25. *Corroborating Evidence for "Cold" Fusion Reaction*

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Abstract: It was acknowleged that a "cold" fusion reaction is not caused by only an intense "on-off effect" in deuterized palladium (Pd), but also even with a weak "on-off effect".

In addition to the Pd-cathode, the authors used Ni-cathode plasma-spray coated with Pd-powder. We found that this new-cathode was able to produce a "cold" fusion reaction of long duration, and this results will open a new field of study.

Key words: Cold fusion; on-off effect; spray-coated nickel cathode; ROI.

Introduction. The authors recently discovered that the phenomenon of an intense "on-off effect" occurs in a Pd-cathode during electrolysis in heavy water. The existence of such a phenomenon made possible, for the first time in the world, production of an intense "cold" fusion reaction.[1),2)] In order to produce "cold" fusion it is important to generate intense mobility in the deuterium contained in the Pd-cathode. It is currently thought that this "on-off effect" is the only way to provide accelerating energy on a continuous basis to the deuterium in the Pd-cathode.

In general, when deuterium diffuses into Pd, the amount and rate of heat generated are dependent upon the experimental conditions. The reaction heat due to the intense "on-effect" in a large Pd-cathode is high enough to push the temperature up to 110°C, higher than the boiling point of heavy water. As a result of this high temperature, an "off-effect" automatically occurs and causes rapid cooling of the Pd due to an endothermic reaction, at the same time producing an intense inner pressure in the deuterium diffused in the Pd. If the amount and rate of heat generation are not sufficient to push the temperature up to 110°C, this "on-off effect" is weaker, we termed this an "incomplete" or "weak on-off effect". This weak "on-off effect" is considered to be one of the important factors in the occurence of the weak "cold" fusion reaction.

We have tried new experiments in which a Ni-cathode thinly spray coated with Pd powder was used instead of a Pd-cathode. This Ni-cathode is termed "Ni*" in this text. We have discovered that Ni*-cathode also occurs "cold" fusion reaction. Authors expect that this results will open a new field of study. Here Pd and Ni* during the occurence of "cold" fusion are denoted as Pd● and Ni●*.

Experiment 1. The experiments were carried out with the equipment we used before.[1),2)] Pd-cathode was charged with a current of 50–100 mA/cm^2 for 3 days, after that the charge was stopped for 2 hours to polish the cathode surface. The total time required for charging and uncharging is regarded as 1 cycle of the experiment. When this experiment was repeated a large amount of neutrons were observed at 16th cycle. These fast neutrons discharged from the Pd●-cathode are changed into thermal neutrons with a paraffin block and then these thermal neutrons are measured using a BF_3 detector, as shown in Appendix.

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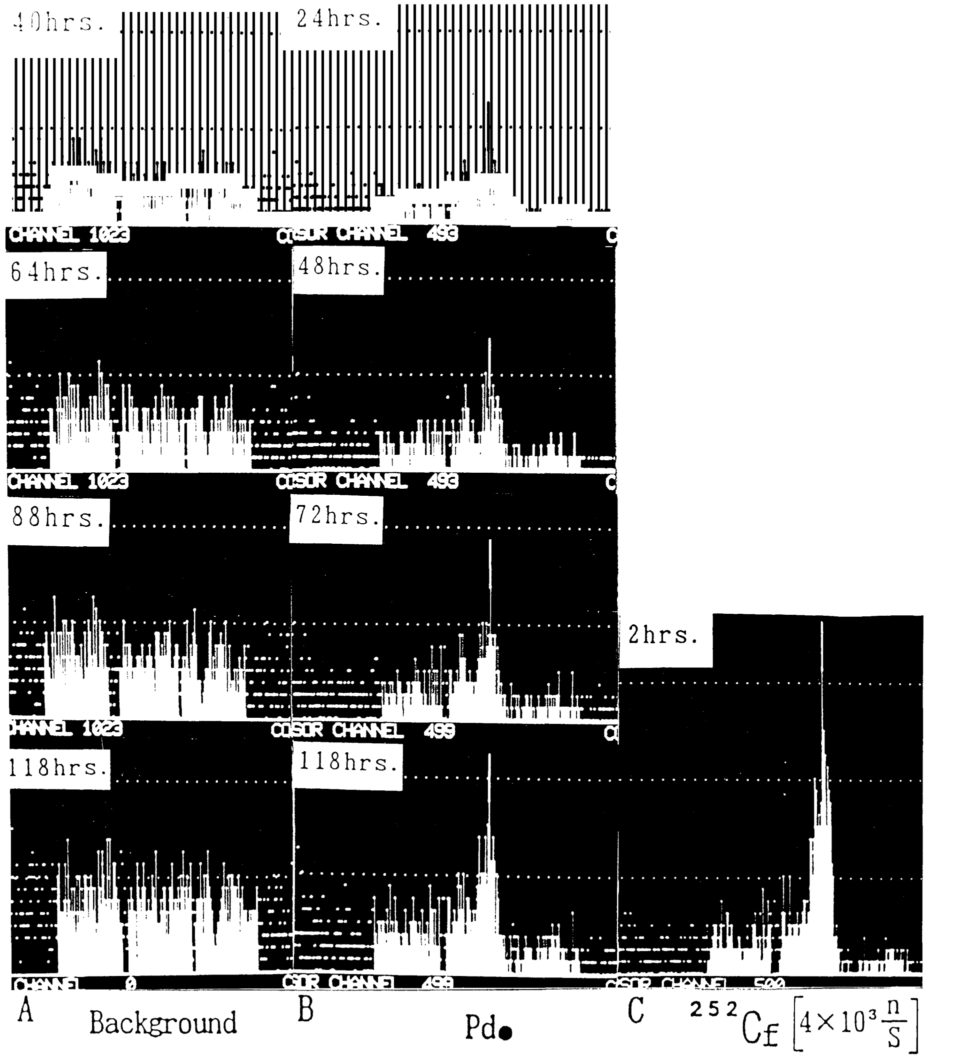

