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10 APR 97

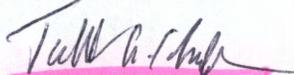
Dr. Walter Polansky
Department of Energy
ER-16; F-240
Washington, DC 20585

Dear Dr. Polansky,

Enclosed is a copy of Drs. Arata and Zhang's latest paper on cold fusion. I think that their clear-cut measurement of an anomalously high helium-3/helium-4 isotope ratio in gases embedded in palladium following heat production will convince fellow physicists of the reality of lattice-induced nuclear fusion. Also they have had 6 successful excess heat runs out of 6 tries. Please let me know if ER becomes interested in cold fusion work. We sponsored Drs. Arata and Zhang's visit to the US last June, and I visited their laboratory in October. I have photographs of their lab. We are anxious to do some experimental work, but need some start-up support. Do you have a research need toward which such work could be directed?

I think we now have a pretty good understanding of cold fusion theory. Scott Chubb and I presented 3 talks at the March APS meeting in Kansas City, which were well received. Copies of the Abstracts are enclosed.

Thanks,



Talbot A. Chubb

Chief Scientist, Oakton International Corporation
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Arlington, VA 22207

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Abstract Submitted
for the MAR97 Meeting of
The American Physical Society

Sorting Category: 38.b

Paired-Particle Coherence in a Lattice S.R. CHUBB,
T.A. CHUBB, *Oakton International Corporation, 5023 N 38 St, Ar-
lington, VA 22207* — The many- body wave functions $\phi(r_1, \dots, r_n)$ for
non-interacting band state particles in an ordered solid preserve lat-
tice symmetry: $|\phi(r_1+R_n, r_2+R_j, \dots)| = |\phi(r_1, r_2, \dots)|$ for arbitrary lattice
vectors R_n and R_j . These states manifestly exhibit a form of coher-
ence with respect to outside perturbations that preserve periodic order.
When two, initially non-interacting band state particles are allowed to
interact with each other, it is possible for their mutual Coulombic repul-
sion to be constrained in a manner that also preserves periodic order.
Implications associated with the resulting coherence are discussed.



Prefer Oral Session



Prefer Poster Session

Scott R. Chubb
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Special instructions: Please put in same session as T.A. Chubb and S.R. Chubb "2-Deuteron
Wave Function" paper

Date submitted: December 6, 1996

Electronic form version 1.1

Abstract Submitted
for the MAR97 Meeting of
The American Physical Society

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Small Crystals Aid Cold Fusion T.A. CHUBB, S.R. CHUBB, *Oakton International Corporation, 5023 N 38 St, Arlington, VA 22207* — The 1996 world meeting on cold fusion in Hokkaido, Japan (ICCF6) provided strong evidence that the nuclear product of radiationless cold fusion in a lattice is ^4He . Arata and Zhang^{1,2} at Osaka University observed ^4He in thermal desorption studies of deuterided Pd powder that had produced 5 kWh/g excess heat; non-deuterided powder showed no ^4He . Gozzi et al.³ at the University of Rome observed ^4He correlating with excess heat power over a thousand hour time period in the gas flow from an open-cell D_2O electrolysis cell, using a bundle of 150 0.25-mm Pd wires as the cathode. Arata and Zhang used a "double structure" cathode consisting of a Pd-metal bottle, evacuated and filled with Pd black (0.4 micron powder)^{1,2}. They have recorded excess heat from 6 out of 6 cathodes. We attribute the cold fusion successes to use of small Pd grains. Deuterons coherently occupying ordered regions in a metal matrix are predicted to produce heat at higher power density with decreasing crystal size⁴.

¹Y. Arata and Y-C Zhang, *Proc. Japan Acad.* 71B, 304 (1995).

²Y. Arata and Y-C Zhang, *Proc. ICCF6*, to appear (1997).

³D. Gozzi et al., *Proc. ICCF6*, to appear (1997).

⁴T.A. Chubb and S.R. Chubb, *Proc. ICCF6*, to appear (1997).

