Cold Fusion for Dummies

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The field and the name "Cold Fusion" started in 1989 when chemists Stanley Pons of the University of Utah and Martin Fleischmann of the University of Southampton reported the production of excess heat in an electrolytic cell that they concluded could only be produced by a nuclear process. [1, 2] This claim was based an extraordinary amount of energy being produced. Over the years, additional claims for unexpected nuclear reactions have been reported based on energy and nuclear product production. These results were and continue to be replicated by some laboratories, but not by others. Consequently, the reality of the claims is frequently rejected and remains a subject of controversy. [3] A few people even take the extreme position that this is an example of pseudoscience. [4] Accurate histories of the controversy can be found in two recent books on the subject. [5, 6]

Three basic questions need answers. Why are some people so hostile to the claims; why should a person believe the claims are real; and why should anyone care if the claims are real or not?

Let's explore each question in order, but first some background is required.

Nuclear reactions are normally initiated using neutrons or high energy elemental particles. The process taking place under these conditions is well known and is the basis for the field called nuclear physics. When a plasma is used to produce fusion between two deuterons, the process is called "hot fusion". This reaction is known to emit neutrons and produce tritium in equal amounts. Past experience and established theory have demonstrated that nuclear reactions can not be initiated without application of significant energy because the charge barrier between nuclei, called the Coulomb barrier, can not be overcome any other way. Neutrons can pass through the barrier because they do not have a charge. However, neutrons are normally made by processes that are well understood and they are not known to exist as free particles in ordinary materials.

Profs. Pons and Fleischmann, and others since then, propose that nuclear reactions can be initiated without extra energy or application of neutrons just by creating a special solid material in which deuterium is present, the so called nuclear active environment (NAE). When fusion of deuterium takes place in this environment, they claim the main product is ordinary helium rather than neutrons and tritium. In addition, subsequent studies claim that more complex nuclear reactions can occur that are able to convert one element into another, a process for which the Coulomb barrier is even greater than between deuterium nuclei. Conventional theory can not explain such claims and the observations have been difficult to reproduce. These two facts are used to reject the claims. In addition, some claims can be explained as being caused by error or unrecognized prosaic processes. As a result, many scientific journals will not publish papers on the subject and the US Patent and Trademark Office is very reluctant to issue patents based on such claims.

In spite of these objections, study of the effect has continued over the last 16 years [7] , and now involves laboratories in eight countries. Evidence for a variety of nuclear processes have been presented including transmutation, fusion, and fission. For this reason, the terms "Low Energy Nuclear Reactions" (LENR), “Chemically Assisted Nuclear Reactions”(CANR), and "Condensed Matter Nuclear Science" (CMNS) are now used to describe work in this area of study. Many theories are being explored in order to identify a possible mechanism, although none have yet gained acceptance by conventional science. Many international conferences have been held and papers on the subject are regularly presented at American Physical Society, American Nuclear Society and American Chemical Society meetings in the US and at conferences in other countries. A website is available which provides most of the information on the subject. As a result, much more is known about the process than was available when initial skepticism developed. Consequently, it is worthwhile to examine some of this new information before reaching an opinion about the reality of the claims.

Excess heat production is an important characteristic of the effect and has created the most criticism. This is understandable because calorimetry [8] can be a difficult measurement and it is not well understood by most scientists. In addition, the original measurements, as well as a few other studies, were based on complex and unconventional methods for measuring energy. Nevertheless, evidence based on well designed and well understood methods is now available. For example, McKubre et al. [9] at SRI spent millions of dollars developing a state of the art flow calorimeter, which was used to study many samples that showed production of significant anomalous energy. Over 36 similar studies [10] have observed the same general behavior as was reported by these workers. Of course, all of the positive results could be caused by various errors. This possibility has been explored in many papers, which have been reviewed and summarized by Storms [11] . Although a few of the suggested errors might have affected a few studies, no error has been identified that can explain all of the positive results, especially those using well designed methods. At this time, it is safe to conclude that anomalous energy is produced regardless of its source. This conclusion is important regardless of whether nuclear reactions are the source or not and needs to be acknowledged independent of the controversial nuclear explanation.

For a nuclear reaction to be proposed as the source of energy, it is necessary to show that the amount of energy is related to the amount of a nuclear product. Until the work of Miles et al. [12, 13] , various unexpected nuclear products had been detected but never in sufficient amounts. Miles et al. showed that the helium was generated when anomalous heat was measured and that the relationship between the two measurements was consistent with the amount of energy known to result from a d-d fusion reaction. Since then 5 other studies [14] have observed the same relationship. Of course, some of the detected helium could have resulted from helium known to be in normal air. Also, the heat measurements could be wrong in just the right amount every time the measurements were made. Even though these possibilities might explain one study, it is unlikely that such an advantageous combination of error can explain all of the results, especially when active efforts were made to reduce these errors. At the present time, heat and helium appear to be related, but the nuclear process producing helium is still to be determined.