Fig. 1. Comparison of "N-patterns" from Pd●, ^{252}Cf, and a background using a multichannel analyzer (MCA-7800: 1024 channels) and BF_3-Ⓐ detector. (BF_3-Ⓐ: Mitsubishi ND-8523-A-90: ϕ14 mm×175 mm).
Note; A: Background, B: Pd● and C: ^{252}Cf.

These Pattern measured over a long duration were compared with Patterns from the background and standard neutron source ($^{252}Cf \simeq 4\times10^3$ n/s). The result of this comparison are shown in Fig. 1. In this report, the pattern obtained from a "cold" fusion reaction connected with the appearance of these neutrons will be referred to as the "neutron pattern" or "N-pattern" (ref. Appendix). Fig. 1 shows that "N-pattern" of Pd● is almost similar to that of ^{252}Cf. In order to make a quantitative comparison easily between these results, 101 channels (433–533), including the "particular channel" (517±3) corresponding to pulse

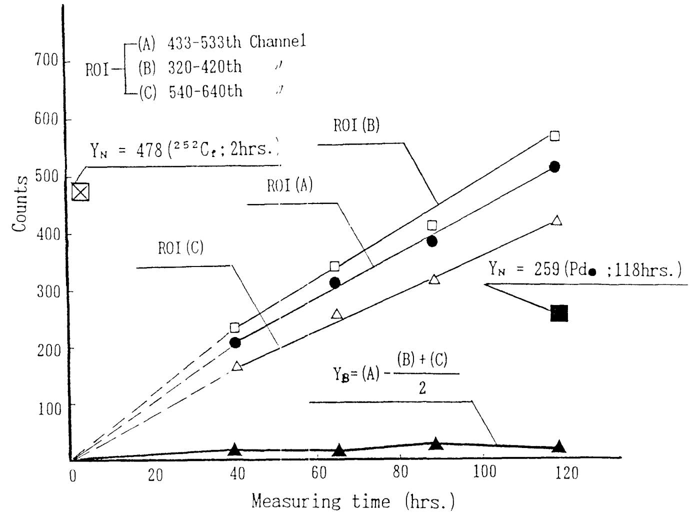

Fig. 2. The characteristics of background measured by BF_3-Ⓐ detector (ROI Ⓐ, Ⓑ, Ⓒ and Y_B for A (Background) indicated in Fig. 3).

height value 2.30 MeV, related with the characteristic of "N-pattern" are selected as "remarkable range", and it is labeled Ⓐ, the left side of Ⓐ; the range (320–420) is labeled Ⓑ and the right side of Ⓐ; the range (540–640) is labeled Ⓒ, as shown in Appendix.