Prefer Oral Session

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2-Deuteron Wave Function T.A. CHUBB, S.R. CHUBB,
Oakton International Corporation, 5023 N 38 St, Arlington, VA 22207
— The 2-particle wave function describing electrostatically interacting deuterons in an external field is a 6 degree-of-freedom function, describable in center-of-mass r_{cm} and separation r_{12} vector coordinates. Consider the case where the external field is periodic and r_{cm} and r_{12} can be treated as separable. Then, $Y(r_{cm}, r_{12}) = F(r_{cm}) g(r_{12})$. The function $g(r_{12})$ can be called a dimming function since, when r_{12} approaches 0, $|Y(r_{cm}, r_{12})|$ approaches a minimum value. $g(r_{12})$ has a cusp in separation space at $r_{12}=0$. When $Y(r_{cm}, r_{12})$ has lattice symmetry, $|F(r_{cm} + R_n)| = |F(r_{cm})|$, where R_n is any lattice vector. The question to be answered is whether lattice symmetry also requires $|g(r_{12} + R_m)| = |g(r_{12})|$, where R_m is any lattice vector, i.e., whether $g(r_{12})$ has a cusp in every unit cell in separation space. It can be shown that if $g(r_{12})$ has Bloch symmetry for band state deuterons in a metal crystal lattice and if the Coulomb repulsion interaction vanishes outside a screening radius r_{sc} less than half the edge of a unit cell, then the energy-minimizing 2-deuteron wave function provides d-d overlap and there is no Coulomb barrier to fusion.



Prefer Oral Session



Prefer Poster Session

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Oakton International Corp., 5023 N. 38 St., Arlington, VA 22207

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Date submitted: December 6, 1996

Electronic form version 1.1

Helium (${}^4\text{He}$, ${}^3\text{He}$) within Deuterated Pd-black

By Yoshiaki ARATA, M. J. A., and Yue-Chang ZHANG

Osaka University, 11-1 Mihogaoka, Ibaraki, Osaka 567

(Communicated Jan. 13, 1997)

Abstract : Authors have clearly proven for the first time that deuterium nuclear reaction was continuously generated inside a highly deuterated solid by showing both of the excess energy and corresponding amount of helium as the reaction product generated simultaneously. Whenever there is a nuclear fusion reaction inside a metal, helium generated is unable to escape to the surroundings and is trapped in a frozen state inside that metal. The concentration of the helium within the metal will rise with increasing rate of reactions. Pd-black is under such state as the sample used and sealed within the "closed QMS" developed by the authors (closed vessel including the Getter pump and the QMS). It is completely separated from the surroundings and the internal gases are removed to create super-vacuum. The reaction product released by the "Sample-Heating" process (room temp. \rightleftharpoons 1500[°C]) is thus the only matter which occupies the interior of the closed vessel and its detection by the QMS is assured. When the "closed QMS" works under the above mentioned-state, it was clarified that the "ash" or the reaction product of this fusion reaction within a solid is ${}^4\text{He}$ and ${}^3\text{He}$ and their ratio is ${}^4\text{He} / {}^3\text{He} \approx 4$. It can be concluded from the result that the main reaction product is ${}^4\text{He}$ and it is created directly as an inherent feature of the solid-state nuclear fusion. Authors think that the reaction process responsible for the creation of ${}^3\text{He}$ may be a different one from that creates ${}^4\text{He}$. One of which is the Rutherford reaction process and the other occurs based on the specific properties of solid, similar to the case of ${}^4\text{He}$. The existence of ${}^3\text{T}$ will be required that the process is responsible for the generation of ${}^3\text{He}$ as the Rutherford reaction. The proof for the existence of ${}^3\text{T}$ within the "closed QMS", however, was not obtained in this experiments.

Key words : Helium (${}^4\text{He}$, ${}^3\text{He}$); cold fusion; Pd-black; closed QMS; coupled spectrum.

Introduction. Authors¹⁾ have developed the "closed QMS" (Quadrupole Mass Spectrometer and Getter pump) and used highly deuterated Pd-black as the sample sealed within this closed vessel. The process in which helium (${}^4\text{He}$) is suddenly released from this sample at high temperature was reported in detail in authors previous reports.¹⁾ It was also identified that ${}^3\text{He}$ is released at the same time and the ratio of the two is ${}^4\text{He} / {}^3\text{He} \approx 4$. Details were omitted and only results were mentioned in the previous report.¹⁾ This report will look further into the process of that experiment.

Experiment. As stated in the previous report,¹⁾ elements released from highly deuterated sample placed in the "closed QMS" with high vacuum ($\approx 3 \times 10^{-9}$ [Torr]) is trapped inside the apparatus indefinitely. Helium will continue to exist under the effect of the "Getter action", but the hydrogen series elements and others vanish or diminish to the limit of

the "Getter action's" functional limit. Thus the existence of helium (${}^4\text{He}$, ${}^3\text{He}$) is easily and accurately determined.

