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Search for Nuclear Products of D + D Nuclear Fusion

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ABSTRACT

Nuclear products which were caused by the D + D nuclear fusion reaction were searched in electrolytic cells and in gas phase of Pd + D systems. Measurements of nuclear products were made for gamma-ray, neutron, tritium and helium. To detect neutron, liquid scintillation and ^{3}He counters were used. For gamma-ray measurement, a NaI detector was used. For tritium concentration measurement in gas phase, a gas proportional chamber was fabricated and operated in low background level. The signals of those detectors were fed to Pulse Height Analyzer and recorded as energy spectra which were carefully compared with background spectra. A different type of neutron hunting was also tried in the instants of pressurizing and depressurizing the deuterium gas in crystal. A large size crystal of tungsten bronze was prepared for the experiment.

Key Words: Nuclear Fusion, Nuclear Products, Electrolytic Cell, Tungsten Bronze

I) Introduction

Since excess heat generation was reported in Pd/D_2O electrolytic cells, [1)] searches for nuclear reaction products had been started by many groups, considering in mind that the amounts of the excess heat could not be explained by the chemical reactions but by the nuclear reactions. After the report, there were many claims to detect nuclear products in electrolytic cells and in other different systems. In our laboratory, searches for nuclear products (proton, neutron, gamma-ray, tritium, helium, etc.) were started using with our familiar techniques for nuclear study. We studied these phenomena focusing on the following three points: (1) searching for the nuclear products of helium and tritium in the gases and liquids in the calorimetric cells, (2) confirmation of the generation of tritium in the gas phase of Pd + D systems and (3) detection of neutron at the instants deuterium gas was pressurized and depressurized in single crystals.

For the experiment (1), calorimeters of closed system were prepared. For the experiments (1) and (2), a gas proportional chamber was made to detect beta-rays from tritium decay. For the experiment (3), large single crystals of tungsten bronze were grown. These details were reported in the proceedings of the 4th and 6th International Conference on Cold Fusion [2, 3, 4)].

II) Detection Methods

a) Neutron and Gamma-ray

Neutron from the reaction: $D + D = {}^3He + \eta$ was measured by two different type of detectors. One was a standard Helium-3 filled proportional detectors (Model RS-P4-0810, Reuter Stockes Inc.) which was surrounded by a cylindrical plastic neutron moderator. Another was a 5 cm diameter × 5 cm long liquid scintillation neutron detector. Pulse signals from the detectors were amplified and fed to a Pulse Height Analyzer (PHA) and recorded in a Personal Computer as energy spectra. Gamma-rays originated by the reaction: $\eta + \rho$ (in water) $= D + \gamma$ and $D + D = {}^4He + \gamma$ were measured by a 5 cm diameter × 5 cm long NaI (T1) detector along with the PHA system.

b) Tritium

Tritium from the reaction: $D + D = {}^3H + \rho$ was measured by two methods. Tritium concentration in electrolyte and recombined heavy water of the electrolytic cells was measured by a liquid scintillation counting method. Tritium concentration in deuterium gas was measured by a gas proportional chamber which was made for this purpose. The chamber consisted of an anode with five 20 μm sense wires and six 100 μm potential wires, and of two cathodes of 100 μm mesh. The effective area was 50 mm × 140 mm and the thickness was 10 mm. It could measure the energy spectrum of beta-rays emitted from the tritium atoms. Sampled gas was injected by a syringe into the chamber and output signals were analyzed by the PHA system. The detection limit was 0.5 Bq per 20 ml sampled gas volume.

c) Helium

Helium which should be created by the reaction $D + D = {}^4He + \gamma$ was measured by a gas chromatographic method. Molecular sieve 5A grains were packed in two stainless steel pipes of 3 mm diameter and 10 m long. Argon carrier gas was led to the pipes at constant flow rate of 16 ml/min. Gas samples from the calorimetric cell were ejected by a syringe into the one of the pipes. Disturbances due to helium and other impurity gases were sensed by a thermal conductivity detector, whose signals were stored by a recorder as a function of retention time. A chromatogram of air in the experimental room gave us a concentration reference was 5.24×10^{-4} for helium.

