PERGAMON

International Journal of Hydrogen Energy 25 (2000) 513–516

International Journal of HYDROGEN ENERGY

Localized nuclear transmutation in PdH_x observed by Bockris and Minevski revealed a characteristic of CF phenomenon

Hideo Kozima*, Kunihito Arai

Cold Fusion Research Laboratory, Yatsu 597-16, Shizuoka, 421-1202, Japan

Abstract

In the Pd/H_2O electrolysis system, new elements, Mg, Cl, Fe, Al, Ca, K, and others, absent in the original system have been observed by Bockris and Minevski (Infinite Energy 1995–96:5 and 6:67) in the surface region of the metal hydride PdH_x cathode with a thickness of 2 μm up to 10% of the matrix element Pd. The data is analyzed using the TNCF model to give consistent explanation of these new elements by fission of nuclei formed from Pd isotopes in cathode by absorption of a thermal neutron. The parameter of the model, n_n is determined to be $n_n = 3.0 \times 10^{11}$ cm^{-3} consistent with the values determined by other experimental data in various events of CF phenomenon.

Keywords: Cold fusion; Metal hydride; Nuclear transmutation; Neutrons–protons cluster; TNCF model

1. Introduction

After earlier observations of events [1–5] of the cold fusion (CF) phenomenon including the excess heat, tritium, ^4He and neutron production, the nuclear transmutation (NT) has been observed in these five or six years. The appearance of foreign elements far away in the periodic table from the original elements in the system puzzled people to explain it. The easiest way to treat the phenomenon was to make the observation defect of faults of the experiments. Sincere scientists, however, have taken the data seriously and tried to give the explanation of the event based on the conventional physics or on the extension of the present knowledge of microscopic science.

The TNCF model for the CF phenomenon proposed by one of the authors (H.K.) in 1993 was one of these trials and applied to the NT as to other events in the CF phenomenon. The NT observed hitherto has been classified into two groups explained by (1) decay (NT_D) and (2) fission (NT_F) of nuclei formed from originally existing nuclei in the system by absorption of a thermal neutron abundant in the environment. The model has given a consistent explanation of whole events with only one adjustable parameter n_n and the result of the analyses has been compiled into a book, Ref. [6] and recent application of the model is given in Refs. [7,8].

In this paper, we analyze the data of NT in a palladium hydride PdH_x system obtained by Bockris and Minevski [9] as a result of reactions in solids including

* Corresponding author. Tel.: +81-54-278-0327; fax. +81-54-278-0327.

E-mail address: cf-lab.kozima@nifty.ne.jp (H. Kozima).

0360-3199/00/$20.00
PII: S0360-3199(99)00070-1

There are some experimental facts showing acceleration of nuclear reaction [in other words, enlarging the instability factor ξ of the model in the following Eq. (11) larger than one] in the surface layer of materials including the trapped neutrons. Taking this fact into consideration, we assume in the following analysis that the time constants of the above fission or decay reactions are all very short and can be taken to be zero in the calculation.

The number of events N_{A+1} in unit time and in unit volume of the reaction generating the unstable isotopes ${}^{A+1}_{46}\mathrm{Pd}^*$ is expressed in the TNCF model by the following relation [6–8];

$$N_{A+1} = 0.35 n_n v_n nPd\Sigma(\sigma_A P_A)\xi, \qquad (11)$$

where $0.35 n_n v Pd$ is the flow density of the trapped thermal neutron, n_n and v_n are the density and the thermal velocity of the trapped neutron, respectively. nPd is the initial density of the Pd atom ($= 6.88 \times 10^{22}$ cm^{-3}), σ_A and P_A are the cross sections of thermal neutron absorption for the above reaction and the natural abundance ratio of the isotope ${}^{A}_{46}$Pd, respectively. ξ is the instability factor of the trapped thermal neutrons and has been taken as one in the surface layer where the reactions occur [6].

The cross sections for the reactions are given in Ref. [12] on nuclear physics: $\sigma_A = 3.363$, 3.03×10^{-1}, 8.50, 2.27×10^{-1} b for A = 102, 106, 108 and 110, respectively. The summation in relation (11) is over A for unstable isotopes ${}^{A+1}_{46}\mathrm{Pd}^*$.

