TNCF Analysis of Excess Heat in Ni/H/K System

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Synopsis

Both a pioneering measurement of the excess heat and a precision replication of the apparent excess heat effect in Ni-H_2O-K_2CO_3 electrolytic cells were analyzed by the TNCF model with success. Mills and Kneizys observed the exress beat ~ 0.13 W from Ni plate cathodes (7.5 x 5 cm^2 x 0.125 mm) in the electrolysis of H_2O + 0.57 M K_2CO_3 solution with high qualitative reproducibility. On the other hand, a group in NASA checked the excess heat generation in a similar system provided from Hydrocatalysis Corporation (HPC). A Ni cathode of long (5 x 10^3 m) and thin (0.5 mmø) wire was used in the system with the same electrolytic solution as Mills et al. The maximum excess heat production measured in this experiment was 11.4 W when the input energy was 59.6 W. The TNCF analysis of both data assuming *n* - *p* reaction in volume instead of in the surface layer gave 3.4 x 10^{10} and 1.4 x 10^9 cm^{-3} for the density *nn* of the trapped neutron, respectively.

1. Introduction

The TNCF model for the cold fusion phenomenon has been used to explain various events measured in materials containing hydrogen isotopes with a great success[1-3]. There have been too many experimental data to treat in a short time since the accomplishment of the model about two years ago. We are going to analyze with the TNCF model remaining excellent data obtained in these 8 years after the discovery of this phenomenon[4]. The pioneering experiment[4] of the cold fusion itself was already done by the TNCF model[5] and the perplexing complex relations among observed quantities were disclosed clearly.

The system Ni/H/K has been used successfully in the cold fusion experiment[6-11] giving interesting results of the excess heat[6-9] and nuclear transmutation (NT)[10,11]. The data of the excess heat[7,8] and NT[10] were analyzed by the TNCF model[12-14] consistently with values of the parameter n_n = 3 x 10^{12}, 9 x 10^9 and

1.4×10^9 cm^{-3}, respectively

Another system with a Ni cathode, light water H_2O and an electrolyte Rb_2CO_3 was used in a cold fusion experiment[15]. In the experiment, there were observed the excess heat Q and a change of isotope ratio $^{88}Sr/^{86}Sr$ correlated with the amount of Q. The TNCF analysis of the data[16] gave a quantitative explanation of the experimental data. The parameter n_n determined from the experimental data was $n_n = 1.6 \times 10^7$ cm^{-3}. In addition to these electrolytic systems, there are discharge systems with H_2 gas where observed the excess heat. One of the data[17] was analyzed with the TNCF model and the parameter n_n was determined: $n_n = 4 \times 10^9$ cm^{-3}.

In this paper, we have taken up the pioneering data obtained by Mills and Kneizys[6] and the precision measurement by Niedra et al.[9] of th excess heat generation from Ni/H/K system. The results are consistent with data obtained before showing again the ability of the model to interpret the cold fusion phenomenon.

2. Experimental results

2.1 Data by Mills and Kneizys[6]

Mills and Kneizys made a pioneering experiment on $Ni/H_2O(K_2CO_3)$ electrolyte system to measure the excess heat with Ni plate cathode. Though the interpretation of the result by their model is not necessarily persuasive, the experimental result has been confirmed by many researchers including Notoya et al.[10] analyzed in a preceding paper[14] and Niedra et al.[9] analyzed in the next subsection.

Their Ni cathode was with a size 7.5 cm x 5 cm x 0.125 mm in H_2O + 0.57 M K_2CO_3 (100 m*l*) and produced the excess heat of 0.13 W with good qualitative reproducibility. In the case of another electrolyte Na_2CO_3, there was no excess heat at all.

2.2 Data by Niedra et al.[9]

A group in NASA checked the excess heat generation in $Ni/H_2O(K_2CO_3)$ system provided from Hydrocatalysis Power Corporation (HPC), where the set used in this experiment had given a result of the excess heat 50 W when input energy was 59.6 W. A long (5×10^3 m) and thin (0.5 mmø) Ni wire was used as the cathode in the system with the electrolytic solution of H_2O + 0.57 M K_2CO_3 (volume of the solution was 28*l*). Careful check of calorimetry was conducted for the exact replication of the excess heat production by NASA group.

The maximum excess heat production measured in this experiment was 11.4 W when the input energy was 59.6 W compared with the referred value 50 W measured before in HPC with the same sample size.

3. Analysis of the Data by the TNCF Model

Using the recipe described in the preceding papers[1-3], we can explain the data of the too large excess heat to explain by any chemical reaction obtained by Mills and Kneizys[6] and by Niedra et al.[9] The TNCF model assumes existence of the trapped thermal neutron with a density n_n in a sample as an adjustable parameter.

The nuclear reactions responsible to the excess heat generation in Ni/H/K system are considered as follows:

$n+p=d\,(1.33\,\text{keV})+\gamma(2.22\,\text{MeV})$, (1)
$n+d=t\,(6.98\,\text{keV})+\gamma(6.25\,\text{MeV})$, (2)
$t\,(6.98\,\text{MeV})+d=$
$^4\text{He}\,(3.5\,\text{MeV})+n\,(14.1\,\text{MeV})$. (3)

The cross sections of these reactions are 3.32×10^{-1}, 5.5×10^{-4} for thermal neutron and 3.04×10^{-6} barn, respectively.

