LITHIUM FISSION TO FUSE DEUTERIUM?

Billings Brown
Salt Lake City, UT 84109

ABSTRACT

The excess enthalpy generated in some Pd/LiOD/D_2O electrochemical cells can be explained by invoking fission of the ^{6}Li followed by T(D,n)α in a chain reaction. Initiation occurs haphazardly by a cosmic ray. Initiation on demand might be accomplished by use of a commercial neutron source. Tritium and neutrons formed are largely utilized in maintaining the chain.

INTRODUCTION

The excess enthalpy generated by some (but not all) Pd/LiOD "cold fusion" experiments has been attributed to classical deuterium fusion:

$$^2H + {}^2H \rightarrow {}^4H^* \begin{matrix} \nearrow {}^3H + n \\ \searrow {}^3H + {}^1H \end{matrix}$$

Often invoked is the assistance of muons, heavy electrons, ion plasma, channeling, crystal fracture, or other exotic physics. This "frontal fusion assault" has not generated any practical solutions.

Science has become splintered and compartmentalized since Plato. In the pursuit of $E = mc^2$ we have chemistry versus physics, hot fusion vs. cold, fission vs. fusion, classical physics vs. exotic. Like the three blind men describing an elephant, each theorist with his or her own narrow training and experience views the problem uniquely. Perhaps a more global, interdisciplinary approach is needed. What follows combines electrochemistry, heterogeneous catalysis, fusion and fission technology and organic chemistry (for the concept of chain reactions).

It is Lithium Fission

Many of the reported experimental results in the Pd/LiOD system can be explained by postulating lithium-6 fission followed by deuterium-tritium fusion. This is a chain reaction set (1,2):

$$^6\text{Li} + \text{n} \rightarrow {}^3\text{H} + {}^4\text{He} + 4.79\ \text{MeV} \quad (1)$$

followed by

$$^3\text{H} + {}^2\text{H} \rightarrow \text{n}\ (14.05\ \text{MeV}) + {}^4\text{He}\ (3.54\ \text{MeV}) \quad (2)$$

Reaction (1) is unique in yielding no gammas [3]. Little tritium from reaction (1) is observed because it is used up in reaction (2). Few neutrons from reaction (2) are observed because they are used up in reaction (1). The deadly radiation hazard predicted by some Pons detractors is much reduced.

The change in the ^{6}Li/^{7}Li ratio would be so slight as to escape measurement. Murphy [4] detected no

change in ^{6}Li or ^{7}Li. Bush [5] however cites Thompson as detecting ^{6}Li depletion.

The thermal cross section for reaction (1) is 945 barns [1] falling to 2.75 barns at 0.258 MeV and to 0.6 barn at 6 MeV. Thermalizing of teh neutrons is no problem in the D_2O solvent. Much enthalpy would be transferred to the solvent in this process.

The reaction cross section for reaction (2) is 5 barns at 0.1 MeV [1], falling to 1 millibar at 0.01 MeV.

Thus reactions (1) and (2) are both probable considering the energy released in each.

Chain Initiation

It is proposed that each of Pons' experiments [14] was initiated by a random cosmic ray (or a bremstrahlung):

$$\gamma\ (2.2\ MeV) + {}^{2}H \rightarrow {}^{1}H + n \qquad (3)$$

Gai [6] measured 1.8 ± 0.4 gamma counts hr^{-1} in his fusion experiments, or one per 10^{3} s.

This suggestion could be readily tested by employing a commercially available neutron source (from the fission industry) to initiate reaction (1). Such sources include ^{252}Cf (2 Mev), Pu-^{9}Be(4 MeV), Po-^{9}Be and ^{241}Am (available from a home smoke alarm?).

Incubation Period

Pons [14] claimed 2 to 3 weeks (10^{6}s) to "charge" or "load" his 4 mm diameter Pd rods with deuterium [7]. Lewis [8] reached "charge" in 0.l22 mm rods in 20 minutes (2 x $l0^{3}$s). These different times are consistent with a diffusion mechanism.

Pons waited 10^{6}s for a reaction to occur. None of his detractors exhibited so much patience. **Their touted negative results are meaningless**.

Neutron Sinks

Neutrons are needed to maintain the chain reaction. But everybody's apparatus contains neutron sinks and leaks. Rolison [11] used SIMS to probe the isotopic composition of Pd. She should have looked also for Ag according to

$$^{108}Pd + n \rightarrow {}^{109}Ag\ (12\ barns\ thermal)$$

DeAngelis [12] has suggested another route to silver

$$^{108}Pd + {}^{2}H \rightarrow {}^{109}Pd + {}^{1}H$$

$$^{109}Pd \rightarrow {}^{109}Ag + {}^{0}e\text{-}$$

Any neutrons leaving the cell would encounter first, the boron in the Pyrex cell wall (750 barns), then second, the bath water where the reverse of reaction (3) occurs

$$^{1}H + n \rightarrow {}^{2}H + \gamma \text{ (2.2 MeV, 0.33 barn)} \quad (4)$$

Perhaps reaction (4) is the source of the disputed gamma spectrum.

If neutrons must be conserved to supply reaction (1), maybe a neutron reflector would be useful.

