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ANOMALOUS γ PEAK EVOLUTION FROM SrCe SOLID STATE ELECTROLYTE CHARGED IN D_2 GAS

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Abstract—A proton conductor, the solid state electrolyte, made from an oxide of strontium, cerium, niobium and yttrium can be charged in a hot D_2 gas atmosphere. Anomalous radioisotopes were detected in all samples charged with an alternating current with voltages ranging from 5 to 45 V, at temperatures ranging from 400 to 700°C. No radioisotopes were detected from the sample treated in a H_2 gas atmosphere. The radioisotopes may be induced from a catalytic reaction between the metal and oxide interface to deuterium atoms. Copyright © 1996 International Association for Hydrogen Energy

INTRODUCTION

Nuclear reaction in the solid state, so called cold fusion phenomena, has been confirmed by much data. It is vital to obtain precise quantitative relationships between each potential nuclear atom and its corresponding reaction product. We submit that the ideal way to do this is to observe as many parameters as possible simultaneously on-line: heat evolution; neutron emission; tritium generation and so on. Unfortunately this is very difficult to do, because the phenomenon is so hard to reproduce and control. Even when it has been possible to measure several parameters at once the amounts of reaction products are very low and often close to or under the limit of detection products making quantitative calibration difficult. Therefore, the best technique to analyse this, has been radioactive products from the sample before and after the experiments, rather than on-line in real time.

EXPERIMENTAL

In the present work, samples were made from a mixture of metal oxide of Sr, Ce, Y and Nb, according to procedures worked out by Iwahara *et al.* [1–3]. These powdered oxides were first mixed, and then sintered in an electric furnace at 1400°C in air for 16 h. The samples were pulverized, mixed and alcohol was added. They were placed in a press and formed into disk plates of 20 mm diameter and 1 mm thickness. These plates were again sintered at 1300–1480°C in air for 16 h. Sample densities ranged from 3.0 to 5.2. The theoretical density for a perfectly sintered sample is 5.8. Both sides of the sintered sample were coated with porous Pt film by one of two methods: (1) by painting a Pt organic compound and deposition at 700°C; (2) by coating with Ar sputtered onto Pt in a vacuum. The resulting Pt film thickness was 0.15–0.3 μm. The film is porous and has a very rough surface, and hydrogen gas easily passes through the film to reach the ceramic surface. Schematic representations for measurement system and reacting system are shown in Figs 1 and 2, respectively.

Experimental procedures were as follows: (1) the reactor cylinder was evacuated with a rotary pump, followed by a diffusion pump (with liq. N_2 trap) to 2×10^{-5} Torr. (2) The temperature of the sample was raised to 400–700°C. (3) Gas was introduced into the cylinder at 0.1–50 Torr. (4) The sample was charged with EPD power at 5–45 V a.c., with frequency set between 10^{-4} and 1 Hz depending on the sample temperature and thickness. (5) All the samples were tested with a Ge(Li) detector for gamma radiation before and after electrolysis.

RESULTS

All the samples were tested for emission across the full gamma radiation spectrum. Typical results are shown in Fig. 3; (B) is before electrolysis, (A1) and (A2) are after

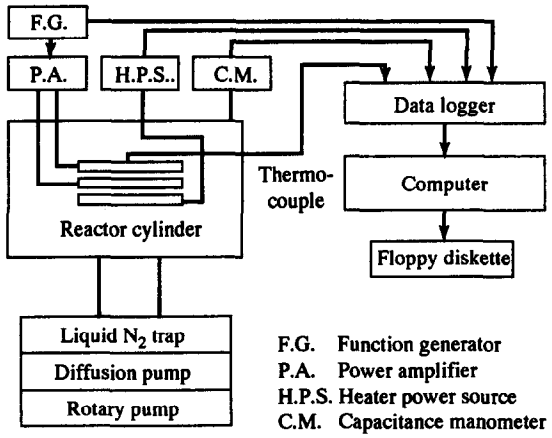

Fig. 1. Experimental arrangement. The sample was heated to a constant temperature with an electric heater covered with stainless steel. Electric power was supplied from a stabilized power source. The electric fields of constant voltage (electric power of proton driving: EPD) was supplied from a function generator via a power amplifier. Pressure was measured by a capacitance manometer with 0.1 Torr accuracy. Temperatures were recorded with 0.1°C accuracy by three thermocouples that were coated by a thin stainless cover. All parameters, EPD (voltage and electric current), heater power, sample temperature, gas pressure and cylinder wall temperature were recorded through a data logger and computer to a floppy diskette. The reaction cell was made from a stainless steel cylinder 40 cm long, 20 cm in diameter, with walls 5 mm thick. Gamma and X-ray emission during electrolysis were detected by the handy type of neutron rem counter and gamma detector placed close to the reactor cylinder.