III) Results of Searches

a) Electrolytic Cell

To confirm the generation of the excess heat, a calorimetric system was made. The calorimetric cell was composed of an inner tube, an outer tube and thermal shielding box. A cathode of 30 × 25 × 1 t Pd sheet was sandwiched between two 50 × 50 × 0.1 t Pt anodes. Both the cathode and the anodes were supported by a 10 mm Teflon frame. A calibrating heater, the lower gas sampling port, a gas guiding tube and electrolytic solution were put in the inner tube together with the cathode and anodes. The electrolytes were 0.1 M LiOD heavy water solutions or 0.1 M LiOH light water solutions. The inner tube was shielded by a plastic plug with a gas guiding tube. The inner tube was settled in the outer tube. Running water was introduced to the

outer tube at the constant flow rate so as to cool down the inner tube. The calorimetry was done by monitoring the temperature of the cooling water. Excess heat generation was observed (see ref. 2). At the same time, nuclear products (η, γ, α, t) were carefully searched. The experimentally obtained values were the same as background values within errors in each detection methods.

b) Pd + D System

In a certain process, when deuterium gas was absorbed in or released from Pd, the possibility of small amount of the nuclear reaction was pointed out. [5] Nuclear products were also searched for gas phase in the Pd + D system. Palladium wires of 2 mm diameter and 10 cm length were used. The wires were annealed at 800°C in vacuum for 12 hours, and the surfaces of wires were modified by a method of sand blasting. Those were set in a vacuum duct (3.5 cm diameter and 21 cm length) which was connected with a standard volume of 2 liters. After evacuation of the duct, deuterium gas was supplied from the standard volume. The maximum pressure was 3 atm. Normally, after one week, D/Pd loading ratio n = 0.65 was obtained. Furthermore, to achieve high loading ratio, deuterium gas was loaded in Pd wire (28 cm, 2 mm diameter) by electrolysis. The wires were coated with thin Au layers by electroplating, before and after the electrolysis. Those wires were set in a vacuum duct and high currents (first 1 min, 80 A and next 1 min, 60 A) were applied to the wires. The wire was heated up to 1000°C, then deuterium gas was abruptly released within 35 seconds. During gas released, neutron was always monitored and tritium in the released gas was measured by sampling. The spectra measured by the proportional chamber were compared with the background spectra but there were no difference between them.

c) Single Crystal of Sodium Tungsten Bronze

Reproducible neutron generation was reported [6] just at beginning of pressurization or depressurization of deuterium gas to a single crystal of sodium tungsten bronze Na_xWO_3, in which many vacancies had been formed in cathodic treatments by applying negative voltage at high temperature in vacuum. To test this phenomenon, single crystals were prepared by electrolysis of molten mixtures of sodium tungstate and tungsten (VI) oxide. The bronze composition x was well controlled by changing the raw material composition. Several cubic single crystals of Na_xWO_3 (x = 0.9) with volumes up to 8.0 cm^3 were obtained. One of the crystals was sliced by a diamond saw to get square pieces with the thickness of 0.2 cm. The surfaces of the pieces were chemically cleaned. Two or three sliced pieces of the bronze were set on the anode in a heating chamber. The distance between the bronze and the cathode was 2 mm. The bronze was heated at the temperature between 700°C and 970°C under the pressure of 1×10^{-6} Torr. Negative voltage was applied to the cathode to extract Na^+ ions from the surfaces of the bronze. The voltage was set constant between -1.5 kV and -3.0 kV. After finishing the cathodic treatment, the bronze samples were cooled down.

The application of the negative bias was stopped and the integrated charge was recorded. The pumping system and the vacuum valve were stopped. It took 30 seconds to pressurize the deuterium gas up to 120 Torr. After 30 minutes had passed, the gas was evacuated to the pressure of 1×10^{-3} Torr within 30 seconds. Two ^3He counters were set at the top of the heating chamber. Counts of neutrons were started 30 minutes before the pressurization and stopped 30 minutes after the depressurization. No significant difference was observed in each count at any time intervals.

Conclusion

We searched for nuclear products in electrolytic cells in which were observed excess heat, in gas phase of Pd + D systems and in D + single crystal. The detection methods for gamma-rays and neutrons were common techniques for nuclear study and the counters were properly tuned for the experiments. The gas proportional chamber was newly designed to measure tritium. The detectors were carefully calibrated and checked for reliability. The detectors were run for long period to measure background and check stability. The signals from the detectors were analyzed by the Pulse Height Analyzer and recorded in the personal computer as spectra. Having done that, we could surely identify the signals due to noise or true events. The results of experiments reported here contradict other groups' claims of finding various sorts of nuclear products. We could only obtain the upper limit of existing nuclear products in our systems.

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