Analysis of Excess Heat Generation in a Proton Conductor

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Synopsis

A careful observation of the excess heat generation in a proton conductor $SrCe_{0.9}Y_{0.08}Nb_{0.02}O_{2.97}$ in D_2 gas at about 400 °C was analyzed using the TNCF model. Small but definite relative excess heat generation at most 0.7 to 0.8 % had been confirmed using a newly constructed Seebeck calorimeter in a small number of disk samples of a dimension 2 cmø x 0.1 cm coated with thin (~300 nm) surface layer of Pd (or PtMo) metal. The data was analyzed on the assumption that the excess heat was generated by reactions of the trapped neutron with nuclei in the volume and in the surface layer of Pd (PtMo) and the whole liberated energy is thermalized in the system. The experimental results including the excess heat without d.c. power were explained consistently. The density of the trapped neutron was determined by the experimental data as nn = 4.0×10^{10} cm^{-3} which is in the middle of the values determined in other cold fusion materials.

1. Introduction

In cold fusion materials the proton conductor has characteristics different from others, for instance transition metals occluding hydrogen isotopes. The proton conductor belongs to ceramics and their high melting points seems to be advantageous as a substance to be used in a cold fusion pile. Hydrogen isotopes in the proton conductor have rather higher mobility and therefore the mechanism of the excess heat generation might be different from that in the hydrogen occluding metals.

Difficulty in the calorimetry for the proton conductor made the experimental data rather qualitative and out of the object of our theoretical analysis. Oriani[1,2], however, made very careful measurements of the excess heat Q using the Seebeck calorimeter and confirmed the relative amount of the excess heat as 0.7 to 0.8 %, or 0.7 W in optimal cases, though the production occurred only in a small ratio in the total experiments.

We will analyze the experimental data on the TNCF model[3-4] assuming that the mechanism of the excess heat generation is the same in this case as that in the transition metal occluding hydrogen isotopes. The result of our analysis showed a consistent explanation of the phenomenon including the excess heat generation, poor reproducibility, long preparatory drive and heat generation without current.

2.Experimental Results

In the recent papers[1,2], Oriani had pointed out two problems in the isoperibolic calorimeter used widely in the experiments hitherto preventing the verification of excess heat generation. The two problems are summarized as follows: First, the steady-state thermocouple reading did not show the correct expected value when alternating d.c, power was applied to the specimen and produced a spatial distribution of input power from that during calibration. Second, a change in the composition of the gas phase within the reactor caused a significant change of steady-state temperature.

To avoid these problems in the determination of the excess heat generation in ceramics, he had constructed a new Seebeck calorimeter operating at 400 °C[1]. Using the Seebeck calorimeter, he determined the amount of the excess heat in a proton conductor $SrCe_{0.9}Y_{0.08}Nb_{0.02}O_{2.97}$ in D_2 gas at about 400 °C . The sample had a shape of a disk with dimensions of 2 cmø x 0.1 cm and the faces of the disk had been thinly (300 nm) coated with metal, either Pd or PtMo.

Two of these specimens described above produced positive deviations from the calibration curve by more than four standard deviations so that thermal power was produced that was greater than the d.c. power of alternating polarity supplied to the specimen. The amount of the excess power was 0.7 W in both cases or relative amount of 0.7 and 0.8% of the input power.

There are some typical features of the cold fusion phenomenon in these experimental results: (a) The poor reproducibility, (b) the preparatory drive was sometimes necessary without any events and (c) some events without input power. We will allow the author to tell the results himself[1].

(a) "It is clear that the ratio of experiments that can claim success in generating excess power to those which yield only points lying on the calibration line is small," the author says.

(b) The author also explains about the preparatory drive necessary for the excess heat generation in some case, "It is also worth recording that Run B developed excess power only after some days, during which the determinations were on the calibration line, after which a lengthy, high-temperature continuous evacuation of the reactor and heating of the vacuum lines were carried out."

