Transmutation

Analysis of Nickel - Hydrogen Isotope System on TNCF Model

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Abstract

Experimental results obtained in the Ni - H and Pd - H systems generating the excess heat and/or with transmutated nuclei (NT) were investigated on Trapped Neutron Catalyzed Fusion (TNCF) model proposed by one of the authors (K.H.).

Experimental results, which are not able to be explained by d - d or p - p reaction, are explained by n - p or n - ^{6}Li and the following breeding reactions on TNCF model assuming the existence of the trapped thermal neutron. The trapped neutron works also as a key particle to transmute elements in the system. As same as the excess heat, it is difficult to understand the NT without thermal neutron.

On TNCF model, excellent experimental data of excess heat and NT in the Ni - H and Pd - H systems are explained consistently and quantitatively.

1. Introduction

In addition to Pd - D and Ti - D systems, the Cold Fusion (CF) phenomena in Ni - H and Pd - H systems were reported. The CF phenomena have shown the generation of the excess heat, ^{4}He, tritium (t), neutron (n), nuclear transmutation (NT) and so on. In those nuclear products, tritium and NT show apparent facts of occurrence of nuclear reaction in the sample.

From our point of view based on TNCF model[1,2], NT is the evidence that neutron is the key particle causing the nuclear reaction.

In this paper, we will compare the results obtained in the excellent experiments that one showed the NT and another showed the excess heat production, and will show the consistent interpretation of the phenomena by TNCF model.

2. Summary of Experimental Data

2 - 1) A Experiment Showing Nuclear Transmutation in Ni - H System[3)]

The electrochemically induced nuclear transmutation in Ni - H system was reported[3)]. In this experiment, generation of the excess heat and shift of Sr isotope ratio (^{86}Sr/^{88}Sr $\equiv \eta$) were observed, using electrolysis of light water with electrolyte Rb_2CO_3 and RbOH.

Before the experiment, in cathode material of Ni, the relative percentages of two Sr isotopes were determined as ^{86}Sr (10.51 ± 0.04 %) and ^{88}Sr (89.49 ± 0.04 %); this gave the original value $1/\eta = 8.515 \pm 0.004$.

After the Experiment (I) where the excess energy Q_1 was detected, the percentages changed to ^{86}Sr (22.20 ± 0.05 %) and ^{88}Sr (77.80 ± 0.05 %); the ratio became $1/\eta_1 = 3.504 \pm 0.002$.

After the Experiment (II) where the excess energy was $Q_2 = 5\ Q_1$, the percentages changed to ^{86}Sr (26.80 ± 0.05 %) and ^{88}Sr (73.20 ± 0.05 %); the ratio became $1/\eta_2 = 2.731 \pm 0.003$.

2 - 2) Another Experiment in Ni - H System of Gas Phase[4)]

We took another experiment which showed excess heat production in hydrogen - loaded Ni rod in H_2 gas. In this experiment, an excess heat of 44 W was detected for a period of twenty - four days (corresponding to about 90 MJ) and no penetrating radiation (neutron, γ - rays) was detected.

2 - 3) Experimental Data of Patterson Power Cell[5)]

Patterson Power Cell (PPC), using microspheres (beads) coated with Pd - Ni layers and Li electrolyte with light water, accomplished a good qualitative reproducibility. The experimental data[5)] showed the output power of 1.77 W ($= 1.1 \times 10^{13}$ MeV/s) using 1200 microspheres which had a diameter of 1 mm, with 2 μm thickness of all metal layers.

3. Analysis of Experimental Data on TNCF model

Let us analyze these experimental results by TNCF model.

This model assumes the stable existence of the trapped thermal neutrons in crystal. Inhomogeneous distribution of hydrogen in sample metal, produced by specific chemical or gas loading method, and surface layers of the electrolyte work to trap the thermal neutrons in the sample. The trapped thermal neutron exists stable against β - decay.

When the trapped thermal neutron suffers a strong perturbation induced by disorder of the crystal potential, the trapped neutron fuses with a proton (deuteron) to generate a deuteron (tritium) and gamma and also with minor elements to transmute the elements to show a change of isotope ratio.

Possible mechanisms of the neutron trapping were discussed in previous papers in detail[1,2)].

3 - 1) Analysis of the Experiment Showing Nuclear Transmutation in Ni - H System

We will give a result of analysis of the experiment[6)] showing nuclear transmutation[3)].