These 3 ranges Ⓐ, Ⓑ and Ⓒ are denoted as "ROI" (Region of Interest). In this report 101 channels are designated as "ROI", but if a more clearer indication of neutron occurence is desired, it is possible to make "ROI", including the "particular channel", more wider or narrower by selecting "ROI" as a appropriate range for channels in a similar way to Ⓐ, Ⓑ, and Ⓒ above. The most important parameter for the "N-pattern" is neutron intensity discharged from $^{252}C_f$ and Pd●, which we call Y_N. This parameter is defined as follows;

$$Y_N = Ⓐ - \frac{Ⓑ + Ⓒ}{2}$$

If the values for ROI Ⓐ, Ⓑ, Ⓒ and Y_N are calculated for the "N-pattern", it can be accurately determined whether neutron emission has been achieved. Comparing the Appendix with the results shown in Fig. 2 and Fig. 4 shows that neutron emission was accurately observed. This means that the measurements obtained for the Pd● are also accurate and that the observed level of neutron discharge did occur, implying without a doubt that the phenomenon of "cold" fusion was observed.

The first in order to determine the characteristics of BF_3–Ⓐ detector we firstly obtained the characteristics of ROI Ⓐ, Ⓑ, Ⓒ of background and Y_B($=Y_N$ of background). Fig. 2 shows the relation between those characteristics and measuring time. Here Y_B zone exist along near horizontal time axis even if it can be taken positive or negative value ($\pm Y_B$) and changes with linear increasing. This is one of the important characteristics of the background. Fig. 2 also shows Y_N of Pd● and $^{252}C_f$($\simeq 4\times10^3$ n/s) which indicate 259 counts during the course of 118 hrs. and 478 counts during the course of 2 hrs., respectively. These Y_N values are larger far beyond Y_B. Calculation based on Y_N of $^{252}C_f$ be able to

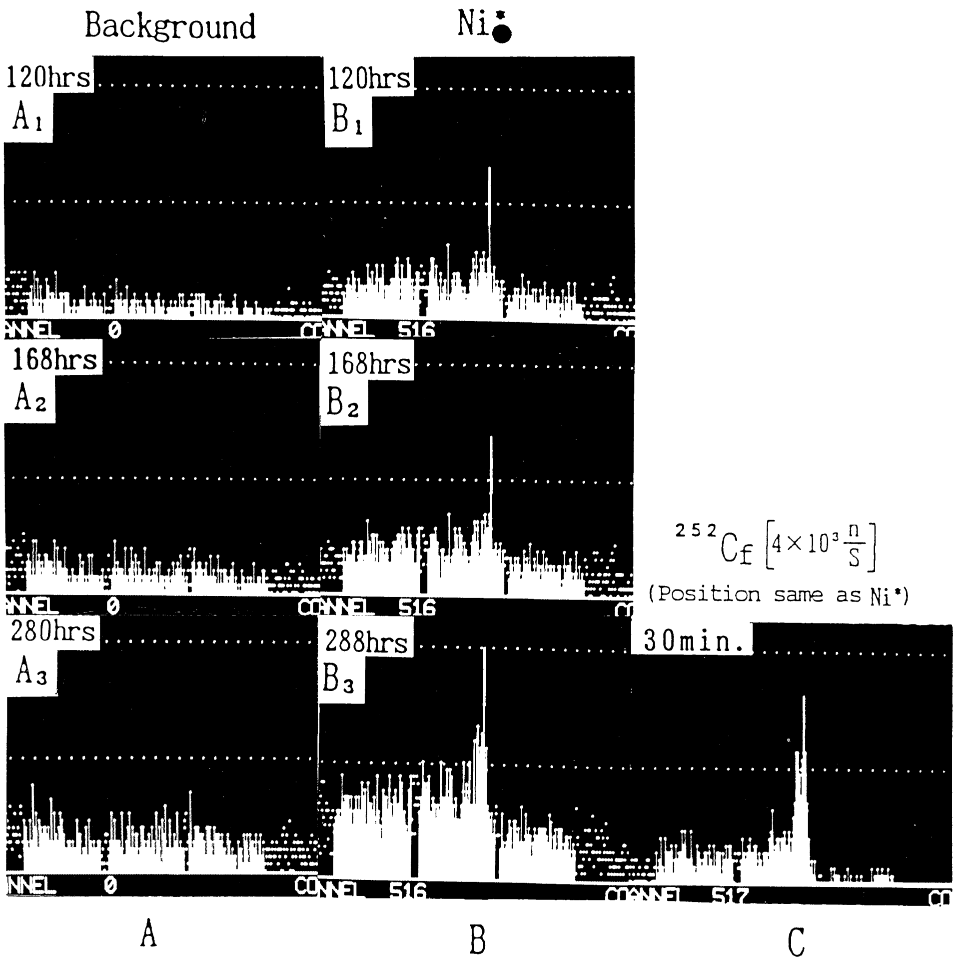

Fig. 3. Comparison of "N-pattern" from Ni*●. ^{252}Cf and background using BF_3-Ⓑ detector (Mitsubishi ND-8354-30: ϕ25 mm×348 mm).

