8. "Cold" Fusion caused by a Weak "On-Off Effect"

By Yoshiaki ARATA, M. J. A., and Yue-Chang ZHANG^{*)}

(Communicated Feb. 13, 1990)

Introduction. The authors discovered a substantial "on-off effect" in a palladium cathode during continuous electrolysis of heavy water, and succeeded in utilizing the phenomenon to produce, for the first time anywhere in the world, an intense "cold" fusion reaction.^{1),2)}

What follows is a summary of the achievement of so-called "cold" fusion^{3),4)} through a weak "on-off effect". A necessary condition for a "cold" fusion reaction is the imparting of intense "mobility" to a strong build-up of deuterium within the Pd cathode. This leads us to consider the relation between deuterium mobility and the weak "on-off effect". Fig. 1 shows the specific relation between the deuterium content (D/Pd) and the temperature of the Pd cathode.

As deuterium penetrates the Pd cathode, variation can be seen in both amount of exothermic reaction and rate of heat generation under some conditions. At the high end, when the temperature of the Pd is brought past the boiling point of the electrolyte to 110°C or higher, an extreme increase occurs. This results in an explosive release of deuterium from the cathode surface ("off-effect") in an endothermic reaction. When the Pd cathode is cooled to 80°C, there is a rapid absorption of deuterium ("on-effect") in an exothermic reaction and the Pd temperature again rises. This complete cycle keeps repeating, generating a strong, spontaneous "on-off effect".^{1),2)}

However, when the amount or rate of heat generated by the exothermic reaction in the cathode is somewhat limited, causing an insufficient increase in temperature, an incomplete or weak "on-off effect" occurs. The result forms some processes of $a_0 \rightarrow a_{01} \rightarrow a_1$ or $a_0 \rightarrow a_{02} \rightarrow a_2$ (below boiling point: $T < T_B$), $a_0 \rightarrow a_{03} \rightarrow a_3$ (at boiling point: $T = T_B$), $a_0 \rightarrow a_{04} \rightarrow a_4$ or $a_5 \rightarrow a_{05} \rightarrow a_5$ (above boiling point: $110^\circ\text{C} > T > T_B$), and after that, the process takes the form of $a_2 \rightarrow a'_2$, $a_3 \rightarrow a'_3$, $a_4 \rightarrow a'_4$ or $a_5 \rightarrow a'_5$ and then, each of $a'_2 \sim a'_5 \rightarrow a_0$.

During electrolysis, when the current is switched off, deuterium is released from the Pd cathode in an endothermic reaction ("off-effect"), and when the current is on, deuterium is absorbed in an exothermic reaction ("on-effect"). These phenomena have been termed ["on-off" of the current] by authors,¹⁾ and what transpired was the incomplete, weak "on-off effect" described above, without major variation.

To clarify the relation between the achievement of "cold" fusion and the twin phenomena of the "on-effect" and "off-effect" in the weak "on-off effect", the following experiments were conducted.

Experiment 1. As an example of a weak "on-off effect", a process can take the form of $a_0 \rightarrow a_{01} \rightarrow a_1 \rightarrow a_0$, $a_0 \rightarrow a_{02} \rightarrow a_2 \rightarrow a'_2 \rightarrow a_0$, $a_0 \rightarrow a_{03} \rightarrow a_3 \rightarrow a'_3 \rightarrow a_0$, $a_0 \rightarrow a_{04} \rightarrow a_4 \rightarrow a'_4 \rightarrow a_0$ or $a_0 \rightarrow a_{05} \rightarrow a'_5 \rightarrow a_0$ in Fig. 1. That is, when electrolytic cell temperature repeatedly changed between 45°C and T_B (Boiling point); $45^\circ\text{C} \gtrless T_B$, after these several cycles, neutron emission was measured by two different de-

^{*)} Welding Research Institute, Osaka University, Ibaragi 567, Japan.

Fig. 1. Illustration of weak "on-off effect".