Assuming the existence of the trapped neutrons, there occurs nuclear reaction between the neutron and nuclei (hydrogen isotope or minor elements in Ni cathode). For nuclear reactions between neutron and nucleus of minor elements in Ni cathode, a nucleus absorbed the neutron forms an intermediate nucleus which may decay by β emission. In this case of nuclear transmutation, we can write down the reactions as follows:

$$n + {}^{85}\mathrm{Rb} = {}^{86}\mathrm{Rb} = {}^{86}\mathrm{Sr} + e^- + \bar{\nu}_e, \tag{1}$$

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$$n + {}^{87}\text{Rb} \ = \ {}^{88}\text{Rb} \ = \ {}^{88}\text{Sr} + e^- + \bar{\nu}_e. \tag{2}$$

Denoting natural abundance of ^{85}Rb and ^{87}Rb as N_a (72.15 %) and N_b (27.85 %), ^{86}Sr and ^{88}Sr as n_a (10.51 %) and n_b (89.49 %), the ratio η after the n - Rb fusion reaction in the experiment will be given by a relation,

$$\eta = \frac{n_a + n_n v_n T_i \xi \sigma_a N_a}{n_b + n_n v_n T_i \xi \sigma_b N_b}. \tag{3}$$

where $n_n v_n$ is the flux density of the thermal neutron ($\text{cm}^{-3}\text{s}^{-1}$), v_n is the thermal velocity of the trapped neutron, T_i is the time of electrolysis in the experiment i (i = 1, 2), ξ is ratio of number density of Rb and Sr, σ_j (j = a, b) is fusion cross section; $\sigma_a = 0.7$ and $\sigma_b = 0.2$ barns. The thermal velocity is given as $v_n = 2.7 \times 10^5$ cm/s (for 300K).

Using the relation (3), we can calculate the neutron density. With the numerical values corresponding to experiments (I) and (II), we obtain following values for $n_n v_n T_i \xi$; $n_n v_n T_1 \xi = 0.307 \times 10^{24}$ and $n_n v_n T_2 \xi = 0.459 \times 10^{24}$ cm^{-2}, respectively.

Taking an average value for $n_n v_n T_i \xi$, ($< n_n v_n T > \xi = 0.38 \times 10^{24}$ cm^{-2}), we can obtain the value $n_n T \xi$ as follows:

$$n_n T \xi \ = \ 1.4 \times 10^{18} \ \text{cm}^{-3}\text{s}.$$

If we assume $\xi = 1$ and $T = 2.59 \times 10^6$ s (one month) arbitrarily, we obtain the density of trapped neutron in Ni cathode:

$$n_n = \ 5.4 \times 10^{11} \ \text{cm}^{-3}.$$

3 - 2) Analysis of the Experiment in Ni - H System of Gas Phase

Next, we will give a result[7] of the case of Ni - H system in gas phase[4]. We assume a following reaction between the trapped neutron and occluded hydrogen in Ni:

$$n + p \ = \ d \ (1.3 \ \text{keV}) + \gamma \ (2.2 \ \text{MeV}). \tag{4}$$

If all of observed excess energy was generated by this reaction, the number of events is estimated as $\nu = 1.25 \times 10^{14}$ s^{-1}.

We can estimate the trapped neutron density n_n using the following relation,

$$\nu \ = \ 0.35 n_n v_n N_p \sigma_{n-p}, \tag{5}$$

where $0.35 n_n v_n$ is the flux density of the thermal neutron ($\text{cm}^{-3}\text{s}^{-1}$), v_n is the thermal velocity of the trapped neutron as above, N_p is the number of occluded protons in the sample ($N_p = 3.0 \times 10^{21}$), σ_{n-p} is the fusion cross section of the thermal neutron and a proton; $\sigma_{n-p} = 0.13$ barns.

Thus, we obtain the value of the density of trapped neutron,

$$n_n = \ 3.0 \times 10^{12} \ \text{cm}^{-3}.$$

This value can be compared with the result we got in section 3 - 1). The assumption of the existence of a number of the trapped thermal neutron in Ni has given a consistent value of the density of the trapped neutrons $n_n \simeq 10^{12}$ and a unified interpretation of both of nuclear transmutation and excess heat generation.

If breeding reactions occur after the reaction mentioned above effectively, tritium will be produced by the following reaction:

$$n + d = t\ (6.98\ \mathrm{keV}) + \gamma\ (6.25\ \mathrm{MeV}). \tag{6}$$

In an optimum situation where the gamma is absorbed effectively in the sample[8], the excess heat becomes large, while tritium is only the detected byproduct in the situation where the absorption is scarce. In this experiment[4], however, tritium was not observed.

3 - 3) Analysis of the Patterson Power Cell

In the case of PPC, surface layers of $PdLi_x$ (or $NiLi_x$) alloy and Li metal will be formed on the surface of the microsphere. We assume only PdLi (NiLi) alloy layer with the thickness $l = 2\ \mu$m in the following analysis.