Besides helium, other nuclear products are detected in much smaller quantities. Early in the history, great effort was made to detect neutrons, an expected nuclear product from the d-d fusion reaction. Except for occasional bursts, the emission rate was found to be near the limit of detection or completely absent. This fact was used to reject the initial claim. It is now believed that the few observed neutrons are caused by a secondary nuclear reaction, possibility having nothing to do with the helium producing reaction. Tritium is another expected product of d-d fusion, which was sought. Too little tritium was detected so that once again the original claims were inconsistent with expectations. Nevertheless, the amount of tritium detected could not be explained by any prosaic process after all of the possibilities had been completely explored. The source of tritium is still unknown although it clearly results from a nuclear reaction that is initiated within the apparatus. Various nuclear products normally associated with d-d fusion also have been detected as energetic emissions, but at very low rates. Clearly, unusual nuclear processes are occurring in material where none should be found.

Finally, the presence of heavy elements having unnatural isotopic ratios and in unexpected large amounts are detected under some conditions. These are the so called transmutation products. Work in Japan [15-19], through new methods, has opened an entirely new aspect to the phenomenon by showing that impurity elements in palladium, through which D 2 is caused to pass, are converted to heavier elements to which 2D, 4D or 6D have been added. The claims have been replicated in Japan and similar efforts are underway at the Navel Research Laboratory.

Although initial observations were made using an electrolytic cell in which the active material was palladium and the source of fuel was D 2O, many other methods are now claimed to produce the same kind of nuclear reactions. In addition, the active material can be several other materials besides palladium, all of which need to have a unique structure and generally are present with nanosized dimensions. Many theories are being explored, a few examples of which are:

- Reduction of the Coulomb barrier by electrons being concentrated between the nuclei,
- Conversion of deuterium into a wave structure that ignores the Coulomb barrier,
- Creation or release of neutrons within the structure, which add to nuclei that are present,
- Creation of clusters of deuterons that interact as units,
- Involvement of phonons to concentrate energy at the reaction site and carry away the released energy,
- Models showing that the Coulomb barrier is not as high as previous thought if certain conditions are present, a variety of which have been explored.

All of these mechanisms are only possible because a regular lattice of atoms and electrons is available and because the normally applied large energy does not hide these subtle processes. Models based on experience using high energy and/or a plasma, in which this regular array of atoms is not present, are not applicable. In summary, belief in the reality of the claims is now based on an increasing number of replications, on a clear relationship between heat production and appearance of nuclear products, and on a growing understanding of the process.

If the claims are real, regardless of their explanation, what are the consequences to society? Like “hot fusion”, which is being supported through ITER, cold fusion is proposed to produce energy from the fusion reaction. Unlike “hot fusion”, cold fusion produces only helium without radioactive products. Like “hot fusion”, the main source of energy is deuterium, which is present in small concentration in all water. As a result, the supply is almost unlimited. “Hot fusion” requires huge installations in order to be practical. In contrast, “cold fusion” is expected to be practical on a small scale, perhaps as small as conventional batteries. Consequently, if cold fusion is made to work on a commercial scale, mankind can expect to have pollution-free power, without the risk posed by radioactive products, for many centuries. Isn’t this possibility worth giving the claims the benefit of the doubt? A new book available on line explores these consequences in more detail. [20]

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(Most citations are available in full text at www.LENR-CANR.org)

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ENDNOTES

A **plasma** is a very hot collection of isolated ions. It is considered by some to be a fourth form of matter because it is so unlike a gas, a solid or a liquid.

A **neutron** is a particle found in the nucleus of atoms that has no electric charge. When it is present outside of the nucleus, it quickly decays into an electron and a proton.

Tritium is a radioactive isotope of hydrogen , the nucleus of which is made up of one proton and two neutrons. Because its half life is only 12.3 years, the amount in the normal environment is very small.

The **Coulomb barrier** occurs because all nuclei have a positive charge that is equal to their atomic number. Therefore they repel one another.

The **helium** being made contains two neutrons and two protons in its nucleus, i.e. ordinary helium.

The process of **converting one element into another is called transmutation**, with fusion being a special subset of this process.

The **countries** in which the process is being actively studied are China, Japan, Italy, Israel, Russia, Ukraine, France, and the United States.

The **International Conference** on Cold Fusion (ICCF) has now been held 12 times in six countries.

The **Web site is www.LENR-CANR-org**. Many other sites can be accessed through links on this site.

Calorimetry is the method used to measure the amount of power or energy associated with heat. The method has many variations and potential errors, but has reached very high standards over the more than two centuries of development.

This work shows that some of the observed nuclear reactions involve dimers of deuterium that easily enter the nucleus of heavy elements many times to produce a sequence of products.

These **other new methods** include ion bombardment, exposure to D 2 gas, sonic implantation, and low energy plasma discharge. Many variations of these methods have been explored, some with success.

The concept of **phonon** is used to describe how energy can be transported in a lattice by vibration of atoms or electrons.

The international effort to explore “**hot fusion**”, now located in France, has spent over 50 years and over 20 billion dollars to generate more energy than is required to run the machines. So far this effort has failed to make more energy than is used in the process. In addition many of engineering conditions required to make the effort practical have not been explored.

The hot fusion process is expected to produce a large quantity of tritium and large amounts of **radioactive products** created by neutron activation of construction materials.