two general groups of reactions exist in the field. In addition to the heat-producing reaction discovered by Fleischmann and Pons, the field encompasses a set of experiments that demonstrate transmutation with heavy elements that are not all fusion reactions. This is another reason for referring to the field as low energy nuclear reactions rather than cold fusion.

The LENR term does not imply that the potential energy output is low; rather, it distinguishes the research from high-energy nuclear physics, which involves either the use of high temperatures or energetic devices such as particle accelerators and magnetic confinement fusion machines.

The First Department of Energy Cold Fusion Review

An early significant milestone in the history of LENR occurred in the first year of what was then called cold fusion. The president of the United States in 1989, George H.W. Bush, sought the guidance of Glenn T. Seaborg, a Nobel prize winner in chemistry and former chairman of the Atomic Energy Commission, to counsel the White House on the highly public matter of cold fusion.

Seaborg was convinced that the whole idea was entirely wrong. Nevertheless, he recommended that Bush form a committee to review the idea. He predicted that the committee would decide that the idea was not a valid form of science and not a worthwhile application of government funding.

Bush followed Seaborg's advice, and through the Energy Resources Advisory Board, an investigative panel was formed. John Huizenga, a professor of chemistry and physics at the University of Rochester, a major government-funded hot fusion research facility, was selected to lead the panel. Huizenga, later wrote in his book *Cold Fusion: The Scientific Fiasco of the Century* that cold fusion was entirely a mistake.

Not surprisingly, six months later, the panel concluded that cold fusion did not produce fusion products in the expected quantities and proportion. Therefore, the panel said, the experimental results reported by Fleischmann and Pons were entirely mistaken.

The members of the panel either failed to recognize or failed to communicate the possibility that some other novel nuclear process may have been at work.

Public Confusion

During the confusion about cold fusion in the following years, many people lost sight of the developing science.

The first significant milestone occurred in July 1990 with the publication of Fleischmann and Pons' seminal paper, "Calorimetry of the Palladium- Deuterium-Heavy Water System," in the *Journal of Electroanalytical Chemistry* (*1*).

They reported very strong results: Nineteen runs registered positive excess heat, with an average of 586 milliwatts. Fourteen control runs showed negative excess heat, averaging -1.3 milliwatts. Their detection limit was 1 milliwatt, and their signal over background ratio was 450-1. (Fleischmann and Pons provided an explanation for the slight negative readings in their paper.)

Later that year, University of Minnesota professor Richard Oriani published the first corroboration of Fleischmann and Pons' excess heat claim in the December 1990 issue of *Fusion Technology* (*2*).

A common public perception is that the Fleischmann-Pons claims were disproved because others failed to replicate their experiment. This is a gross misunderstanding that not only presents a lesson to historians and observers of this subject but provides insight to future explorers in other fields of science. As the example of the cold fusion episode shows, failure to replicate does not equal disproof of a claim.

The key question to consider is whether critics found an explicit error of protocol, procedure, or analysis in the Fleischmann-Pons work. With the exception of flawed gamma/neutron data, which was a minor component of their laboratory evidence, the Fleischmann-Pons 1990 paper and that of Oriani were never refuted successfully in the formal, scientific literature.

In July 1992, the Wilson group from General Electric did its best to find fault with the Fleischmann-Pons 1990 *Journal of Electroanalytical Chemistry* paper; however, the group failed to disprove it. In fact, the effort effectively, and likely unintentionally, provided a third-party confirmatory analysis. Wilson concluded that the Fleischmann and Pons cell generated 40 percent excess heat, amounting to 736 milliwatts, more than 10 times the error level associated with the data.

Excess Heat

Excess heat is the fundamental observation and claim of Fleischmann and Pons. In electrochemistry, when a researcher applies a certain amount of electrical energy to an electrolytic cell, he or she expects a commensurate amount of heat to come out of the cell based on Joule heating.

Fleischmann and Pons found that, in their cold fusion cell, more heat was coming out of their experiment – on the order of 1,000 times more – than could be explained by normal chemistry.

Calorimetry

Part of the challenge of this field has always been the acceptance of the phenomenon of excess heat. Calorimetry was a relatively obscure art, and the levels of heat in these experiments were, and still are, typically registering in the milliwatt range, though occasional experiments have registered in the tens of watts. Experiments performed at such low power require the utmost care and precision with the instrumentation and data analysis. These issues gave rise to much skepticism and doubt in the early period of this history.