The neutron with 14.1 MeV generated in the reaction (3) can induce a dissociation of deuteron by the following reaction with a cross section 0.18 barn:

$$n\,(14.1\text{MeV})+d=n+p+n. \quad (4)$$

Number of reactions N_N between the trapped thermal neutron and a nucleus N is calculated by the following formula:

$$N_N=0.35 n_n v_n n_N V \sigma_{nN} \xi, \quad (5)$$

where $0.35n_n v_n$ is the flow density of the neutron per unit area and time, n_N is the density of the nucleus, the thermal velocity $V_n = 2.2 \times 10^5$ cm/s (300 K), V is the volume where the reaction occurs, σ_{nN} is the fusion cross section for the reaction. The factor ξ as taken into this relation expresses an order of the stability of the trapped neutron in the reaction region. In the surface layer of the alkali metal in the electrolytic system, ξ was taken as 1 while in volume of Pd, Ti and Ni, it was concluded that $\xi = 0.01$ is reasonable[14].

In the analysis given in the following sub-sections, we assume only the reaction (1) in volume as a source of the excess heat. Also assumed is that the whole energy liberated in the above reaction is thermalized in the system and measured in the experiment.

3.1 Analysis of the data by Mills and Kneizys

The data obtained by Mills and Kneizys[6] with good qualitative reproducibility was analyzed using the $n-p$ reaction (1) in volume of the sample assuming H/Ni = 1.0 and $\xi = 0.01$ in the relation (5). The density of the trapped neutron was determined by the relation (5) as follows:

$$n_n = 3.4 \times 10^{10}\ \text{cm}^{-3}.$$

It is remarked that the surface to volume ratio S/V of the cathode in this experiment is 160 cm^{-1}.

3.2 Analysis of the data by Niedra et al.

The data obtained by Niedra et al.[9] was analyzed as above assuming $n-p$ reaction (1) with $\xi = 0.01$ in the relation (5). The result gives the following value for the density n_n of the trapped neutron: $n_n = 1.4 \times 10^9\ \text{cm}^{-3}$.

In the case of the excess heat of 50 W obtained in the same system by HPC (described in the paper[9], the density of the trapped neutron becomes as $n_n = 4 \times 10^{10}\ \text{cm}^{-3}$.

The S/V ratio of the cathode in this experiment is 80 cm^{-1}.

4. Conclusion

The result of the analyses of two independent experiments with Ni/H/K system gave very similar values for the arbitrary parameter n_n — the density of the trapped neutron — of 3.4×10^{10} to 1.4×10^9 (4×10^{10}) cm^{-3}. The value n_n determined[14] for the experiment of the same system, which observed the number of nuclear transmutations[10] was 1.4

x 10^9 cm^{-3}, the same to the value from the data by Niedra et al.[9]. This accordance is perfect but may be by accident. Anyway, it is better to have coincidence than discrepancy.

The accurate and careful measurements of quantities in the systems composed of Ni and light water H_2O with electrolyte K_2CO_3 or Rb_2CO_3 have verified the existence of some events of the cold fusion phenomenon — generation of the excess heat, tritium and nuclear transmutation — in these systems. Those data have been analyzed in the present and preceding papers and the results have given a consistent understanding of the events occurring in the cathodes of these systems. It is now clear that the cold fusion phenomenon occurs in a system not only with heavy water as first discovered but also with light water. The cathode material occluding hydrogen isotopes is not limited to Pd and Ti but includes Ni which is more abundant than the former.

Our TNCF analyses of data applied to various systems of Pd, Ti and Ni and with D or H for different observables have given a very consistent interpretation using only one parameter nn. This success probably shows something is true in the TNCF model related with the physics in the cold fusion materials. We can take the TNCF model as a working hypothesis to disclose the truth hidden in solids with hydrogen isotopes through the cold fusion phenomenon.

An interesting feature of the results of the analysis is a relation between the qualitative reproducibility and the surface-to-volume ratio S/V observed in the electrolytic systems. In the case of reproducible data analyzed in this paper, S/V ratios are 160 (Mills et al.) and 60 (Niedra et al.) in contrast to a value 6 of the cathode of the massive cubic one used in the first cold fusion paper[4] with huge excess heat but very poor reproducibility.

In general, the larger the S/V ratio becomes, the higher the qualitative reproducibility is. This tendency shows its existence in many experiments including typical examples of Arata's Pd black[18], Patterson's beads[8], Celani's and Celluci's thin wires[19,20].

Another feature appeared in experience is matching of the cathode and the electrolyte effective to realize the cold fusion phenomenon. As is generally recognized empirically, Pd-Li and Ni-K (Rb) are the best combinations in the electrolytic experiment of cold fusion phenomenon. A result of these combinations will be the condition for formation of the alkali metal (or alloy) layer on the cathode surface. Another possible result might be a relation among the neutron affinities of matrix metal, solute hydrogen isotope and electrolyte: the average neutron affinities are 1.2 (Ti), 3.9 (Ni) and 26.5 (Pd); 2.22 (H) and – 0.02 (D); and - 14.8 (Li), – 5.51 (Na), – 1.5 (K) and – 2.7 (Rb).

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