Using the data of a decreased number of Pd atoms, or the total number of generated atoms (Fe in the above reactions, for simplicity) assumed above, i.e. $N_{Fe} = 3.8 \times 10^{15}$ cm^{-3} and the branching ratio 0.054 of Fe generating reaction (calculated by the above reactions taking into ratios of Pd isotopes and cross sections of $n-{}^{A}$Pd reactions), we can determine the adjustable parameter n_n by relation (11) as follows:

$$n_n = 3.0 \times 10^{11}\ cm^{-3}.$$

This value should be taken with a possible change of the value by a factor of an order of one or two depending on factors used in the calculation. With this reservation, we can compare this value 3.0×10^{11} with the values of 10^{8}–10^{12} cm^{-3} determined by various data given in Ref. [6] and those determined by the data of the same group given in Refs. [10,11] 3.6×10^{7} and 1.5×10^{6} cm^{-3} by tritium [3] and tritium and helium [5] data, respectively. The rather small values [11,12] n_n of the last two cases are determined by values of tritium measured in long periods and mean the average values for the periods including intervals inactive for CF reactions.

It should be noticed that the nuclear products observed in the experiment [9] are not wholly explained quantitatively [e.g. Fe and Ca should be obtained equally from Eq. (6)] by the fission reactions written above induced by absorption of a single thermal neutron by the Pd atom in the surface layer. Furthermore, there are more elements observed than those in Eqs. (2)–(10). It is clear that these discrepancies should be explained by mechanisms other than the single neutron process expressed in Eq. (1). A possible extension to a process with multi-neutron absorption will be discussed in the next section.

4. Conclusion

In the ten years since the discovery of the cold fusion phenomenon in electrolytic systems with hydrogen isotopes, discussion on the reality of the phenomenon has lasted without interruption, although enthusiasm has recently decreased.

The main reason for this decrease is lack of unified explanation for various event in the CF phenomenon from the excess heat, tritium and ^{4}He generation to nuclear transmutation and for poor reproducibility.

The TNCF model proposed by one of the authors (H.K.) in 1993 at ICCF4 held in Hawaii has given phenomenological explanation of whole events with only one adjustable parameter, n_n, with several supplemental premises common to all events and materials. The fundamental assumption, existence of trapped thermal neutrons in appropriate materials, has been pursued using conventional physics and some new ideas about the neutron state in solids have been worked out [13] in accordance with phenomena in different branches of physics. The neutron band, the neutron Cooper pair in solids and the neutron cluster in the boundary region are some of the concepts deduced.

To explain the wide spreading mass spectrum of nuclear products observed in experiments [9,14], Fisher [15], used an idea of a polyneutron to realize multi-neutron absorption by nuclei in solids and gave a qualitative explanation of the mass spectrum. The existence of the polyneutron in the surface region where the products of NT observed as in the work [9] analyzed in this paper has not yet been confirmed by any other phenomenon.

The TNCF model has given, however, a possible mechanism of the formation of a polyneutron in the surface region [13]. Recent development of physics of the exotic nuclei [16] further suggest that there might be a formation of neutron–proton or neutron–deuteron clusters in the surface region where there are observed nuclear products of NT_F. This possibility suggested by CF experiments gives the inevitably important role of the hydrogen isotopes in the CF system not taken into consideration until now.

In addition to this, the model explains the poor reproducibility or, in other words, irreproducibility used as a proof of unreality of the CF phenomenon by critiques. The condition to realize an optimum situation of the specimen in the experiment is conditioned microscopically by processes induced there by the applied external action. The atomic process is inevitably stochastic, impossible to control quantitatively but statistically. Therefore, the expected reproducibility of the cold fusion phenomenon is qualitative and not quantitative as explained in Ref. [6] and papers [17,18]. This nature also reflects the variety of values n_n determined by observed values of CF events in various materials.

By the idea of the TNCF model for the CF phenomenon, the optimum condition in the electrolytic system is related intimately with the surface layer formation on the cathode and inclusion of hydrogen isotopes into the cathode. It is, therefore, not restricted to the deuterium system but to the protium system where the CF phenomenon occurs. It is also clear that both matching of the cathode material and the electrolyte and the mode of electrolysis are essential factors in realizing the optimum situation in the cathode. These features in the successful experiments have been widely recognized without an appropriate explanation which prevented the smooth growth of CF science and the development of CF technology.