Fig. 1 is the experimental data which points out this fact. It shows the chronological change of the elements with mass M_4 and M_3 ($=M / e$) released from the highly deuterated sample within the "closed QMS". M_4 includes ${}^4\text{He}$ and "D₂" (and also DH₂, TH but these elements \ll "D₂" even if they exist), and M_3 includes ${}^3\text{He}$ and "DH" (and also ${}^3\text{T}$, "H₃" \ll "DH" even if they exist). It may be concluded that M_4 is "D₂" and ${}^4\text{He}$ and that M_3 is "DH" and ${}^3\text{He}$.

M_3 is much common than M_4 and it is estimated that "DH" outnumbered D₂ at the starting Qs. The chronological change for the spectra of M_4 is shown in Fig. 2 (A). D₂ and ${}^4\text{He}$ form a "coupled spectrum" and the process of releasing of these elements is observed clearly. D₂ diminishes rapidly as time passes and ${}^4\text{He}$ increases gradually reaching a constant level after no

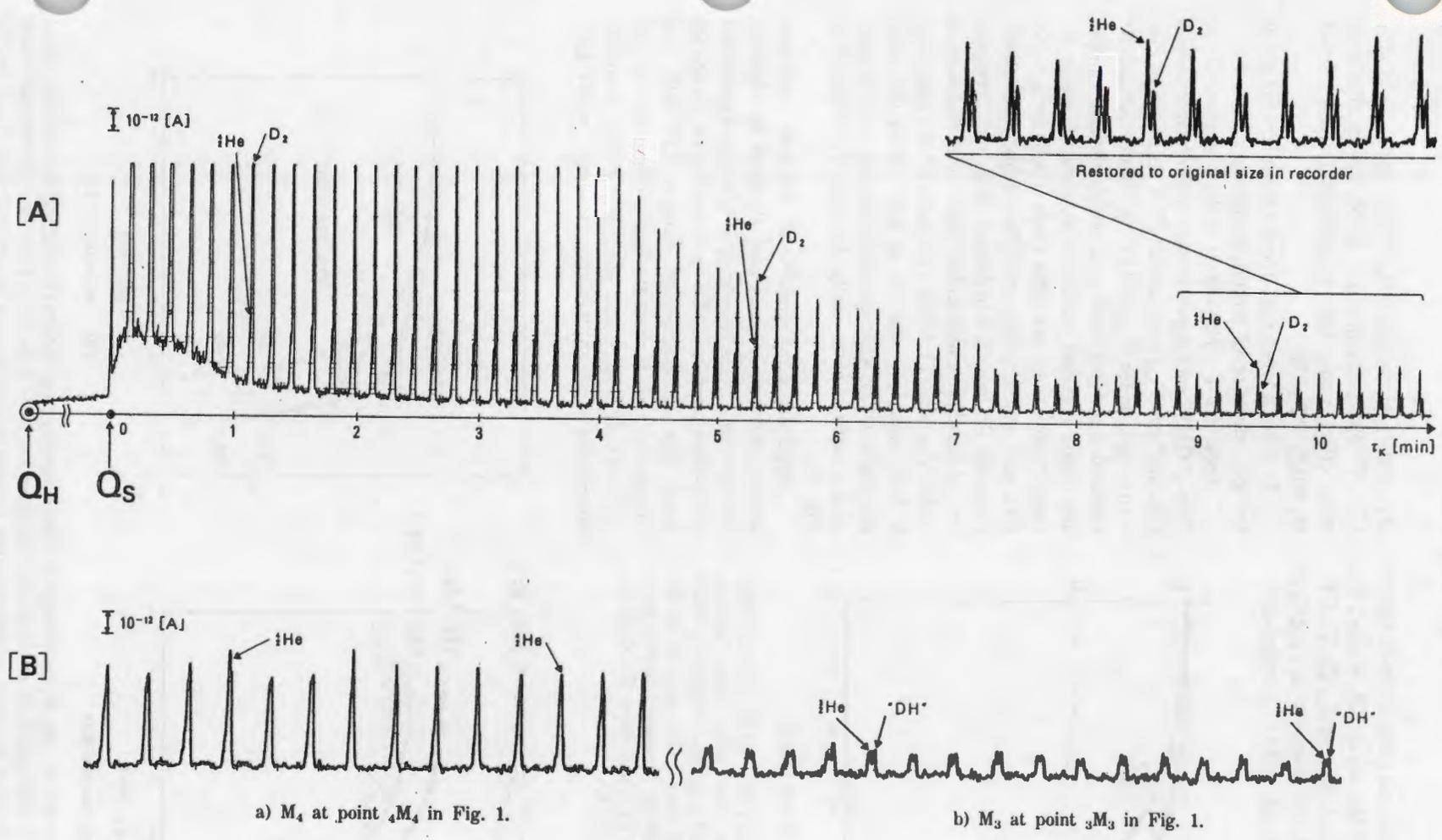


Fig. 2. "Coupled Spectrum" at some important points (Q_S , Q_E) in Fig. 1. Note (1): [A] shows chronological change of "Coupled Spectrum" of mass M_4 (${}^3\text{He}$: D_2) generated at point Q_S due to "Sample-Heating" inside "closed QMS". (2): [B] shows chronological change of "Coupled Spectrum" of mass M_4 and M_3 spectra at point Q_E (${}^4\text{M}_4$ and ${}^3\text{M}_3$) in Fig. 1.

