Presence of Helium (^4He , ^3He) Confirmed in Deuterated Pd-black by the “Vi-effect” in a “closed QMS” Environment

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(Communicated April 14, 1997)

Abstract : Although helium is generally quite insoluble in metals, large amounts of this element can be stored within a highly deuterated host metal such as Pd-black as a result of deuterium nuclear reactions continuously generated over long periods. However, since it is almost impossible for these helium atoms to then escape from the Pd-black host to the surrounding environment at ambient temperature, to confirm their presence it is absolutely essential that Pd-black samples be heated to high temperatures to expel whatever helium they may contain. Therefore, to confirm the existence of helium atoms generated from deuterium in samples of Pd-black, we simply employed the “Sample Heating” process (room temperature $\rightleftharpoons$ 1500°C), but carried it out using both a “QMS” system and a super-high vacuum favorable “Getter pump” inside a totally sealed vessel. We termed this methodology “closed QMS”, and developed a related discrimination method which applies an opportunely changing voltage to the anticipated elements present inside the “closed QMS” environment. Measurements were then taken as the applied voltage was both increased and decreased between 70 $\rightleftharpoons$ 20 [V] (here, range being determined by the ionization potential V_i [eV] for helium series elements). Using this principle, which we call the “Vi-effect”, in brief, we were able to conclusively confirm the presence of both ^4He and ^3He atoms, as well as their relative ratio. It is evident that development of both the “closed QMS” system and the “Vi-effect” methodology were vital to finally prove the presence of helium generated by deuterium nuclear fusion within highly deuterated Pd-black.

Key words : Helium (^4He , ^3He), cold fusion; Pd-black; closed QMS; “Vi-effect”.

Introduction. To prove the existence of a deuterium nuclear reaction inside a solid, the following five key processes proves necessary. In other words, only after comprehending and applying the principles or methodologies outlined in the five steps below was it possible to achieve “cold fusion” and conclusively confirm its empirical reality.¹⁾

1) *First key: Creation of an intensely pressurized, highly deuterated host metal (concentrated even more than solid body density).* A Double Structure cathode (“DS cathode”) had to be fabricated using Pd-black as the inner cathode enclosed within a vacuum sealed “Pd vessel” which functions as the outer cathode.

Note 1): The “Pd vessel” supplies rapidly pure D^+ ions to the Pd-black during electrolysis via the “spillover effect” and extremely high interior D_2 gas pressure ($\geq$ several thousand [atm]) in accordance with Sievertz, well known law. That is to say, both the phenomena respectively described by the “spillover effect” and “Sievertz law” are indispensable to the function of the “DS cathode”.

Note 2): Pd-black (dia $\approx 400 \text{ \AA}$) rapidly absorbs D^+ ions at almost 100% efficiency due to intrinsic physical phenomena such as “Atom Cluster”.

2) *Second key: Exploitation of helium’s unique impermeability with respect to metal (and consequent difficulty involved transporting it into/out of a metallic body).* The authors noted the impenetrable resistance metal generally presents to the passage of helium, effectively preventing either its entry or escape. This led to the conclusion that if a nuclear fusion reaction were to occur within a metal, in this case Pd-black, a large amount of helium would perforce not only be held fast and retained inside, but also it will rise with increasing rate of reactions.

3) *Third key: Recognition of the special prerequisites for releasing helium from metal.* Helium can only escape from a metal when the latter is heated to high temperature and/or dissolved in a liquid solution. The former method is far superior for accurately and reliably detecting helium, because helium atoms can be released simply by using the standard “Sample Heating” process (room temperature $\rightleftharpoons$ 1500°C).

Fig. 1. Experimental "Vi-effect" curves for non-deuterated Pd-black (Graphs (A), (C)) and highly deuterated Pd-black (Graphs (B), (D)).

