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^{4}He Detection In A Cold Fusion Experiment

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Excesses enthalpy consistent only with a nuclear process (deuterium fusion) has been claimed since 1989, even though these results are considered inconsistent with modern nuclear science and have been discarded by the most of nuclear scientists.

We started an experimental programme aimed at probing these issues:

- ✓ Thermal anomalies can be observed only when the concentration x= [D]/[Pd] overcomes a threshold (x=1) [1];
- ✓ This threshold can be easily obtained in a suitably Pd geometry;
- ✓ The thermal anomalies can be started and stopped controlling the experimental procedure;
- ✓ ^{4}He is simultaneously generated, commensurate with the level of the excess enthalpy [2], [3], [4].

Understanding a triple coincidence – the reaching of the threshold of the D concentration in Pd, the appearance of the excess of enthalpy, and the appearance of ^{4}He – is the primary objective of this investigation.

In such a frame the fusion among deuterons occurs within a medium (namely, inside a coherent ensemble of deuteron) and not in vacuo. Thus energy and momentum can be shared among many components of the coherent condensed system (see Mössbauer effect for comparison), allowing in principle a fast cooling of the "hot" D-D compound nucleus and then preventing its splitting. Consequently ^{4}He should be expected as the final product of this newly discovered nuclear fusion.

1. Experimental

The experimental layout consists of a small (8.5 cm^3) electrolytic cell with an anode made of a Platinum sheet and a cathode made of a Pd stripe sputtered on an inert surface. The cell is filled with 5.5 ml of 10^{-4} M LiOD solution. Electrolytic currents in the range 2 - 10 mA were used to load Deuterium into the Palladium lattice. The cell is equipped with a Peltier element in good thermal contact with the Pd cathode in order to record a possible unbalance between the power electrically dissipated into the cell and the power detected. A detailed description of the experimental layout and of the cathode loading technique has been given elsewhere [5], [6].

The gas mixture evolving from the cell contains mainly O_2 and D_2 with a very small amount of ^{4}He. In such conditions the helium analysis by mass spectrometry has posed numerous special problems. The risk of contamination, too, has required special care. To overcome these problems, an innovative “pseudo-static” gas analysis method has been developed. Non evaporable getter (NEG) pumps remove effectively all the non inert components of the gas mixture (especially hydrogen isotopes), whereas noble gases remain in the gas phase. This technique allows us to analyze easily the content of inert gases in the sample as well as to monitor for contamination by comparing the time evolution of different noble gases. We have found it is necessary to avoid cryosorption pumps, as they trap helium erratically in the condensates.

Furthermore, the particular arrangement used in our experiments allows us to sample periodically the gas during the loading phase, without perturbing the electrolytic process at all.

During the measurement, the gas is periodically sampled (at about 40 minute intervals), without influencing the electrolytic process, and sent to a Quadrupole Mass Analyser (QMA); this allows us to check in real-time the ^{4}He content of the electrolytic cell.

In order to have a reference value (a blank experiment) we started the electrolysis keeping the electrolytic current to a very low value (2 - 4 mA) for some hours leaving thus the D/Pd systems “under-critical” at x < 1. We then increased the cell current and consequently the longitudinal voltage, to about 20 Volts. The R/R_0 ratio fell below the value 1.3. That corresponds, according to the well known R/R_0 vs. x curve, to x=1. That, and the excess heat detected in the calorimeter within its response time, signal the onset of the phenomenon. Since we are able now to count the ^{4}He atoms over intervals as short as 40 minutes we can check the coincidence of excess heat production and ^{4}He generation.

2. Results

During a typical experiment we can distinguish four phases (see Fig.1):

1) *Preloading phase*. During this normal electrolysis phase, the output power P_{out} coincides with the power P_{in} supplied by the electrolytic current, the number of ^{4}He atoms is compatible with the background value of the detector. At this time the cold fusion phenomenon is absent and these measurements exclude the existence of systematic errors or artefacts.

2) *Loading phase*. The application of an electrical potential across the cathode makes possible to increase the Deuterium loading over the threshold necessary to observe the phenomenon.

3) *Supercritical phase*. Upon crossing this threshold, “anomalies” appear in the system, namely: a) the temperature of the cathode increases above the previous equilibrium value, signalling a source of enthalpy in the cell; b) a significant deviation of ^{4}He from the baseline is observed from this time onwards

4) *Control phase*. After some hours of cell operation, the cathode potential V_c is switched off: both anomalies a) and b) disappear. ^{4}He yield settles back to the initial zero value, excluding that leakages or permeations have occurred.

3. Conclusions

We have observed ^{4}He production during electrolysis in LiOD solution on a Palladium cathode a factor of about 60 times out of the baseline. Simultaneously, an anomalous enhancement of the temperature measured in the cell was detected. Our calorimetric technique (measuring the average cathode temperature measurement) requires that the system be at thermal equilibrium (or in a succession of thermal equilibrium states). Non thermal (radiative) part of the energy produced in the phenomenon will not be accounted for by the temperature transducer (the Peltier element) if it thermalises out of the cell. Thus, we are able to estimate, at the present time, a lower bound for the produced energy.

The experiments performed so far suggest the following conclusions:

1. The reported production of excess heat and helium demand the overcoming of a critical threshold of D concentration in Pd.
2. The demonstration of the presence of ^{4}He provides evidence that a nuclear process occurred in the cell; a nuclear reaction is therefore obtainable by chemical procedures.
3. Thermal calorimetry can demonstrate the presence of a small amount of excess heat although the only high precision calorimetry would be based on a quantitative evaluation of the ^{4}He.