difference of almost a figure one place between before and after deuterated). (3) M_2 , M_3 and $M_4 \approx f(Q_p)$; $M_5 \approx f(Q_p^2)$, where $f(Q_p)$, $f(Q_p^2)$, represent H_2 , D_2 , T_2 , DH , TH , DT , etc. and H_3 , D_2H , etc., respectively, and Q_p is gas pressure inside "closed QMS". Consequently,

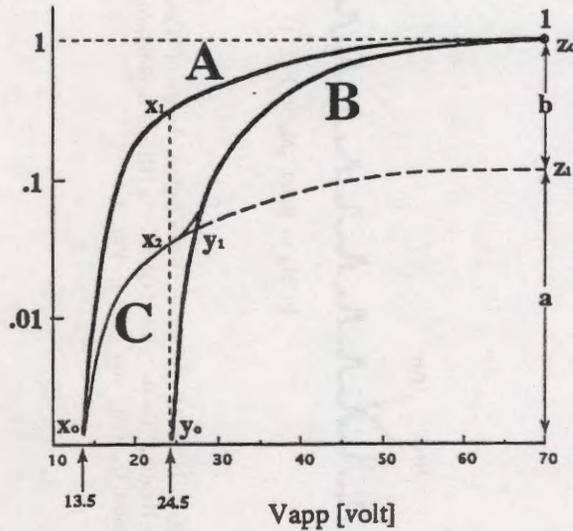


Fig. 3. Separation method for ^3He and the pollutant "DH" using "Vi-effect" inside the "closed QMS". Note: Curves A, B and C indicate A, B and C groups respectively. When curve A and the "extended curve C" form same curves, the ratio b/a can be obtained precisely, where curve A (x_0, x_1, z_0), curve B (y_0, y_1, z_0), curve C (x_0, x_2, z_0), "extend curve C" (x_0, x_2, y_1, z_1).

M_2 ("H₂"), M_3 ("DH"), M_4 ("D₂") and M_5 ("D₂H") (if "DT" exist, the intensity of M_5 will be displayed with $f(Q_p)$, but the experimental data shows $M_5 = f(Q_p^2) = \text{"D}_2\text{H"})$.

It is considered that above results are not proof for the existence of tritium compounds.

Appendix 1. *Pollutants to be generated inside "closed QMS" with supervacuum under both "Sample-Heating" and V_{app} (=70 and 25 [V]).* As shown in Fig. 6 although, under $V_{app}=70$ [V], pollutants A* and B* released from only surface of non-deuterated sample and inside included surface of deuterated one in b), respectively, these are same kinds of pollutants, while their each quantity only are different from each other. Pollutant C* in c) is a hydrogen series only irrespective of non-deuterated and/or high deuterated sample under $V_{app}=25$ [V]. When pollutants C* are compared in both samples, whether or not tritium (its compounds) exist or what elements released from deuterated sample can be easily detected as indicated in Fig. 5.

Appendix 2. *Comparison between non-deuterated and highly deuterated Pd-black by electron-micrograph.* These micrographs show an appearance of Pd-black used inside DS-cathode. Photos. (a) and (b) show the non-deuterated sample ($[D]^* = 0$) and Photos. (c) and (d) show the highly deuterated sample ($[D]^* \approx 1$). It seems that the particle size is mainly distributed 0.02 to 0.06 [μ] (average: ≈ 0.04 [μ]).