Note): In case of non-deuterated sample, both curves M_2 ("H₂") and M_3 ("DH") in Graph A coincide entirely with each other as shown in Graph (C), but in highly deuterated sample as Graph (B), hydrogen-region ($V_{app} \leq 25$ [V]) on M_3 curve overlap with M_2 curve, just the same with Graph (C), while in helium-region ($V_{app} \geq 25$ [V]), both curves are considerably separated (shadow zone) as shown in Graph (D). Such separated zone quantitatively corresponds to existence of ^3He and the ratio $[\text{He}^*] (= ^3\text{He}/^2\text{He}) \approx 4$ was obtained in this case, while using many samples the ratio extends as explained later on $[\text{He}^*] \approx 2 \sim 10$.

4) *Fourth key: Creation of a "closed QMS" system.* The authors developed a "closed QMS" (Quadrupole Mass Spectrometer) system which has thus far proven indispensable for identifying and measuring helium at high levels of accuracy and reliability.

Note 1): Samples are placed inside the "closed QMS" environment at ultra-high vacuum and for long periods ($\leq 3 \times 10^{-9}$ Torr, ≈ 10 hrs).

Note 2): The conditions outlined in Note 1 assure that the QMS only detects elements/compounds released from the "Heated Sample" itself and is minimally disturbed by ambient contaminants, especially "Pollutant ^4He " and "H-series."

Note 3): Inside the "closed QMS" system, the effect of "Getter action" (at least to its practical limits) eventually eliminates or radically diminishes all adulterating constituents (here, the hydrogen series elements/compounds) leaving only the helium series elements.

5) *Fifth key: Application of the "Vi-effect" (as described in the following section).* The authors developed a new discrimination method based on the "Vi-effect" (authors' term) which distinguishes helium in a "closed QMS" environment in terms of its known ionization potential (Vi [eV]). Using this method, the existence of both ^4He and ^3He was not only positively established, the $^4\text{He}/^3\text{He}$ ratio was also accurately ascertained.

Definition of the "Vi-effect". When a diversity of elements exist inside a closed vessel, they can be

separated and classified into discrete groups (A, B, C, D, ...) in terms of their ionization potentials (Vi [eV]). That is, group A will be defined by the same Vi(A), group B by identical Vi(B), etc.

For example, when $Vi(A) = 13.5$ [eV] and $Vi(B) = 24.5$ [eV], group A corresponds to the hydrogen series and group B to the helium series as follows:

Group A: hydrogen series = (H, D, T), (H_2 , D_2 , T_2), (DH, TH, DT), (D_2H , DH_2 , TH_2 , T_2H , T_2D , TD_2), (H_3 , D_3 , T_3), etc.

Group B: helium series = (^4He , ^3He)

In conditions where these two groups exist together we may consider the combination itself as an inclusive group and define it as:

Group C: an intermixture of groups A and B.

In the situation above, each of the elements or molecules belonging to these groups can be further classified in terms of its mass M_n ($n=1, 2, 3, \dots, n$). For example, when $n=2$, $n=3$, $n=4$ (i.e., the necessary mass numbers for detecting the presence of helium):

Group A: $n=2$ (M_2 : H_2 , D), $n=3$ (M_3 : DH, T, H_3), $n=4$ (M_4 : D_2 , TH)

Group B: $n=2$ (M_2 : ...), $n=3$ (M_3 : ^3He), $n=4$ (M_4 : ^4He)

Group C: $n=2$ (M_2 : H_2 , D), $n=3$ (M_3 : ^3He , DH, T, H_3), $n=4$ (M_4 : ^4He , D_2 , TH).