However, many researchers responded to the distrust that many critics had with Fleischmann and Pons' isoperibolic calorimetry and initiated experiments using far simpler methods. Isoperibolic calorimetry is not intrinsically complex, however, it becomes so when a mixture of radiative, conductive, and convective heat flows must be accounted for.

One alternative method which became popular in the early 1990s is the use of the Seebeck-type enclosure. This method uses a fully enclosed thermally insulated container in which an experiment is placed. Many thermocouples are embedded within the walls of the enclosure, and they measure temperature both within the container and outside it. These data are collected and used to determine the heat generated from the experiment.

Another method uses mass-flow calorimetry (Figure 1). These systems are practically more difficult but they have the advantage of being much easier to calibrate and errors are easier to recognize. In this method, the experiment is fully enclosed within a chamber, and a recirculating fluid surrounds this chamber or uses a closely contacting heat exchanger to extract heat. The temperature of the fluid is measured when it enters the chamber as well as when it exits the chamber. The difference in the temperatures along with the flow rate can be used to accurately calculate the heat coming from the reaction.

One disadvantage of the mass-flow calorimeter system is that it has the effect of cooling an experiment. Researchers have found that, when an experiment starts to generate heat, the heating effect, if allowed, provides positive feedback and amplifies heat generation from the reaction.

LENR Materials

Deuterium, in the form of heavy water, as well as palladium, as used by Fleischmann and Pons in 1989, still appear to be the essential materials used in most LENR research.

However, many experiments also have been performed with deuterium gas and palladium, as well as with normal water and nickel and, occasionally, other metals, too. An important question remains unresolved: To what extent is palladium consumed in the reactions, if at all?

What is Known

Many facts are now understood about these reactions, and several other essential mysteries remain. Somewhere on the order of five hundred researchers from a dozen nations have been active in the field, most since it began. Three thousand papers exist on the subject, a third of them in peer-reviewed journals. Together, they represent many thousands of experiments.

The dominant byproducts of the palladium-deuterium experiments are excess energy, in the form of heat, and helium-4. LENR reactions contrast with conventional nuclear fusion, in which helium-4 is the least dominant byproduct, which, when observed in conventional nuclear fusion is always accompanied by gamma radiation. LENR reactions do not produce gamma radiation at anywhere near the levels seen in conventional nuclear fusion.

Half a dozen independent reports show a very close correlation between the excess heat and the evolution of helium-4 (*3-7*). This correlation matches the energy that would be expected as a release from the fusion of two deuterons. Remaining discrepancies between the expected amount of helium-4 and the observed amount are accounted for by the expected absorption of helium into the palladium in the experiments.

On very rare occasions and in low but statistically significant proportions, tritium and helium-3 (thought to be decay from tritium) have been observed in LENR experiments. Tritium has been measured both in the gas phase and in the electrode.

Required Threshold Parameters for Excess Heat

Michael McKubre of SRI International was one of the first to identify three essential parameters that, when obtained, produce excess heat reactions repeatedly. By far the most significant of these is the ratio between deuterium and palladium atoms within a cathode. This is also called the loading ratio.

In general, a minimum deuterium to palladium loading ratio of 0.90 is required to achieve the excess heat effect. Loading ratios lower than 0.90 sometimes produce the excess heat effect, but it becomes increasingly unlikely below this threshold. A 1-1 ratio, along with the other required parameters, appears to yield consistently excess heat.

In most, but not all cases, many days, if not weeks, were required before researchers could get bulk palladium loaded to these levels. This long wait was one of the crucial facts that appeared to be unknown to most of the people involved in early replication attempts, and a major culprit for most early failures to replicate. In most of these failed attempts, people did not even bother to measure the loading. In addition, they were doing their electrochemistry in such a way that they would never have obtained the required loading. More recently,