(c) Here is also an explanation of the events without input power by the author, "In several episodes excess power was produced without supplying any d.c. power."

In the next section, we will explain these features of the excess heat generation in the proton-conducting oxide on the TNCF model.

3.Analysis of the Experimental Data

The TNCF model[3-4] assumes an existence of the trapped neutrons in the cold fusion materials. The neutron is supposed to be fairly stable and only fuses with foreign nuclei which are in the boundary layer where the neutron suffers large perturbations and becomes unstable (in the classical sense). An analysis[7] of tile experimental data where observed the nuclear transmutation at room temperature[8] showed that the stability of the trapped neutron in the volume of the material is higher by a factor of 10^2 compared with at the boundary. On the other hand, an assumption of the fusion reaction in the volume similar to that in the boundary layer gave a reasonable value for the density n. at higher temperatures up to 2000 °C[9]. Therefore, we will use the same relation we have used for the reactions in the surface layer and in the volume in analysis of the data[1,2] taken at 400 °C.

We will treat the excess heat generation in the proton conductor as follows.

The number of events N_x in a time τ of the fusion reaction between the trapped neutron and the nucleus x is given by a following relation:

$$N_x = 0.35 n_n v_n \rho_x V s_{nx} \tau \xi. \qquad (1)$$

In this relation, $0.35 n_n v_n$ is the neutron flux per unit area and time, ρ_x is the density of the nucleus x in the volume V, ρ_{vx} is the cross section of the fusion reaction. The factor ξ is introduced to signify the stability of the neutron and is 1 in the surface layer and 0.01 in the volume as shown in the analysis[7] of the experimental data in a porous Ni[8].

Considering abundance and fusion cross section of the nucleus, the effective reactions in the volume of the sample $SrCe_{0.9}Y0Nb_{0.02}O_{2.97}$ could be taken as follows:

$$n + d = t + \gamma(6.25\ \mathrm{MeV}), \qquad (2)$$

$$n + {}^{86}\mathrm{Sr} = {}^{87}\mathrm{Sr} + \gamma(8.42\ \mathrm{MeV}), \qquad (3)$$

$$n + {}^{87}\mathrm{Sr} = {}^{88}\mathrm{Sr} + \gamma(11.1\ \mathrm{MeV}), \qquad (4)$$

$$n + {}^{140}\mathrm{Ce} = {}^{141}\mathrm{Ce} + \gamma(5.45\ \mathrm{MeV}), \qquad (5)$$

$$n + {}^{142}\mathrm{Ce} = {}^{143}\mathrm{Ce} + \gamma(5.14\ \mathrm{MeV}), \qquad (6)$$

The natural abundance of the isotopes appeared in the reactions (3) to (6) are 9.86, 7.02, 88.5 and 11.1%, respectively. The cross sections of the reactions (2) to (6) are 4.0 x 10^{-4}, 0.70, 11.0, 0.39 and 0.68 barns at 400 °C , respectively.

The reactions in the surface layer could be taken by efficiency to generate the excess heat as follows:

$$n + {}^{105}\mathrm{Pd} = {}^{106}\mathrm{Pd} + \gamma(9.6\ \mathrm{MeV}), \qquad (7)$$
$$n + {}^{108}\mathrm{Pd} = {}^{109}\mathrm{Pd} + \gamma(6.2\ \mathrm{MeV}), \qquad (8)$$

The natural abundance of the isotopes appeared in the reactions (7) and (8) are 22.3 and 26.5%, respectively. The cross sections of the reactions (7) and (8) are 14,0 and 6.1 barns at 400 °C, respectively.