Fig. 2. Relation between the neutron emission and the weak "on-off effect".

tectors. One was a sealed type ^3He detector and the other was a sealed type BF_3 detector more sensitive than the former. Examples of these results are shown in Fig. 2. The important point is that this figure shows the simultaneous records of the two detectors, with almost totally consistent results for each measurement. Intense emission of neutrons from $\text{Pd}\bullet$ (Palladium in which "cold" fusion was induced during the electrolysis) is clearly seen in both detectors at the same time, indicated as A—A, B—B, and so on for each peak on the chart. The time of each corresponding peak coincides. It was discovered that the strong neutron emission from the $\text{Pd}\bullet$ is also possible even when the weak "on-off effect" is caused, though it is not essentially as intense as that of the complete, strong "on-off effect" (process; $a_6 \rightarrow a'_6$).^{1),2)}

Experiment 2. A great similarity was found in the rate of neutron emission between weak "on-off effect" and "on-off" of the current. Here, what we discovered was a close relationship between neutron emission from the $\text{Pd}\bullet$ and "on-effect" or "off-effect" as explained at the end of the "Introduction". We then

Fig. 3. Relation between the standard source ^{252}Cf and the "on-effect" of the current for the neutron emission which changes with time elapse. note: marked bar (569th channel) corresponds to channel of max. count rate of the neutron emission.

Fig. 4. Relation between max. neutron count rate at the marked bar (569th channel) and deuterized period for the "on-effect" of the current.

investigated what a multichannel analyzer "display" had recorded with time elapse during discharge of the large amount of neutrons from a "standard source" ^{252}Cf and $\text{Pd}\bullet$ activated by the "on-effect" of the current. When the Pd continued a strong absorption of a large amount of deuterium with certain repeated cycles: each cycle contained both processes of sending deuterium into the Pd for 3 days and polishing repeatedly the Pd for 2 hrs, neutron emission by this "on-effect" caused at the 7th and 8th cycle (that is, after about 20 days). Fig. 3 shows a

Fig. 5. Relation between the neutron emission and “off-effect” of the current.

record of the display. A) shows the pattern of neutron generation from ^{252}Cf . When “ τ ” is the recording period on the “display” (“linear” scale with full scale: 10^2) and the marked bar is 569th channel of the 1024 channels; A-1): $\tau=10$ min. A-2): $\tau=1$ hour and A-3): $\tau=2$ hrs. B) shows neutrons discharged from the $\text{Pd}\bullet$; B-1): $\tau=3$ hrs. B-2): $\tau=10$ hrs and B-3): $\tau=15$ hrs. C) shows the background activity; C-1): $\tau=3$ hrs and C-2): $\tau=20$ hrs. The numbers at upper right of the “display” indicate counts at the marked bar: 569th channel. Fig. 4 shows the relation between the max. count rate of the neutron emission at 569th channel (marked bar) and the charging time during the “on-effect” of the current. Fig. 5 shows a record of the display for the duration of just one hour resulting from “off-effect” activity, for neutron emission from the $\text{Pd}\bullet$. This “off-effect” was caused when the above described “on-effect” stopped. That is, these data were obtained during the hour which elapsed after the current was switched off.

Discussion. In the case of a small cathode such as “strip or foil”, a weak “on-off effect” may take place below the boiling point of the electrolyte (for instance, in the process $a_0 \rightarrow a_{03} \rightarrow a_3 \rightarrow a'_3 \rightarrow a_0$). In contrast, for a large cathode, an incomplete “on-off effect” will occur below 110°C (for example, in the process $a_0 \rightarrow a_{05} \rightarrow a_5 \rightarrow a'_5 \rightarrow a_0$). This effect is more powerful than the “on-off effect” for a small cathode. During the current’s “on-off effect” as described in Fig. 3, stronger emission of neutron is achieved by the “on-effect” than by the “off-effect”, as shown in Fig. 3 B) and Fig. 5, respectively.

Acknowledgements. We thank Prof. Y. Imai, M. J. A., and Prof. T. Nagamiya, M. J. A., for their helpful discussion and continuous encouragements.

References

- 1) Arata, Y., and Zhang, Y. C.: Kakuyugo Kenkyu. J. Japan Soc. Plasma Sci. and Nucl. Fusion Research, **62**, 398 (1989) (in Japanese).
- 2) —: Proc. Japan Acad., **66B**, 1–6 (1990).
- 3) Fleischmann, M., and Pons, S.: J. Electroanal. Chem., **261**, 301–308 (1989).
- 4) Jones, S. E. *et al.*: Nature, **338**, 737–740 (1989).