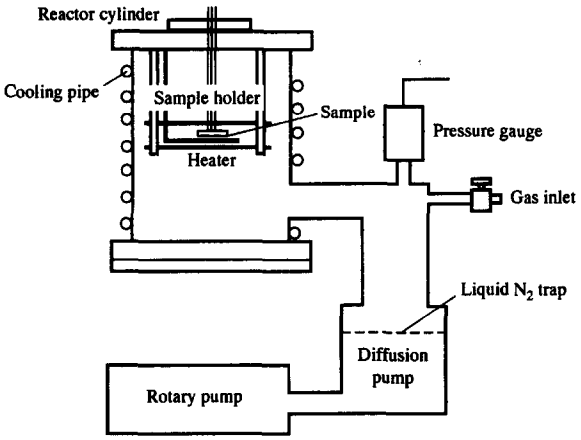

Fig. 2. Reactor cylinder: Upper part of cell. The sample is held on both sides with 0.3 mm thick Pt plates which are in turn sandwiched between 0.3 mm thick Pt plates. Three thermocouples with thin stainless steel are pressed directly on the upper Pt plate. The Pt plates make electrical and thermal contact with ceramic sample and thermocouples. This part is fixed in place of the heater part. Spiral heater wire covered with ceramic insulator is also connected to the bottom part of the sample. EPD power was supplied through copper wires of 1.6 mm diameter. The sample holder is surrounded by Ni plate reflectors. The holder is fixed with four supports made of 6 mm diameter stainless steel rods that were covered by alumina insulator. Four nuts attached under the support rods pressed Pt plate, alumina spacer and sample to make tight contact with thermocouples. These thermocouples have a spring action. The components are welded to the cell cover flange that have several electric connectors. The connectors introduce thermocouple, electric power lines for the heater and electric field supply for the sample.

electrolysis. The peaks that appeared for all spectrums at 63.75, 75.0 and 92.5 are from Th-234, Pb $k\alpha$ and Th-234, respectively. A clear peak is shown in Fig. 3 (A1) and (A2) at 77 keV. The peak was obtained after electrolysis in a deuterium gas atmosphere. It was not observed with hydrogen gas. This peak may be interpreted as coinciding with the radioisotopes ^{197}Pt, ^{153}Sm and ^{155}Sm. However, we do not believe it was caused by ^{153}Sm or ^{155}Sm, because it would have to be accompanied by a stronger peak at 103.2 keV for ^{153}Sm and 104.3 keV for ^{155}Sm. There are no peaks in the 103 keV range. Another peak that may be caused from the second energy spectrum of 191.44 keV was observed. This peak was sometimes difficult to confirm because the intensity is one order of magnitude lower than the first peak. The half-life of the radioisotope synthesized in this experiment is estimated to be about 20 h. We conclude that the first peak is caused from the 77.35 keV γ emission of ^{197}Pt radioisotope.

We have confirmed this in five tests with different samples. The effect is 100% reproducible for that same sample. We performed the electrolysis with the same sample in deuterium gas followed by hydrogen gas: the ^{197}Pt peak was only observed with deuterium gas. No trace of ^{197}Pt was detected around the sample holder materials, and there is no ^{197}Pt in the Pt plates used to make electric and thermal contact with the sample, even in samples of the metal as large as 100 g. The peak intensity appears to depend upon the deuterium gas pressure. We have not yet

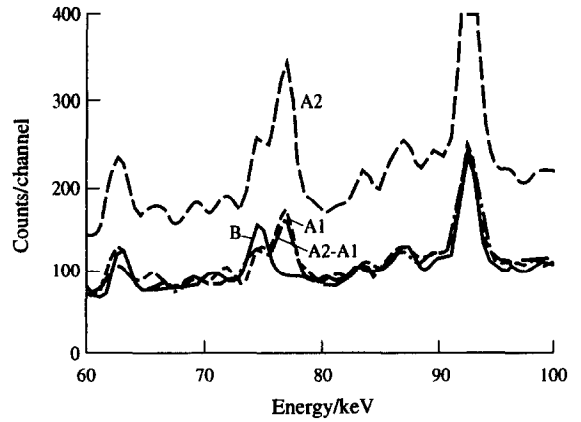

Fig. 3. Gamma ray spectrum before the electrolysis (B) and data are accumulated from 0 to 24 h (A1), and from 0 to 48 h (A2) after electrolysis. (A2 − A1) is subtraction from A2 to A1. Gamma ray spectra were obtained by a 4 inch Ge (Li) detector in four shielded containers of 20 cm and 5 mm thick of Pb outer and Cu inner shields. A multi channel analyser of 8000 channels was made to coincide to 0–4000 keV energy range. A gaussian window was fitted for calculation of the spectrum analysis.

determined what, if any, effect temperature, electrolysis voltage, current and sample material may have on the intensity of the ^{197}Pt emission.