The perspective of the CF phenomenon given by the TNCF model, physics of trapped thermal neutrons in solids including hydrogen isotopes with characteristic surface structure, will accelerate research in science and technology of this new phenomenon.

Acknowledgements

The authors would like to express their thanks to Prof. J. O'M Bockris for his valuable discussion on the cold fusion phenomenon including his data [9] and to Mr H. Yamamoto of Yamaha Motors Inc. for his help in copying the paper by Bockris and Minevski analyzed in this work.

References

[1] Fleischmann M, Pons S, Hawkins M. Electrochemically induced nuclear fusion of deuterium. J Electronanal Chem 1989;261:301.
[2] Jones SE, Palmer EP, Czirr JB, Decker DL, Jensen GL, Thorne JM, Tayler SE. Observation of cold nuclear fusion in condensed matter. Nature 1989;338:737.
[3] Packham NJC, Wolf KL, Wass JC, Kainthla RC, Bockris JO'M. Production of tritium from D_2O electrolysis at a palladium cathode. J Electronanal Chem 1989;270:451.
[4] Morrey JR, Caffee MR, Farrar IV H, Hoffman NJ, Hudson GB, Jones RH, Kurz MD, Lupton J, Oliver BM, Ruiz BV, Wacker JF, Van A. Measurements of helium in electrolyzed palladium. Fusion Technol 1990;18:659.
[5] Chien C-C, Hodko D, Minevski Z, Bockris JO'M. On the electrode producing massive quantities of tritium and helium. J Electronanal Chem 1992;338:189.
[6] Kozima H. Discovery of the cold fusion phenomenon — evolution of the solid state — nuclear physics and the energy crisis in the 21st century. Tokyo, Japan: Ohtake Shuppan Inc, 1998.
[7] Kozima H. Excess heat and helium generation in cold fusion experiments. Cold Fusion 1996;17:4.
[8] Kozima H, Watanabe S, Hiroe K, Nomura M, Ohta M, Kaki K. Analysis of cold fusion experiments generating excess heat, tritium and helium. J Electronanal Chem 425:173 and 445:223. There is a mistake in the errata. The author of this paper should be as written above, 1998.
[9] Bockris JO'M, Minevski Z. Two zones of "impurities" observed after prolonged electrolysis of deuterium on palladium. Infinite Energy 1995–96;5&6:67.
[10] Kozima H, Yoshimoto K, Arai K. First reliable tritium data by Packham et al. analyzed by TNCF model. Int J Hydrogen Energy 2000;25:505.
[11] Kozima H, Arai K, Yoshimoto K. Tritium and ^4He data by Chien et al. confirmed by the cold fusion phenomenon. Int J Hydrogen Energy 2000;25:509.
[12] Shibata K, Nakagawa T, Sugano H, Kawasaki H. Curves and tables of neutron cross sections in JENDL-2.3. JAERI-Data/Code 97-003, Japan Atomic Energy Research Institute, 1997.
[13] Kozima H, Arai K, Fujii M, Kudoh H, Yoshimoto K, Kaki K. Nuclear reactions in surface layers of deuterated solids. Fusion Technol 1999;36:337.
[14] Miley GH, Narne G, Williams MJ, Patterson JA, Nix J, Cravens D, Hora H. Quantitative observation of transmutation products occurring in thin-film coated microspheres during electrolysis. Progress in New Hydrogen Energy (Proc ICCF6), p. 629. Also Cold Fusion 20:71, 1996.
[15] Fisher JC. Liquid-drop model for extremely neutron rich nuclei. Fusion Technol 1998;34:66.
[16] Suzuki T, et al. Neutron skin of Na isotopes studied via their interaction cross section. Phys Rev Lett 1995;75:3241.
[17] Kozima H. The cold fusion phenomenon. International Journal of the Society of Materials Engineering for Resources (Japan) 1998;6(1):68.
[18] Kozima H. The TNCF model for the cold fusion phenomenon. The Best Ever! (Proc. ICCF7) (Vancouver, Canada), p. 192. Also Cold Fusion 26:4, 1998.