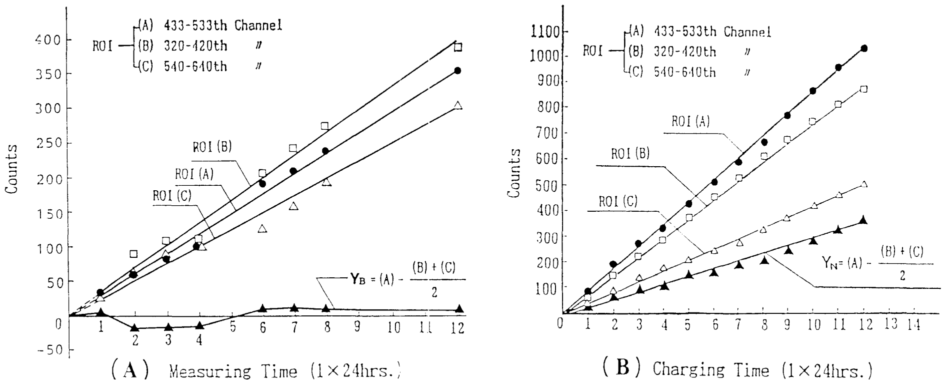

Fig. 4. (A) shows the characteristics of ROI Ⓐ, Ⓑ, Ⓒ and Y_B for the background using BF_3-Ⓑ and (B) shows the characteristics of ROI Ⓐ, Ⓑ, Ⓒ and Y_N of Ni*● using BF_3-Ⓑ detector.

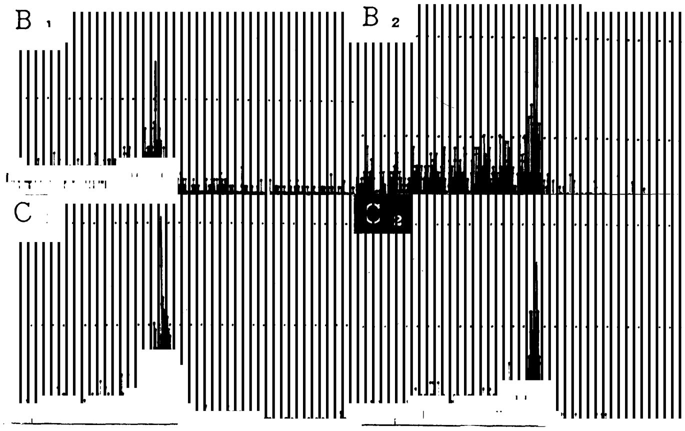

Fig. 5. After the "N-pattern" either of Pd● or Ni*● was measured with two detectors: BF_3-Ⓐ and BF_3-Ⓑ, the measured values are calibrated into the proper values decreased by their background value and then these values compared with the corresponding $^{252}C_f$.

show the neutron intensity discharged from Pd●, that is approximately 40 n/s.

Experiment 2. In Experiment 2, Ni-cathode is used in place of Pd in Experiment 1. Referenced matters of Experiment 2 including a cathode size (ϕ 20 mm×50 mm); equipment and conditions for the experiments, are designed to be the same as for Experiment 1. However, the surface of the Ni-cathode is coated by a 0.3 mm thickness with Pd-powder using a plasma jet. This coated cathode is termed Ni*. In Experiment 2, the BF_3-Ⓑ detector was used for 2 weeks without stopping. Fig. 3 shows Ni*● "N-pattern", $^{252}C_f$ "N-pattern" and background-pattern. If these patterns are compared with each other, it can be acknowledged that Ni*● "N-pattern" is quite similar to $^{252}C_f$ "N-pattern". For Ni*●-cathode Fig. 4 was obtained quantitatively from Fig. 3, by using a similar way as case of Fig. 2. (Ref. Appendix). The influence of the background is great to Ni*● "N-pattern", because this "N-pattern" was requested a long time in comparison with that of $^{252}C_f$. Fig. 5 shows the comparison between the real Ni*● "N-pattern" after removing of the part of background and $^{252}C_f$ "N-pattern" which is a little influence by background. If they are compared with each other, both of them look almost same. All these results obtained from Experiment 2 showed without a doubt that "cold" fusion could also take place in Ni*●-cathode.