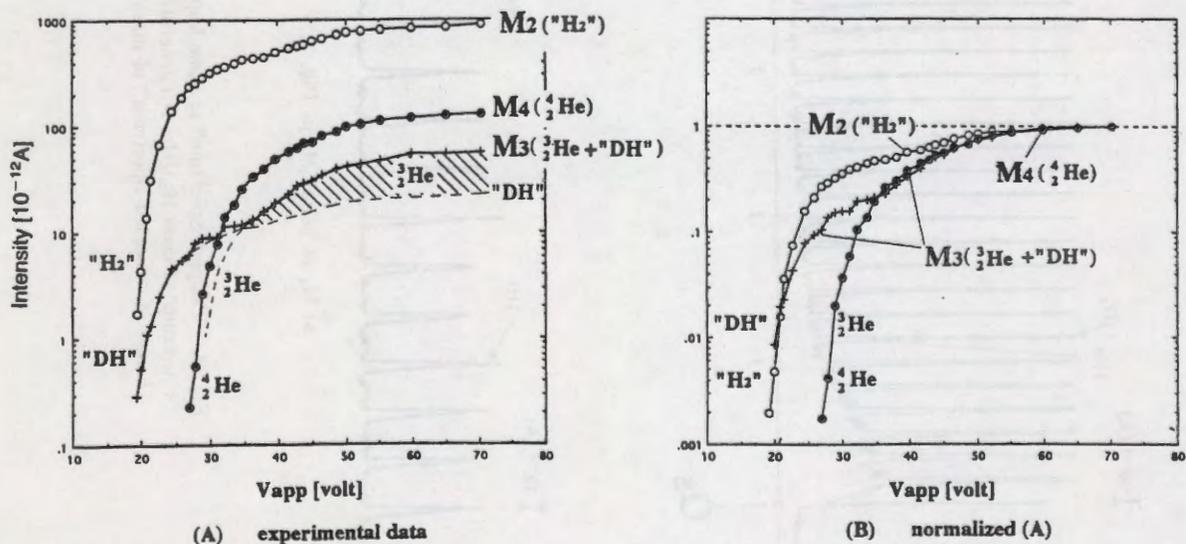


Fig. 4. Relationship between mass M_2 , M_3 , M_4 and the applied voltage changing from 70 to 20 [V] ($70 \approx 20$ [V]) inside the "closed QMS". Note (1): The elements with mass M_2 , M_3 and M_4 are the same gases with those at Q_E in Fig. 1 and Fig. 2 since they are sealed inside the "closed QMS". (2): (A) is the actual experimental data showing relation between the applied voltage (V_{app}) and the spectrum intensity of the ionized gases at the point Q_E in Fig. 1. (B) is the normalized result of (A), and corresponds to Fig. 3.