Then, we can obtain the density of trapped neutron n_n in PdLi layer. We will take up the main reaction of excess heat generation, as follows:

$$n + {}^6\mathrm{Li} = {}^4\mathrm{He}\ (2.1\ \mathrm{MeV}) + t\ (2.7\ \mathrm{MeV}). \tag{7}$$

The number of events per unit time denoted by ν is estimated as follows; $\nu = 1.1 \times 10^{13}$ (MeV/s) / 4.8 (MeV) $= 2.3 \times 10^{12}$ (/s).

On the other hand, the number of events per unit time ν is expressed as follows:

$$\nu = 0.35 n_n v_n \rho_{Li6} V \sigma_{nLi6}. \tag{8}$$

In this relation, ρ_{Li6} is the density of ^{6}Li in PdLi alloy. σ_{nLi6} is the fusion cross section. V is the total volume of PdLi alloy on the surface of 1200 microspheres.

In PdLi alloy, we can take the value of ρ_{Li} as follows; $\rho_{Li} = \rho_{Li6} + \rho_{Li7} = 3.4 \times 10^{22}$ cm^{-3}. The natural abundance of ^{6}Li and ^{7}Li are 7.5 % and 92.5 %, respectively, and therefore $\rho_{Li6} = 2.6 \times 10^{21}$ cm^{-3}.

Using the value $V = 1.6 \times 10^{-3}$ cm^3 and $\sigma_{nLi6} = 1.0 \times 10^3$ barns, the density of trapped neutron n_n is estimated as follows:

$$n_n = 6.0 \times 10^9\ \mathrm{cm}^{-3}.$$

The detail including discussion about breeding of neutrons is reported in the previous paper[9] where an important role of deuterium in Pd - Ni - H_2O + LiOH system was pointed out.

4. Conclusion

In the experiments with hydrogen analyzed in this paper, it was observed that there occurred generations of excess heat and transmutated nuclei. While it has been considered that the hydrogen substitute the deuterium for a reference system, the experimental data analyzed successfully and interpreted as real phenomena substantiate the cold fusion phenomena in the system with hydrogen.

As we have seen, both trapped neutron densities of two experiments in Ni - H system showed approximate coincidence.

Thus, if we allow to assume the existence of stable thermal neutron in crystal, we can explain various CF phenomena showing nuclear transmutation, excess heat generation, tritium production, He production and etc. occurred in several systems along conventional physics by only one adjustable parameter of trapped neutron density.

The TNCF model has been developed to fit various phases and systems of CF phenomena. We have got more than 15 results of analysis of experiments showing CF phenomena in several systems including Pd - D and Ti - D and so on, hitherto. The densities of the trapped thermal neutrons determined from analysis of experiments were in a range of $10^2 \sim 10^{12}$ cm^{-3} [10].

In reverse, the success of analysis on TNCF model shows the reality of trapped thermal neutron in crystal. The other three papers[11~13] given in this conference will help to understand the physics of the cold fusion.

References

(1) H. Kozima, *Trans. Fusion Technol.* **26**, 508 (1994).
(2) H. Kozima, *Cold Fusion* **16**, 4 (1996); *Proc. 3rd Russian Conference on Cold Fusion and Nuclear Transmutation (RCCFNT3)* (Sochi, Russia, Oct. 2 - 6, 1995), 224 (1996).
(3) R. Bush and R. Eagleton, *Trans. of Fusion Technol.* **26**, 344 (1994).
(4) S. Focardi, R. Habel and F. Piontelli, *Nuovo Cimento* **107A**, 163 (1994).
(5) D. Cravens, *Cold Fusion* **11**, 15 (1995) and also *Proc. ICCF-5* (1995) 79.
(6) H. Kozima, K. Hiroe, M. Nomura and M. Ohta, *Cold Fusion* **16**, 30 (1996).
(7) H. Kozima, *Cold Fusion* **8**, 5 (1995); M. Ohta, M. Nomura, K. Hiroe, H. Kozima, "On the Cold Fusion in Ni - H System (II)", *Cold Fusion* (to be published).
(8) H. Kozima, *Cold Fusion* **15**, 12 (1996).
(9) H. Kozima, *Cold Fusion* **17**, 8 (1996).
(10) H. Kozima, *Proc. 3rd Symposium of Basic Reseach Group in NHE Project* (July 3 - 4, 1996, Tokyo, Japan), 17 (1996) and also *Cold Fusion* **18**, 30.
(11) H. Kozima, "On the Existence of the Trapped Thermal Neutron in Cold Fusion Materials" (in this issue).
(12) H. Kozima, K. Hiroe, M. Nomura and M. Ohta, "Analysis of the Electrolytic Cold Fusion Experiments on TNCF Model" (in this issue).
(13) H. Kozima, M. Nomura, K. Hiroe and M. Ohta, "Nuclear Transmutation in Cold Fusion Experiments" (in this issue).