In general, when no significant amounts of tritium

Fig. 2. Logical characteristics of the "Vi-effect" curve for elements released from non-deuterated Pd-black ($[D^*]=0$) and highly deuterated Pd-black ($[D^*]\approx 1$). Note 1): Whether using no sample whatever or using only non-deuterated Pd-black, when measured in a "closed QMS" environment, the intensities for both conditions should essentially demonstrate the hydrogen series curves (M_2 : "H₂", M_3 : "DH", M_4 : "D₂") in graph (A) and the normalized curve "A" shown in graph (B). Note 2): Graph (C) shows normalized data for a composite mixture including both hydrogen-series and helium-series elements/compounds. Normalized curves "A", "B" and "C" ("C" = "DH" + ^3He , "C₀" = "D₂" + ^4He) respectively illustrate the logical characteristics of the hydrogen series, the helium series, and their admixture. These are thus the characteristics that a highly deuterated Pd-black sample must exhibit to demonstrate the presence of helium. Because "D₂" is easily diminished by "Getter action", curve "C₀" is generally not evident as it homologizes to "B" ("C₀" = ^4He = "B") and usually only curve "C" remains. Note 3): Because even "DH" is greatly abated by more stronger "Getter action", "C" also tends to homologize to "B" ("C" = ^3He = "B", just as "C₀" = ^4He = "B"). Therefore, the logical "Vi-effect" curves for elements released from highly deuterated Pd-black in a "closed QMS" environment should finally only show curve "A" for "H₂" and curve "B" signifying the helium series (^3He , ^4He) as shown in graph (B). Note 4): The ratio, $^3\text{He}/\text{DH} = b/a$ ($a+b=1$) is obtained by graph (D).

Graph (A). Note 1): Logical intensity curves corresponding to the "Vi-effect" for each element of group A (hydrogen series: "H₂", "DH", "D₂") and group B (helium series: ^3He , ^4He). Note 2): Non-deuterated Pd-black signifies group A only. Note 3): Highly deuterated Pd-black indicates both A and B groups: ($M_2 = \text{H}_2$), ($M_3 = \text{DH} + ^3\text{He}$) and ($M_4 = \text{D}_2 + ^4\text{He}$).

Graph (B). Note 1): Logical normalized "Vi-effect" curves "A" and "B" for each of the intensity curves for groups A and B in graph (A). Graph (C). Note 1): Logical normalized curves for graph C ("C" and "C₀") including both A and B groups. Note 2): Although highly deuterated Pd-black is usually represented by graph (C), when normal "Getter action" is applied in a "closed QMS" environment, "D₂" finally disappears and curve "C₀" homologizes to curve "B" ("C₀" = ^4He = "B") leaving only curve "C". Moreover, the use of still stronger "Getter action" eliminates even "DH" and thus also homologizes curve "C" to "B" ("C" = ^3He = "B"). The logical normalized curves thus become only "A" and "B" as shown in graph (B).

Graph (D). Note 1): When curve "C" signifies M_3 (= ^3He + "DH") and "extend C" forms same curve with hydrogen-series (curve "A"), the ratio $^3\text{He}/\text{DH} = b/a$.

Fig. 3. Characteristics of the "Vi-effect" curve for non-deuterated Pd-black [$D^*=0$]. Note 1): Data (a₀) and (b₀) respectively correspond to intensity curves of hydrogen-series and normalized curve "A" in Fig. 2. Note 2): M₄ ("D₂") could not be detected because it was greatly abated by "Getter action". Note 3): Curves of "B" and "C" type (as shown in Fig. 2) do not appear at all, demonstrating that no helium series elements whatever exist in this sample.

Fig. 4. Characteristics of the "Vi-effect" curve for highly deuterated Pd-black ($[D^*] \approx 1$). Note): This data show remarkable correspondence to Graphs (A) and (C) in Fig. 2, and decisively demonstrates the existence of helium (${}^4_2\text{He}$, ${}^3_2\text{He}$), and the ratio, ${}^4_2\text{He}/{}^3_2\text{He} \approx 3$ in this case.

(and/or its compounds) exist in a given environment, it is clear that " H_2 " $\gg$ D, " DH " $\gg$ T, and " D_2 " $\gg$ TH. In which case, it is reasonable to conclude that preponderantly as follows:

$$\begin{aligned} M_2 &= \text{"H}_2\text{"}, \\ M_3 &= \text{"DH"} + {}^3_2\text{He} \text{ and } M_4 = \text{"D}_2\text{"} + {}^4_2\text{He}. \end{aligned} \quad [1]$$

If we want to know whether or not helium exists among the substances within a closed vessel, it must therefore be demonstrated whether elements with mass

M₃ and M₄ whose $V_i = 24.5$ [eV] are present inside it.