The excess heat generated by the reactions (2) to (8) was calculated using n_n as an adjustable parameter and assuming; 1) all the liberated energy was transformed into heat in the system, 2) D/Pd = 1 in the surface layer and 3) D/O = 0.05 in the volume. The experimental value 0.7 W of the excess heat in a second, most of which was generated by the reactions (3) to (8), gave a value 4.0 x 10^{10} cm^{-3} for the density of the trapped neutron (contribution from reactions (3) to (6) is comparable to that from (7) and (8)): $n_n = 4.0 \times 10^{10}$ cm^{-3}.

The origin of the excess heat in this proton conductor shows that the coating metal Pd or PtMo did not largely change the amount of the excess heat, but might be definitely responsible to the efficiency of the neutron trapping.

This value $n_n = 4.0 \times 10^{10}$ cm^{-3} of the density of the trapped neutron is in the middle of the values determined by us in the analyses of cold fusion data[6]. The reason of this moderate value in the proton conductor shows that the coating of the sample by Pd (or PtMo) would be very effective to trap the thermal neutron in the volume of the sample.

The characteristics (a) to (c) of the experiment listed above are explained by the TNCF model as follows:

(a) The reproducibility of the events is governed by the ability of the sample to trap thermal neutrons. The structure of the sample determined by atomic processes, which are stochastic processes in its nature, in the preparation procedure is supposedly sensitive for the neutron trapping. Therefore, the reproducibility of the excess heat generation in different samples must be poor depending on the stochastic processes occurring in the whole procedure.

(b) The preparatory drive is necessary to settle the trapping condition and to trap enough neutrons in the sample to generate observable excess heat.

(c) The events without d.c. power are possible if the neutron is once trapped enough to accomplish a condition to realize the fusion reaction in or on the sample.

4. Discussion

The vajue of n_n obtained in the previous section for a proton conductor is consistent with the idea of the neutron affinity in the TNCF model[10]. The neutron affinity of the proton conductor $SrCe_{0.9}Y_{0.08}Nb_{0.02}O_{2.97}$ is +1.27 larger than those of Pd and Ti (0.26 and 0.96, respectively). This fact shows higher stability of the trapped neutron in the proton conductor than in Pd and Ti irrespective to a possible rather imperfect structure of oxide compound than metal. Therefore, if the condition for the the neutron trapping is fulfilled in oxides, the density of the trapped neutron could be similar to that in metals. From this point of view, the positive large neutron affinity of Ni, $\eta = 3.87$, might be relevant with peculiar characteristics of this metal in the cold fusion behavior.

Though photons with energies from 5 to 11 MeV have been assumed to be therinalized entirely in the system, it is probable that we can measure them to verify the assumed mechanism of the excess heat generation in the proton conductor. Another effect we can conclude from our treatment in this paper is the nuclear transmutation in the reactions (2) to (10), which also should be checked by the observation;

$$86Sr \rightarrow 87Sr,\ 87Sr \rightarrow 88Sr,$$
$$140Ce \rightarrow 141Ce,\ 142Ce \rightarrow 143Ce.$$

Analysis of the fine experimental data provides an insight into the physics of the cold fusion phenomenon. The data on the excess heat generation in a proton-conducting oxide obtained by Oriani[1,2] are one of those fine data in the field of cold fusion. The experimental data not only show the real existence of the cold fusion phenomenon in the proton conductor definitely, but also help explain the physics of the phenomenon.

The analysis of the data on the TNCF model given above tells us that there is a consistent plot in intricate facts of the cold fusion phenomenon, i.e. poor reproducibility, necessity of preparatory drive and excess heat generation without exciting d.c. power in some cases.

Those facts are common in all materials showing the cold fusion phenomenon, i.e. transition metals occluding hydrogen isotopes, some high-temperature superconductors, some ferroelectrics other than the proton conductors.

It is an encouraging fact that the cold fusion phenomenon in those various materials can be explained by a phenomenological model, the TNCF model using a single parameter n_n, the density of the trapped neutron. Perhaps, this is a clue to find the final, decisive key to explain the cold fusion phenomenon and develop a new energy source to resolve the energy problem of our culture lying in front of us.

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