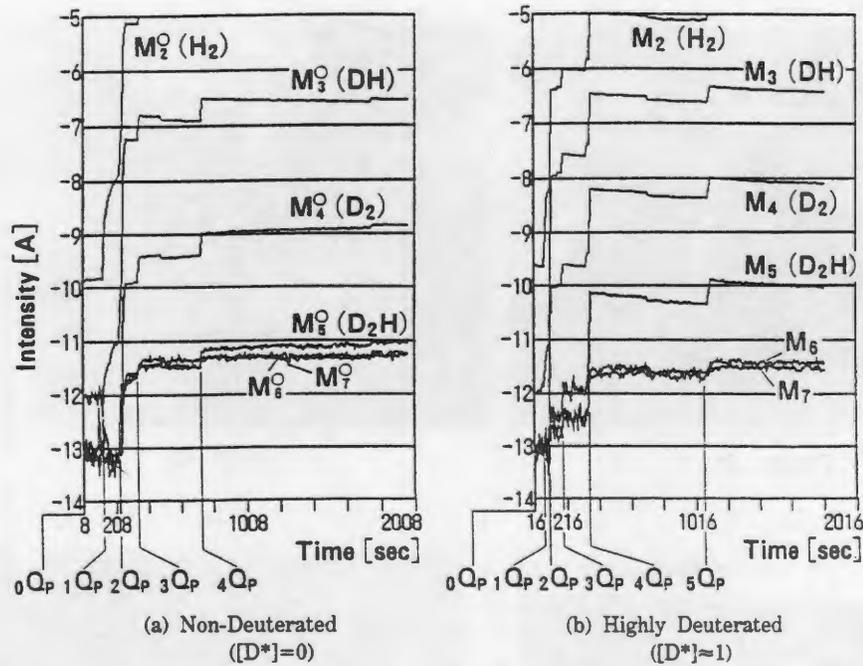


Fig. 5. Comparison between non-deuterated and highly deuterated samples for intensity of "released gases" inside "QMS" under $V_{app}=25$ [V]. (M^o , M : mass of elements released from the former and latter samples, respectively). Note (1): S_p and Q_p show gas pressure inside each isolated sample vessel and "QMS", respectively. (2): Numbers of ①, ②, ③, ④ indicate the order of "closed QMS" operation as follows, ①: ${}_0S_p \approx 3 \times 10^{-9}$ [Torr], ${}_0Q_p \approx 3 \times 10^{-9}$ [Torr]; initial pressure inside each isolated sample vessel and "QMS", respectively. ②: ${}_1S_p > 10^{-4}$ [Torr]; "released gases" pressure after "Sample-Heating" at 1300°C inside isolated sample vessel. ③: ${}_1Q_p, {}_2Q_p, {}_3Q_p, {}_4Q_p, {}_5Q_p$: "released gases" pressure inside isolated "QMS" when it is introduced stepped-state from sample vessel. ④: (a) diagram; ${}_1Q_p \approx 1.5 \times 10^{-7}$, ${}_2Q_p \approx 3 \times 10^{-6}$, ${}_3Q_p \approx 6 \times 10^{-5}$, ${}_4Q_p \approx 8.7 \times 10^{-5}$, (b) diagram; ${}_1Q_p \approx 2 \times 10^{-7}$, ${}_2Q_p \approx 2 \times 10^{-6}$, ${}_3Q_p \approx 4.0 \times 10^{-6}$, ${}_4Q_p \approx 4.2 \times 10^{-5}$, ${}_5Q_p \approx 6.2 \times 10^{-5}$. It was verified that both $M_5 (=M_5^o)$ and $M_7 (=M_7^o)$ change with only noise-level, and $M_5 = \text{D}_2\text{H}$ (without DT), $M_5 = M_5^o$, $M_2 = M_2^o$. This means that the existence of tritium compounds can not be recognized.

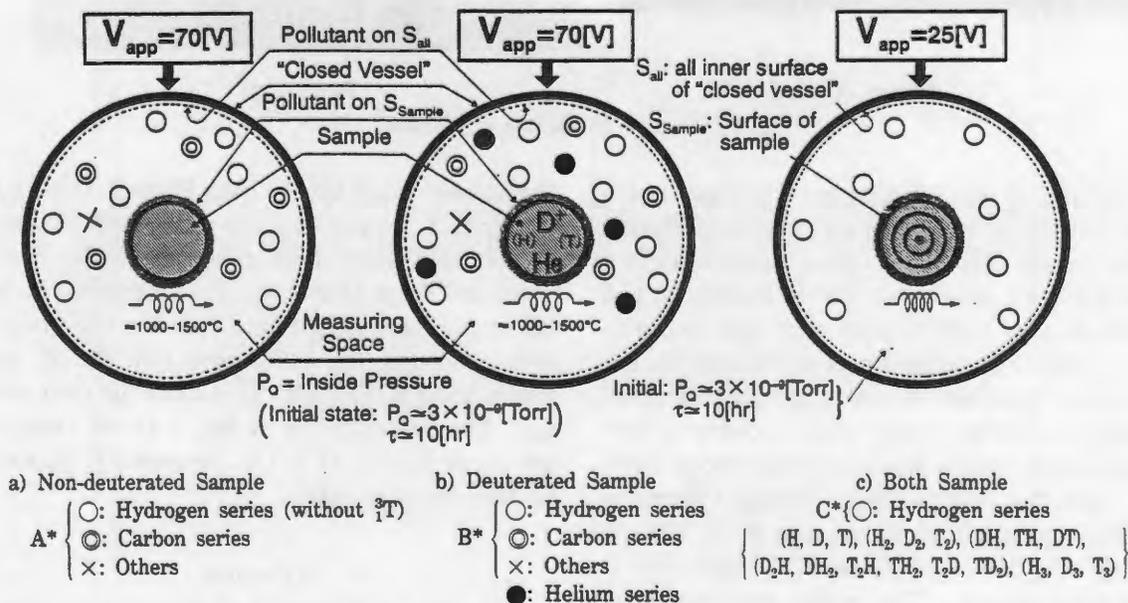


Fig. 6. Comparison between both samples before ($[D^*]=0$) and after ($[D^*]=1$) deuterated for elements released under "Sample-Heating" only. Note: It is very important in substance that pollutants A^* , B^* , and C^* are released from sample only under "Sample-Heating" without coming from inner all surface of closed-vessel inside "closed QMS" with super-vacuum.