It is well established that when an applied voltage (V_{app}) on an element group is lower than its ionization potentials (V_i), it cannot be detected by QMS. For instance, if $V_{\text{app}} \leq 24.0$ [V], then group A elements ($V_i = 13.5$ [V]) can be clearly detected, but group B elements ($V_i = 24.5$ [V]) cannot be detected at all. When V_{app} is gradually changed, therefore, as follows;

$$V_{\text{app}} = 70 \rightleftharpoons 20 \text{ [V]} (\sim 17 \text{ [V]}). \quad [2]$$

Data (a₂) experimental data Data (b₂) normalized (a₂) Data (a₃) experimental data Data (b₃) normalized (a₃) Data (a₄) experimental data Data (b₄) normalized (a₄)

Fig. 5. "Vi-effect" curve for some samples of highly deuterated Pd-black. Note: The ratio ${}^4\text{He}/{}^3\text{He}$ ($\equiv [\text{He}^*]$) distributed with some range such as $[\text{He}^*] = 2 \sim 10$, for instance, $[\text{He}^*] = 3, 10, 4, 10$ and 4 for Data (a₁, b₁), (a₂, b₂), (a₃, b₃), (a₄, b₄) and (a₅, b₅), respectively.

This process made it possible to separate and clearly distinguish groups A and B as represented experimentally as curves M₂, M₄ in Fig. 1 and logically as curves "A", "B" in Fig. 2. Using this "Vi-effect", as we have termed the principle, within a "closed QMS" environment, we then demonstrated the characteristics of group C (including both A and B groups), that is M₃ in Graphs (B), (D) in Fig. 1 and logically plotted it as curve "C" in Fig. 2.

Experiment. a) *Logical "Vi-effect" curve.* The existence of helium among the diverse elements released from non-deuterated Pd-black or highly deuterated Pd-black can be conclusively confirmed by employing the "Vi-effect" within a "closed QMS" environment. If helium exists in a "closed QMS" environment, we can logically deduce the "Vi-effect" curve as shown in Fig. 2.

Confirmation of helium's presence just requires testing for mass numbers M₂, M₃ and M₄ as only these cover both the hydrogen and helium series. In view of the "Vi-effect", the intensity and normalized curves for each of these may be logically plotted as illustrated in Fig. 2 graphs (A), (B) and (C) respectively.

Thus the hydrogen series can be seen to concentrate entirely in normalized curve "A" whereas the helium series is indicated solely by normalized curve "B". Therefore, non-deuterated samples which contain no helium should demonstrate only curve "A", while highly deuterated samples should be distinguished by curve "C" (under normal conditions with "A" and "B"), but will generate both curves "A" and "B" or simply curve "B" alone if no

"DH" or hydrogen series elements/compounds are available.

b) *Actual experimental "Vi-effect" curves for some Pd-black samples.* Fig. 3 shows experimental "Vi-effect" data for non-deuterated sample signifying no-helium-series. This coincides at all with logical "Vi-effect" curves as shown in Fig. 2. Fig. 4 and Fig. 5 display experimental data for highly deuterated samples clearly demonstrating presence of helium (${}^3\text{He}$, ${}^4\text{He}$ and the ratio ${}^4\text{He}/{}^3\text{He}$). These data coincide with logical "Vi-effect" curve in Fig. 2.

As a result of experiment performed using many kinds of samples, the ratio ${}^4\text{He}/{}^3\text{He}$ ($\equiv [\text{He}^*]$) was distributed over the range of $[\text{He}^*] \approx 2 \sim 10$, while it was indicated as $[\text{He}^*] \approx 4$ in the previous reports.¹⁾

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 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.

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