

## Excerpts from "Development of Energy Production Systems from Heat Produced in Deuterated Metals - Energy Production Processes in Deuterated Metals, Volume 1"

### Introduction

The purpose of the series of experiments described in this section was to determine the conditions under which the phenomenon which gives rise to calorimetrically determined excess power can be initiated and sustained.

Having achieved this goal, a secondary goal was to demonstrate whether or not the excess heat produced, correlated with the production of species from nuclear reactions; the primary nuclear product sought was helium...'

### [Excerpts Regarding Source of Helium From Sample 4]

*Hypothesis 1:* The helium sourced between purging at sample 3 and sample 4 can be calculated as... $1.38 \times 10^{10}/s$ .

We can imagine that the source of this helium is one of the following:

- 1.i. Diffusional in-leakage of  $4\text{He}$  contained in room air.
- 1.ii. Convective in-leakage of  $4\text{He}$  contained in room air, either progressively, or at the time of sampling.
- 1.iii. Unobserved production via  $\text{D}+\text{D} > 4\text{He}$  (or some other reaction).
- 1.iv. Slow release of  $4\text{He}$  previously produced or occluded.

*Hypothesis 1.i:* If we ascribe all of this diffusion to the ceramic member holding the electrical feed-throughs...this is much too large a number.

*Hypothesis 1.ii:* The pressure in the system varied from 0.6 to 1.05 atm above ambient in the period between samples 3 and 4...There is therefore no reason to suspect convective leakage of gas out of the system, and much less reason to suspect convective in-leakage.

*Hypothesis 1.iii:* If  $4\text{He}$  were produced by a reaction such as  $\text{D}+\text{D} > 4\text{He} + 22.4 \text{ MeV}$  we must ask the question whether or not we should have expected to observe calorimetrically the associated power or energy...It is also possible (but not likely) that 40kJ of excess heat could have been sourced during one or more of the calorimetric transients, and not seen. We therefore cannot rule out the possibility that  $4\text{He}$  was sourced, with excess heat, in the method reported by Miles and Bush.

*Hypothesis 1.iv:* Hideout. Immediately prior to sample 3 the cell was flushed with  $\text{D}_2$ ...We do not know what the partition coefficient for  $4\text{He}$  is between  $\text{D}_2$  gas,  $\text{LiOD}$ ,  $\text{PTFE}$  and  $\text{Pd}$  metal. Nor do we know the effective diffusion coefficient of

$^4\text{He}$  in PTFE or the rate at which  $^4\text{He}$  sourced within Pd might be expected to leave.

Hypothesis 2: In attempting to evaluate a  $^4\text{He}$  mass balance on the basis of hypothesis 2 (nuclear source), two critical pieces of information are missing: the helium content of the cell immediately before the initiation of excess heat production at 530h, and before purging at 1154h. We can make progress by assuming that, as intended (a, b) or claimed (c):

- a. the system is helium leak tight
- b. the initial helium content is that of the D<sub>2</sub> gas cylinder (=sample 3)
- c. helium is produced by reaction [1] ( $\text{D}+\text{D} \rightarrow ^4\text{He} + 22.4 \text{ MeV}$ )

...we cannot be certain that all  $^4\text{He}$  had been released into the gas at the time of sample 4. This estimated concentration is entirely plausible, but not provable. In this model,  $^4\text{He}$  is created before sample 1 (presumably in the cathode, by reaction [1]). This helium is not, however, immediately available in the gas phase where it is accessible for sampling. Instead, the helium is slowly released over a period of a month or more.

Diffusion with the metal itself, might explain this time-constant. Alternatively, holdup in the electrolyte or PTFE parts could supply the mechanism of delay. It is possibly of significance that the large  $^4\text{He}$  concentration in sample 4, followed the extended period of temperature pulsing and a temperature step in this sample period.

#### *Conclusions:*

1. We cannot rule out the possibility that  $^4\text{He}$  was sourced during the period between samples 3 and 4, or that the measured helium represents a hold-over from helium previously dissolved in D<sub>2</sub>O or PTFE.
2. In the event of delayed release, a satisfactory mass balance can be obtained for  $^4\text{He}$  on the assumption that a) the system is helium leak tight and b) the helium is sourced by reaction [1].
3. Convective in-leakage during cell operation or sampling seems a very unlikely source of the measured  $^4\text{He}$ , and diffusional in-leakage, while possible, would be very hard to account for quantitatively.
4. The possibility of  $^4\text{He}$  hide-out and slow emergence into the gas phase must be tested by experiment. This applies to both the  $^4\text{He}$  thought to be produced by reaction [1] and to an initial inventory of  $^4\text{He}$  in the LiOD and PTFE, due to equilibrium with the ambient.
5. Definitive statements will be difficult to make about  $^4\text{He}$  production in this or future experiments unless or until it is measured at several times the ambient background level.

**Reference for 1998 Paper:**

Development of Energy Production Systems from Heat Produced in Deuterated Metals - Energy Production Processes in Deuterated Metals, Volume 1, TR-107843-V1, Thomas Passell (Project Manager,) Michael McKubre, Steven Crouch-Baker, A. Huaser, N. Jevtic, S.I. Smedley, Francis Tanzella, M. Williams, S. Wing (Principal Investigators,) B. Bush, F. McMohon, M. Srinivasan, A. Wark, D. Warren (Non-SRI Contributors,) June 1998