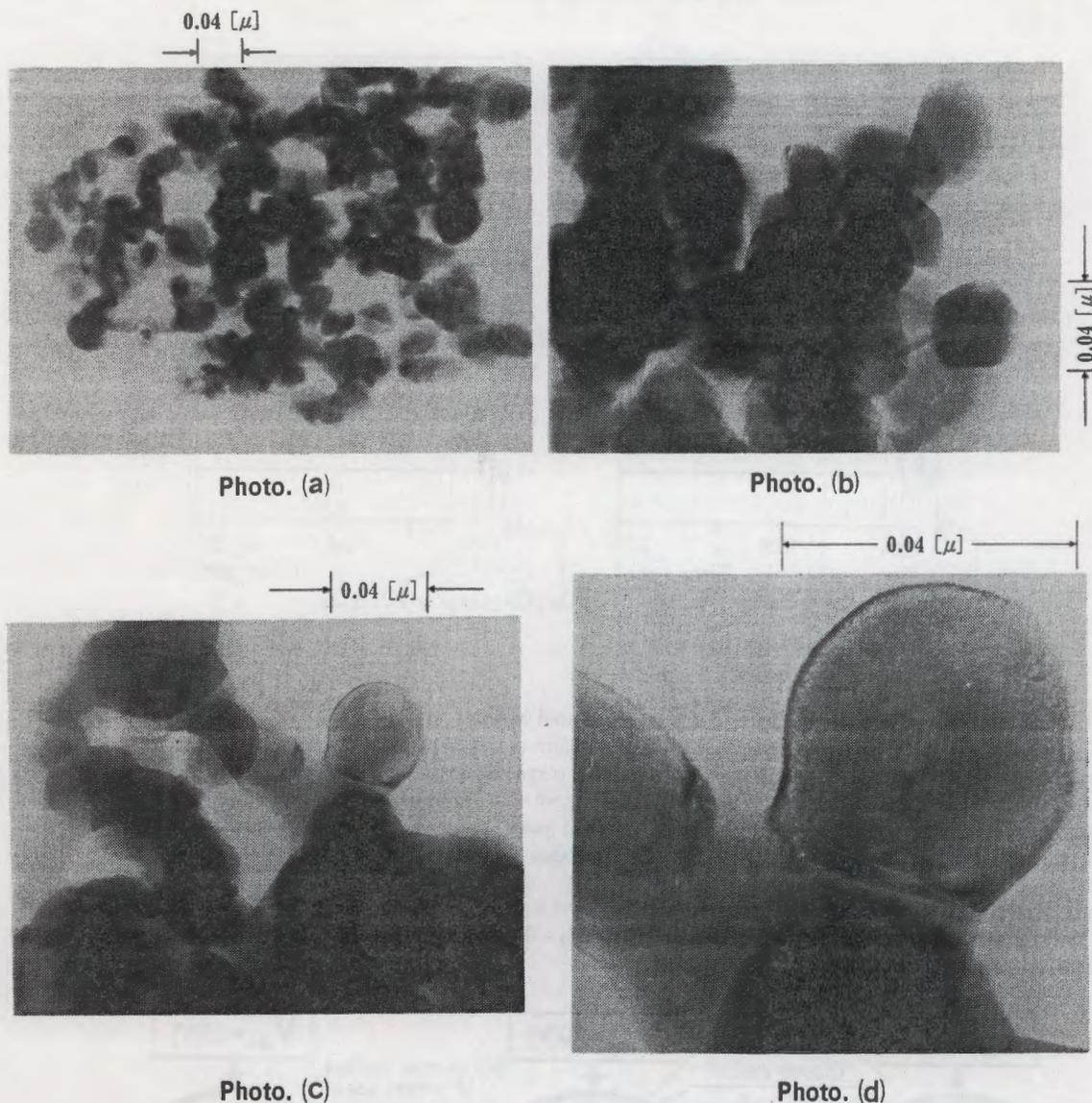


Fig. 7. Electron-micrograph of Pd-black.

Photos. (b) and (d) magnified (a) and (c), respectively. A scale of $0.04\ [\mu]$ is inserted in each photo. In Photos. (a) and (b) many of particles with a squarish surface isolated from each other exist. But in Photos. (c) and (d), there exist no particles with such appearance as Photos. (a) and (b), and almost of much particles are connected and they seem to be mixing with each other. The highly deuterated sample was heated to a very high temperature and it generated huge excess energy. It is startling that no crystal damages seems to exist. (These photographs were taken by K. Hiraga; Prof., Inst. for Materials Research, Tohoku Univ.)

Acknowledgments. This study was conducted through a research grant from the Japan Academy.

The authors would like to thank Prof. Y. Imai, M.J.A., and Prof. T. Nagamiya, M.J.A., for their encouragement in this study. Prof. Emeritus K. Sugimoto of Osaka and Tokyo University, Prof. Emeritus M. Date and Prof. Emeritus H. Fujita of Osaka University for their comments. ULVAC Japan, Ltd: Mr. K. Yanagishita and CRIEPI: Dr. Y. Asaoka for their assistance. The staff members of JWRI, Osaka University and Sulzer Meteco, JPN, Ltd: President F. Kawakami for their encouragement.