Appendix. The Pd and Ni*-cathodes during occurence of "cold" fusion are denoted as Pd● and Ni*●. The neutrons emitted from this Pd● or Ni*●, must have an energy of 2.45 MeV. However, as these cathodes are generally surrounded by heavy water or light water (which is used for cooling of heavy water), some of them change into thermal neutrons. Therefore it is considered that the energy measured is actually dispersed. Accordingly it is not easy to make measurements of the neutron energy by "cold" fusion. The dispersion range of the neutron energy emitted into water from $^{252}C_f$, dispersed between 1–10 MeV, and it is set in heavy water at the same position as like as cathode itself, is assumed to increase more. Accordingly, one of the most reliable methods of detecting neutron generation is to utilize the characteristics of "thermal neutrons" (which changed

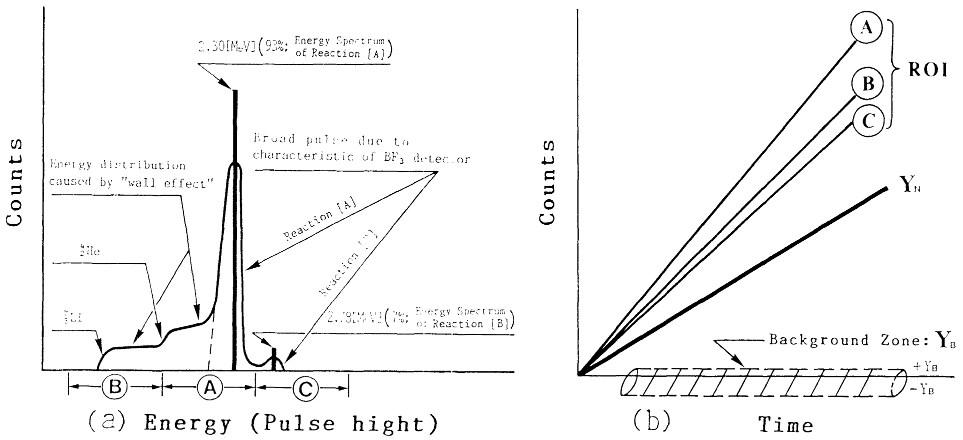

Fig. 6. Principle of measurements using BF_3 Neutron detectors (a) Characteristics of "N-pattern" (b) Characteristics of ROI Ⓐ, Ⓑ, Ⓒ, Y_N and Y_B.

from fast neutrons dispersed in various level of energy).

The fast neutrons from ^{252}Cf, $Pd_{\bullet}$, $Ni^{*}_{\bullet}$ or the background change into a "thermal neutron" and if a BF_3 detector is used in this case, they cause the two kinds of nuclear reaction mentioned below in the detector such that the energy spectrum from the fast particles (α, Li) obtained by these nuclear reactions is displayed.

$$B(n, \alpha)\ Li^{*} \text{ or } {}^{10}_{5}B+{}^{1}_{0}n={}^{4}_{2}He+{}^{7}_{3}Li^{*}+2.30 \text{ MeV.} \quad (A)$$
$$B(n, \alpha)\ Li \text{ or } {}^{10}_{5}B+{}^{1}_{0}n={}^{4}_{2}He+{}^{7}_{3}Li+2.78 \text{ MeV.} \quad (B)$$

It has been acknowledged that the probability of reaction (A) is about 93% and that of (B) is about 7%. Fig. 6 (a) shows the energy spectrums obtained from these reactions and the "actual pattern" obtained with a BF_3 detector. This pattern is here denoted as a "neutron pattern" or "N-pattern". In order to make a quantitative evaluation of "N-pattern", ROI Ⓐ, Ⓑ, Ⓒ and Y_N (or Y_B: Background) can be calculated by multichannel analyzer (MCA 7800) as shown in Fig. 6 (b), when the occurence of reaction is proportional with time elapsed.

The "N-pattern" of ^{252}Cf was used as the basis of comparison and was compared with the "N-patterns" of the $Pd_{\bullet}$ and $Ni^{*}_{\bullet}$. In this way it was possible to establish without a doubt that neutrons were emitted from the Pd and Ni*-cathodes due to "cold" fusion from a "D-D reaction", as the "N-patterns" of the $Pd_{\bullet}$ and $Ni^{*}_{\bullet}$ are almost identical with the "N-pattern" of ^{252}Cf.

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References

1) Arata, Y., and Zhang, Y.-C.: Kakuyogo kenkyu, J. Japan Soc. Plasma Sci. and Nucl. Fusion Research, **62**, 398 (1989) (in Japanese).
2) ——: Proc. Japan Acad., **66B**, 1–6 (1990).