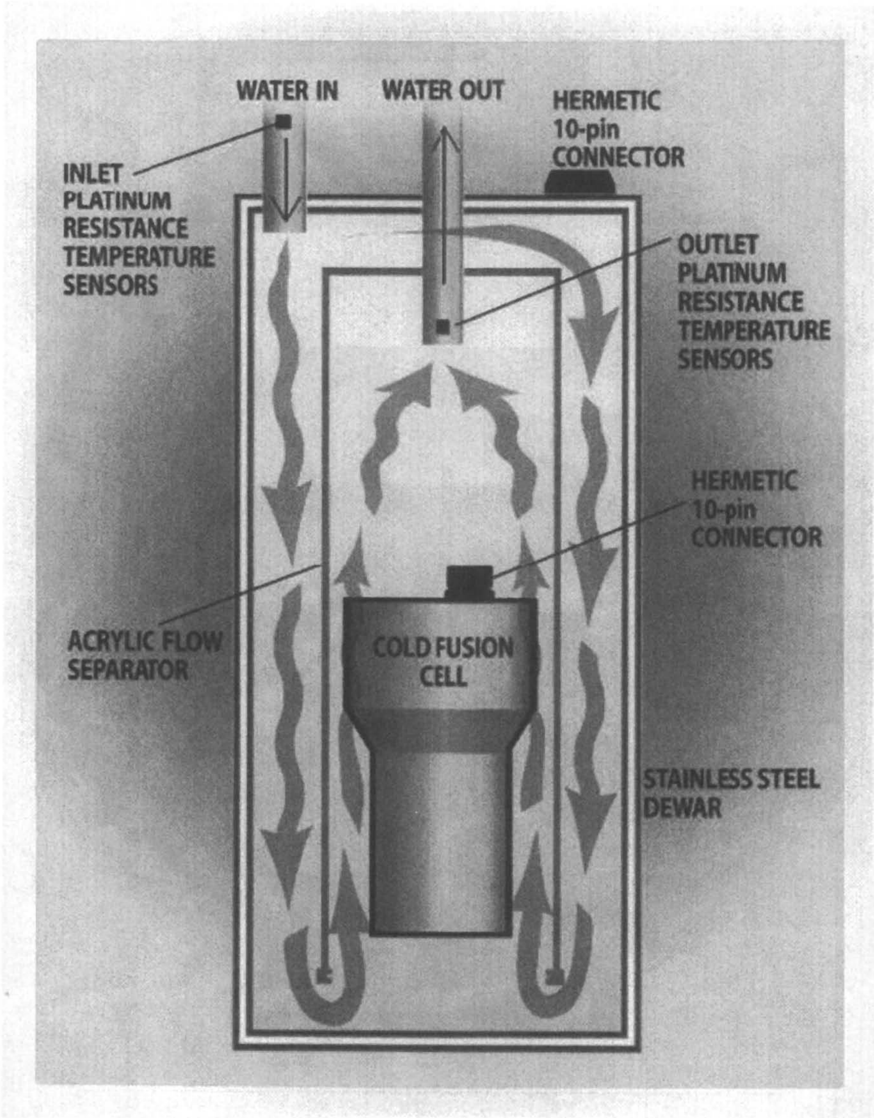

Figure 1. SRI-International Type Mass-Flow Calorimeter

researchers have found ways to obtain the required loading quite early, without the long wait.

The second threshold requirement is a relatively high current density through the cathode surface, a minimum of 250 mA/cm2. However, this parameter varies somewhat based on cathode size and geometry.

The third requirement calls for some sort of a dynamic trigger, a stimulus which will cause the electrochemical cell to enter a state of disequilibrium. For example, Fleischmann and Pons' dramatic 1985 reaction occurred after the current was increased abruptly from 0.75 amperes to 1.5 amperes. Additional known triggers that others have used are the application of temperature changes, low-power (30 mW) laser excitation, external electrical fields, and external magnetic fields.

Power and Energy Release

Numerous energy-releasing reactions have been reported, though reproducibility is inconsistent. Several of the recorded reactions have indicated relatively large capacities for power and energy release.

One of the earliest was in 1992, when Akito Takahashi of Osaka University observed 130 watts of excess heat. Edmund Storms attempted and successfully reproduced the experiment using some of the same palladium used by Takahashi.

The potential energy density of LENR experiments is difficult to predict because the mechanism is so far from being sufficiently understood. However, some attempts have been made to quantify the volumetric energy density relative to the volume of the palladium cathode. These estimates indicate that LENR might have a very high energy density, even higher than that of the uranium fuel rods used in fission reactors.