Brown [13] calculated the neutron mean free path and leakage from Pons' apparatus. Leakage from the 0.0122 cm diameter wires used by Lewis [8] and others would have been 97 percent, and no sustained reaction would have been expected. Leakage from the 0.2 to 0.6 cm diameter Pd rods used by Pons [14], Gai [6] and Weismann [10] would have been 30 to 50 percent. Brown's analysis correlates Pons' data at a cell current density of 8 mA cm^{-2} very well. The data at 64 mA cm^{-2} and 512 mA cm^{-2} fare less well.

Surface or Volume?

If ^{6}Li is a reactant, can Li diffuse into the Pd, or does it need to? Lithium does diffuse into aluminum commercially. The diffusivity of lithium in metals is 10^{-4} that of deuterium.

But not even Pons is certain that the nuclear reaction(s) are internal to the Pd. Nobody has measured the internal (BET/porosity) area of the Pd electrodes.

Pons [14] shows a plot of excess enthalpy per volume (w cm^{-3}) vs current density. But a similar plot of enthalpy electrode area (w cm^{-2}) vs current density correlates his data just as well. Further, the fission/fusion might be occurring in the Bruner-Nernst solvent layer which is also under extreme galvanostatic pressure at the test overpotentials used [8].

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ADDENDUM

The Nernst equation [1]

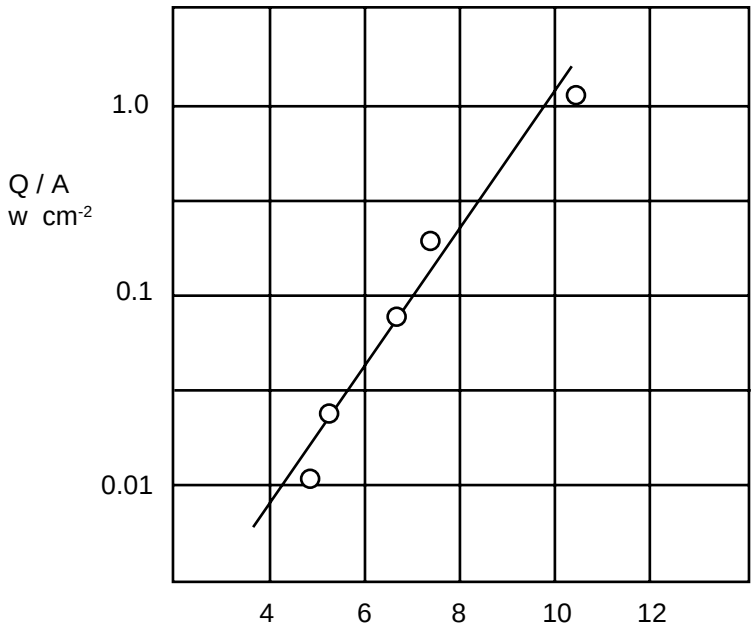
$$E = \frac{RT}{nF} \ln \frac{P_1}{P_2} \quad (1)$$

where E is the open circuit cell voltage, R is the gas constant, T is the absolute temperature, F is Faraday's constant, P_1 and P_2 are related to the thermodynamic ion activity and n relates to the number of electrons transferred. It is the basis for electrochemistry. This equation relates mechanical pressure to electrical pressure or electricity to chemistry.

I cannot find in Pons' publications wherein he has tested his data according to the Nernst equation, although he did discuss its application [2].

The Plot

Pons' data for LiOD with 0.4 cm diameter Pd cathodes are shown platted according to the Nernst equation in the attached Fig. 1. The tacit assumption is made that the excess specific enthalpy generation is proportional to the galvanostatic pressure. Data for other diameter cathodes and/or sulfate anion are more scattered but follow a similar trend. The y-axis of the plot is specific excess power BASED ON Pd ELECTRODE SURFACE AREA computed in w cm^{-2}. The x-axis is the applied voltage to the cell.



Two conclusions can be drawn from the figure:

· Pons' data are correlated and supported by the classical Nernst equation, and
· Electrode surface area (not volume) is important.

In addition, the assumption of QαP appears valid.

Discussion

If the hypothetical fusion reaction (or its proxies)

$$^{2}D + ^{2}D \rightarrow ^{4}He \quad (2)$$

is to be achieved, the competing chemical reaction

$$D + D \rightarrow D_2 \text{ (gas)} \quad (3)$$

must be minimized.

How might this reduction me accomplished? Reaction (3) is catalyzed by the chemically active (high energy) sites on the Pd surface. It is well known since 1905 [4] that poisoning the Pd surface will reduce or eliminate the catalysis.

Pons has never revealed his "special trick" [5] for achieving nuclear fusion (or fission). Based on his data and hints, his trick must be cathode pre-treatment (Pd poisoning). A gold coating would yield the 0.8 volt overpotential reported by Pons [2]. However, his data [3] reflect an achieved overpotential of 1.2 volts.

An overpotential of 0.8 volt in the Nernst equation is equivalent to a galvanostatic pressure of 10^{14} atmospheres. If Pons can achieve his predicted 2.0 volts, the electrode pressure would be 10^{34} atm.

One significant effect of these pressures is to suppress reaction [3]. But what is the effect of such high confinement pressures on nuclear reactions? Does anybody know?

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