^{197}Pt nuclei do not exist in nature. They can only be produced artificially by neutron irradiation, as follows:

$$^{197}_{78}Pt + ^{1}_{0}n \rightarrow ^{197}_{78}Pt \rightarrow ^{197}_{79}Au + \beta^{-}. \quad (1)$$

^{197}Pt changes into ^{197}Au by β decay.

DISCUSSION

There are no reports of chemical reactions affecting nuclear reactions, and no theory that would allow this. However, evidence of cold fusion seems to give us a hint for solving the problem. There are now many reports of cold fusion experiments in which neutron emission, helium isotopes evolution, tritium generation, high energetic particle emission and gamma radiation during hydrogen or deuterium absorption by Pd, Ti, Ni and some metal oxides were observed.

The total amount of ^{197}Pt (n) is calculated from the count number (c) and detector efficiency (η) as follows:

$$n = 2c/\eta. \quad (2)$$

η is roughly estimated as being between 10^3 and 10^4. If we assume that the all the ^{197}Pt was generated by neutron absorption from one reaction, we can readily estimate the total neutrons from the amount of Pt in the sample and the neutron absorption cross-section $\sigma(E)$. The $\sigma(E)$ depends on the neutron energy; it is roughly estimated as 1 barn (10^{-24} cm^2) on average from the thermal to keV range. Total neutrons are then estimated as being between 10^{11} and 10^{12}. However, total neutron emission during the electrolysis is close to or under the background count. It is of the order of 10^2 to 10^3. These values are 10^8 lower than the results require.

Several metals, including Pt, Pd, Ti and Ni and some alloys (LaNi and TiFe) have a strong catalytic effect on hydrogen. They decompose the H_2 molecule to a H atom and H^+ proton. If we assume that the strong catalytic action also somehow causes a nuclear effect between platinum and deuterium, several reactions can be considered:

$$^{196}_{78}Pt + D + D \rightarrow ^{197}_{78}Pt + ^{3}_{2}He + 5.46MeV \quad (3)$$

$$^{196}_{78}Pt + D + D \rightarrow ^{196}_{78}Pt + ^{4}_{2}He + 14.29MeV \quad (4)$$

$$^{196}_{78}Pt + D + D \rightarrow ^{197}_{79}Au + ^{3}_{1}T + 5.85MeV \quad (5)$$

$$^{196}_{78}Pt + D + D \rightarrow ^{199}_{80}Hg + ^{1}_{0}n + 8.74MeV \quad (6)$$

$$^{196}_{78}Pt + D + D \rightarrow ^{200}_{80}Hg + 13.9MeV \quad (7)$$

$$^{196}_{78}Pt + D + D \rightarrow ^{199}_{79}Au + ^{1}_{1}P \rightarrow ^{199}_{80}Hg + \beta^{-} + ^{1}_{1}P \quad (8)$$

$$^{196}_{78}Pt + D \rightarrow ^{197}_{78}Pt + ^{1}_{1}P + 2.20MeV \quad (9)$$

$$^{196}_{78}Pt + D \rightarrow ^{197}_{78}Au + ^{1}_{0}n + 1.82MeV \quad (10)$$

$$^{196}_{78}Pt + D \rightarrow ^{198}_{79}Au + 6.07MeV \rightarrow ^{198}_{80}Hg + \beta^{-} \quad (11)$$

^{197}Pt nuclei can be formed by reactions (3) and (9). However, we have sometimes observed very weak neutron emission during electrolysis, which opens up the possibilities for other reactions such as (6) and (10).

The same type of reaction may occur in Pd. There are many reports of reactions with Pd in dry and wet systems. The following formulas have been proposed to explain this:

$$_{46}Pd + D + D \rightarrow _{46}Pd + ^{3}_{2}He + Q \quad (12)$$

$$_{46}Pd + D + D \rightarrow _{47}Ag + ^{3}_{1}T + Q \quad (13)$$

$$_{46}Pd + D + D \rightarrow Ag + ^{3}_{2}He + Q \quad (14)$$

$$\searrow$$

$$_{48}Cd + Q \quad (15)$$

$$_{46}Pd + D \rightarrow _{46}Pd + ^{1}_{1}P + Q \quad (16)$$

$$_{46}Pd + D \rightarrow _{47}Ag + ^{1}_{0}n + Q \quad (17)$$

$$_{46}Pd + D \rightarrow _{47}Ag + Q. \quad (18)$$

However, Q values are changed with the isotopes of Pd; the value is of the order of few MeV in almost all cases. If we take ^{106}Pd, ^{108}Pd and ^{110}Pd for formula (17), we obtain 1.78, 2.21 and 2.62 MeV, respectively: 99.9% of the energy goes into neutrons. The ^3He from reaction (12) and ^3T from reaction (13) have several MeV of energy. They bombard the other deuterium atoms and induce the d, d nuclear fusion reaction; ^4He, protons and neutrons are generated. The neutron energy was broadened from 14 to 17 MeV in this case. These mechanisms seem to give a solution to the questions of reaction products in cold fusion.

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