Fleischmann and Pons (*8*) and Giuliano Preparata (*9*) published papers showing volumetric power densities in the range of 10^4 and 10^5 watts/cm^3 based on single and nonreproduced experiments. More conservative estimates from McKubre suggest that the maximum rates presently being observed are in the range of 10^3 to 10^4 watts/cm^3. The estimate may even be conservative because the fuel consumed is believed to be deuterium, not palladium.

Excess Heat after Boil-Offs

Several rare excess heat reactions have been reported in which the reactions appear to reach some kind of critical point and run autonomously, long after the input current is turned off or disconnected.

Many of these reports are anecdotal, and none has been repeatable. Only a few have been precisely instrumented and observed because the reactions have come as a surprise.

In 1992, Fleischmann and Pons did not replenish the electrolyte in a cell and allowed it to run dry. When the electrolytic circuit was broken as a result of the absence of the electrolyte, the cell continued to give off excess heat for three hours. A Kel-F plastic support melted, indicating temperatures above 300°C (*8*). Fleischmann and Pons videotaped this experiment.

At an MIT symposium in the early 1990s, Lawrence Forsley of JWK Technologies Inc. reported on a cell in which the electrolytic current was turned off momentarily. The cell had been running at 80°C, at equilibrium, for one day. After the abrupt power interruption, the cell temperature shot up to 125°C, cracked a plastic insulator, and boiled off all the electrolyte – at a power input far below that required for Joule heating.

In the early 1990s, Tadahiko Mizuno of Hokkaido University reported the boil-off of a cell initially running 24 watts of input power that, in its last eight days with current turned off, boiled more than 15 liters of water. Mizuno had placed the cell in a bucket of water after disconnecting it from the power supply. According to Mizuno's calculations, during the time the cell was turned off, it evaporated enough water to account for 8.2 x 107 joules of energy (*10*).

Other researchers to report excess heat after boil-offs are Giuliano Mengoli of the Instituto di Polarografia and Melvin Miles of the U.S. Navy's China Lake Weapons Center.

A recent boil-off event occurred in a U.S. military laboratory in the spring of 2007. However, the researchers have decided not to report it publicly; instead, they are struggling to find how to make it repeatable.

Low Energy Nuclear Transmutation Reactions

Transmutation of heavy elements has been observed in LENR experiments as early as 1990, largely through the work of John O'Mara Bockris at Texas A&M University.

A significant body of work in transmutations has been reported by George Miley, director of the Fusion Studies Laboratory at the University of Illinois, Urbana, and former editor of the American Nuclear Society's journal *Fusion Technology*.

In 2003, he performed a survey, "Review of Transmutation Reactions in Solids"(*11*). He reported LENR transmutation evidence obtained by 15 independent laboratories. Three general combinations of reactions have been described: fusion of various light elements, fusion of light elements with heavy elements, and fission of heavier elements. The resultant elements are often reported as anomalous isotopic ratios, adding support to the hypothesis that such elements are created by LENRs (*12*).

A rigorous set of LENR transmutation experiments has been performed by Yasuhiro Iwamura et al. at Mitsubishi Heavy Industries in Japan. These experiments cause deuterium gas to pass through a multilayered substrate containing palladium and calcium oxide. On the front side of the substrate, atoms from the new element are found in place of the elements initially deposited there.

Iwamura et al. have reported three groups of transmutation reactions: cesium into praseodymium, barium into samarium, and strontium into molybdenum (*13-16*).

Normal Water Reactions

The role of normal water, sometimes inaccurately called light water, is perplexing as it applies to LENR research. Many researchers within the field are skeptical of light-water excess heat claims. In typical heavy-water experiments, introduction of light water to a cell containing some heavy water will poison and halt the excess heat effect. However, some researchers have been investigating anomalous reactions with normal water and nickel and reporting excess heat.

One such group was that of physicist S. Focardi, which published an experiment in *Il Nuovo Cimento* (then the journal of the Italian Physical Society) that produced an average excess heat of 18 watts for 319 days with an integrated energy of 600 MJ (*17*). One author of that paper, Francesco Piantelli, reported later that the introduction of deuterium into their nickel-hydrogen experiment terminated the excess heat effect.

It is possible that the introduction of deuterium into hydrogen experiments as well as the introduction of hydrogen into deuterium experiments may poison the experiments.