The above results fit quite well into the theoretical proposal based on standard Quantum Electrodynamics (QED) [7]. We summarize here its main predictions:

1. when the stoichiometric ratio x = D/Pd exceeds 0.7 (at room temperature) D nuclei (deuterons) enter a stationary coherent oscillatory state, whose phase is sharply defined. This state is described by a unique wave function and is able to respond to externally applied electric potentials (and not only to their gradients).
2. when x exceeds 1, the probability that oscillating deuterons reach a distance that might allow the fusion becomes appreciable. As a matter of fact this threshold is not easily reached and this accounts for many of the failures in trying to reproduce the effect.
3. the fusion among deuterons occurs in a plasma within a medium and not in vacuo. Thus energy and momentum can be shared among many components of the condensed system, allowing in principle a fast cooling of the “hot” D-D compound nucleus preventing its splitting. Consequently ^{4}He should be expected to be the final product of this newly discovered nuclear fusion.

In the next stage of the experiments we will try to address the difficulties of thermal calorimetry with the aim of capturing a larger fraction of the excess enthalpy as indicated by the “helium” calorimetry.

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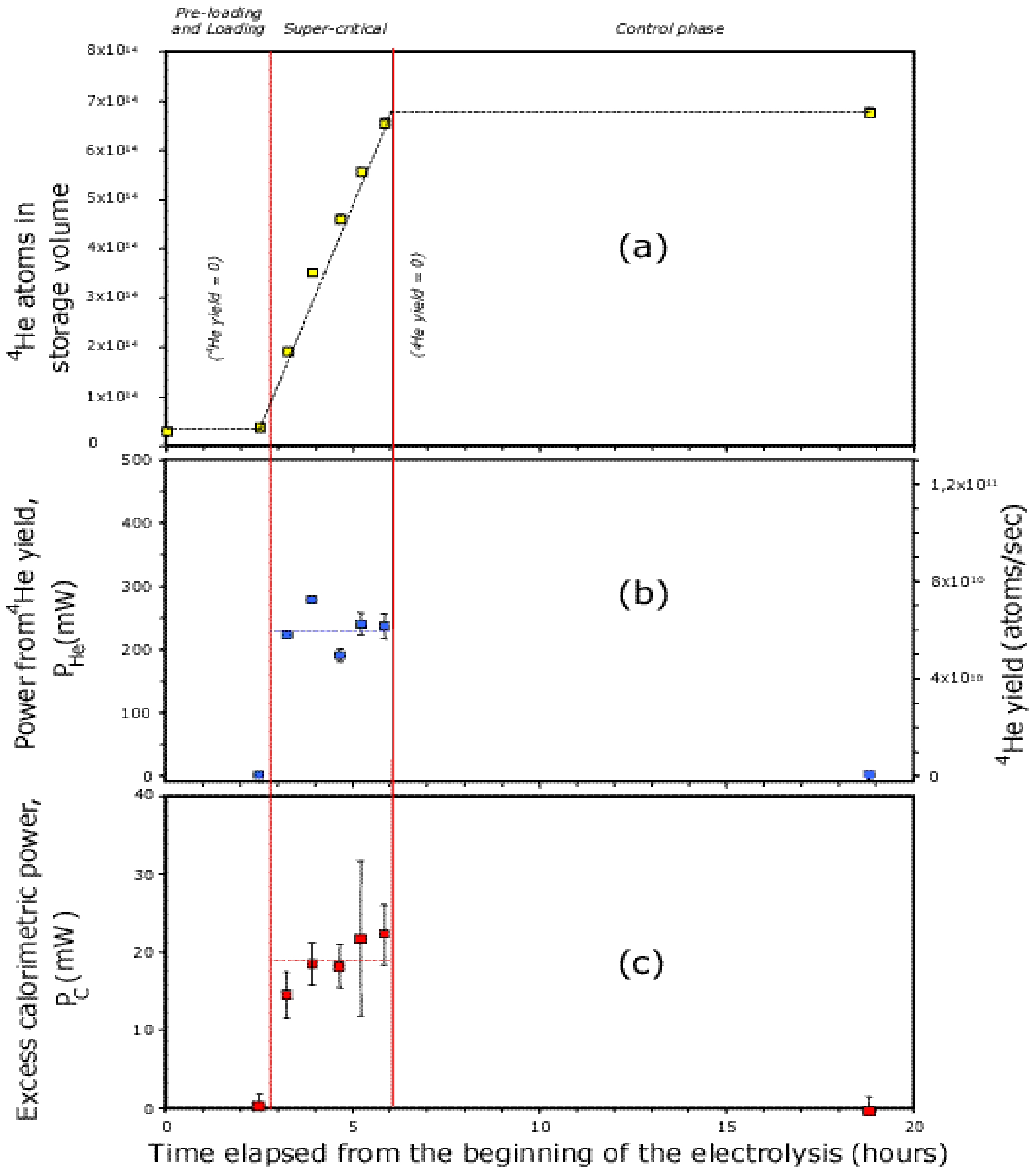

Figure 9

Figure 1 (a) ^{4}He content of the gas mixture inside the storage volume, (b) excess power P_{He} derived from helium yield assuming that 24 MeV are released for each helium atom and (c) average excess calorimetric power P_C in the experiment described in the text. The data are shown as a function of time allowing to check the coincidence.