Reference

- 1) Arata, Y., and Zhang, Y.-C. (1996) Proc. Japan Acad. 72B, 179-184.

Dear Reader,

This latest publication by Drs. Arata and Zhang [Y. Arata and Y.-C. Zhang, *Proc. Japan Acad.* 73B, 1 (1997)] is sent courtesy of Oakton International Corporation.

Drs. Arata and Zhang have published time history data on 6 electrochemical runs in which they have observed major quantities of excess heat from palladium deuteride PdD_x [Y. Arata and Y.-C. Zhang, *Proc. Japan Acad.* 70B, 106 (1994); *Proc. Japan Acad.* 71B, 98 (1995); and *Proc. ICCF6*, 129 (1997)]. In these runs D atoms were plated onto the external surface of a vacuum-sealed palladium bottle. The inside of the bottle was packed with fine Pd powder called palladium black. During electrolysis D atoms diffused through the wall of the bottle and immersed the Pd powder in pure D₂ gas at pressures that have been measured to exceed 800 atmospheres. This latest paper describes the composition of gases driven off powder that had previously produced excess heat. The paper shows the presence of the 2 isotopes of helium, ⁴He and ³He, neither of which was present in the same powder that had not been exposed to D₂ gas. This paper is important because it shows that a nuclear reaction occurred within the Pd powder, producing heat without accompanying neutron or gamma ray emission. The paper confirms the cold fusion process first announced by Drs. Fleischmann and Pons in 1989.

The reader's attention is directed to Figure 1 of the latest paper. Gases were driven off Pd powder as it was heated to very high temperature. These gases were captured in a very clean, sealed-off section of a vacuum system which contained 2 mass spectrometers and a getter pump. The getter pump removes hydrogen from the gases by chemical reaction, leaving the helium content unaffected. The high resolution mass spectrometers repetitively scanned across the Mass-4 and Mass-3 peaks of the mass spectrum. The mass-4 peak contains the signals from D₂⁺ and ⁴He⁺ ions, as shown in Figure 2. Similarly the Mass-3 peak contains signals from DH⁺ and ³He⁺ ions. H₂ is present in the desorbed gas as an impurity. Part of the H was embedded in the powder prior to generation of heat. Figure 1 shows that the mass-4 peak M₄ quickly decays to a constant amplitude, while the mass-3 peak more slowly decays towards a stable amplitude that had not been reached by the end of the plot. The stable M₄ value is shown in Figure 2 to be a measurement of pure ⁴He⁺, while the end value of ³He⁺ is shown to be half ³He⁺ and half HD⁺. The difference in the rates at which D₂ and DH disappear inside the sealed system is a result of the following processes: Both D₂ and DH are removed by the getter pump at equal rates, but the D₂ is also lost by the surface reaction D₂ + surface-H → 2 DH. This reaction occurs on all metal surfaces within the sealed-off vacuum system.

This paper is a second and independent proof of the presence of a nuclear reaction product in Pd black that has produced heat. A year earlier Drs. Arata and Zhang showed that the ⁴He was created in the heat release process [Y. Arata and

Y.-C. Zhang, *Proc. Japan Acad.* **71B**, 304 (1995)]. The product ^4He was strongly trapped in the powder, requiring $>800^\circ\text{C}$ temperatures to drive off the gas. No ^4He was in the powder that had not produced heat. The new data confirms the earlier result, but shows that ^3He also was formed with a $^3\text{He}/^4\text{He}$ ratio exceeding 0.1. Since the natural abundance ratio of $^3\text{He}/^4\text{He}$ is 0.00013, there is no possibility of sample contamination by leaks. The only possible source of the ^3He is by nuclear reaction. Since the reaction energy for production of ^4He is 23.8 MeV, compared with a reaction energy for production of ^3He of 5.45 MeV, more than 97% of the heat came the lattice reaction $\text{D} + \text{D} \rightarrow ^4\text{He}$. Radiationless lattice-induced nuclear reactions can be understood as interaction between ion band states [T. A. Chubb and S. R. Chubb, *Fusion Technol.* **20**, 93 (1991)], and subsequent publications]. The ^3He is likely produced in an ion band state version of the Schwinger reaction $\text{D} + \text{H} \rightarrow ^3\text{He}$.

For more information, contact:

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Chief Scientist, Oakton International Corporation
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For more information, contact:

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