Nuclear Evidence

LENR experiments produce various forms of nuclear radiation. Types of prompt radiations detected include x-ray (*18, 19*), gamma ray (*20*), and energetic particles (ions and electrons) (*21, 22*). All of these radiations are emitted at very low intensities so they are difficult to measure in LENR experiments. Furthermore, most x-rays and energetic particles rarely travel outside of a LENR experiment so, typically, a detector for them must be located inside the experimental vessel.

Some of the most significant in-situ particle detection has been observed in experiments and replications of work originating from the U.S. Navy's Space and Naval Warfare Systems Command Center in San Diego, California (*23*).

Pamela Mosier-Boss, Stanislaw Szpak, and Frank Gordon developed such a method using solid-state nuclear track detectors, also known as CR-39 plastic track detectors, and the co-deposition LENR method.

Other researchers have detected helium-4 and helium-3 (*3-7, 18*) and tritium in other experiments (*24-26*).

A variety of anomalous physical effects on the cathodes has been observed, such as the melting and vaporization of palladium in experiments. None of these effects can be the result of Joule heating, because the energy inputs are too low (*1, 4, 27*). Other changes to the cathodes include unusual morphological deformations (*28*), craters (*10, 28*), and "hot spots" (*29*).

Environmental Issues

As was known from very early in the history of LENR research, all of the observed reactions appear to lack significant high-energy neutron and gamma ray emissions. As a result, this new science shows promise as the possible basis for new types of nuclear power systems that do not need complex containment or disposal systems.

Low levels of radiation are found in at least some of these reactions, but this radiation is usually absorbed directly and promptly within the experiments. Consequently, they offer hope of practical applications that do not pose major health hazards or compromise the environment.

In addition to the lack of high-energy radiation, the experiments do not appear to produce any greenhouse gases or long-lived radioactive decay emissions.

Numerous LENR Methods

Fleischmann and Pons' original method used electrolysis of heavy water, a method which has been used worldwide many times to achieve excess heat.

However, a wide variety of methods has been reported to produce both excess heat and anomalous nuclear products. These include other variations of electrolysis, pressurized deuterium gas, gas-electric field discharge, gas diffusion, plasma electrolysis, ion bombardment, acoustic and mechanically induced cavitation, nanostructured or finely divided palladium, and even biological mechanisms.

No Lack of Theories

The proposed theories for the anomalous effects are numerous and therefore, unfortunately, pose great difficulty for someone trying to develop a coherent understanding of the underlying mechanisms.

Most of the LENR theories incorporate the idea that fusion and/or fission processes are primarily responsible for the observed experimental results. These theories invoke the strong interaction as the underlying physical mechanism.

An alternative approach proposed by Allan Widom and Lewis Larsen of Lattice Energy LLC, which is considered with great skepticism by many researchers within the field, tries to understand and predict LENR phenomena by postulating the creation of extremely cold neutrons that facilitate low energy nuclear reactions. This theory, unlike other LENR theories, uses the weak interaction and does not need to explain how to overcome the Coulomb barrier repulsion problem because neutrons have no charge.

Concluding Remarks

The challenge presented by Fleischmann and Pons was unexpected and surprising, to say the least, for most nuclear experts of the day. Most researchers who initially attempted this difficult work gave up within six weeks of its introduction. Only a few careful, persistent researchers had early success. Their firsthand experience gave them the confidence to trust what they saw in their own labs.

However, during the 1989 Department of Energy cold fusion review, only one member of the panel was willing to entertain the validity of the discovery. Dr. Norman Ramsey, Nobel laureate and professor of physics at Harvard University, was selected as co-chair of the panel, though the historical record (*30*) suggests that this title granted him little authority or influence. To see that his dissenting view was included, he had to threaten to resign from the panel unless the following preamble was included in the Department of Energy report: "Ordinarily, new scientific discoveries are claimed to be consistent and reproducible; as a result, if the experiments are not complicated, the discovery can usually be confirmed or disproved in a few months. The claims of cold fusion, however, are unusual in that even the strongest proponents of cold fusion assert that the experiments, for unknown reasons, are not consistent and reproducible at the present time. However, even a single short but valid cold fusion period would be revolutionary."

Thanks to the work of Fleischmann and Pons, and those who followed them, a complex and important chapter in scientific history is evolving for all the world to witness.

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