A Search for Fracture-Induced Nuclear Fusion in Some Deuterium-Loaded Materials

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ABSTRACT

Attempts to detect neutron emission attributable to D-D nuclear fusion accompanying fracture of deuterium-loaded materials have been carried out using a ball mill specially designed for this purpose.

Chips of Ti, Ti-alloys, Y and $YBa_2Cu_3O_{7-x}$, loaded with deuterium, were crushed in the ball mill to about 10μm in size in 60 or 120 minutes, and neutrons were counted by an array of 4～12 ^{3}He detectors sarrounding the ball mill. The signal-counting efficiency was 0.3～4%.

No positive signature has been obtained for the occurrence of fracture-induced fusion.

1. Introduction

Immediately aftre cold fusion phenomena were reported by Jones et al. (1989) and Fleischmann and Pons (1989), suggestions were made that a d-d fusion reaction could be induced during the crack propagation in deuterium-loaded materials (Cohen and Davies 1989, Mayer et al. 1989, Takeda and Takizuka 1989).

However, experimental evidence for the fracture-induced fusion has not been clear. In LiD, Klyuev et al.(1986) had reported neutron emissions during impact fracture, but recent experiments of Price (1990) using a track-reading plastic detector found no particle emission. Derjaguin et al.(1989) claimed to have observed neutron emission during vibromilling of a complex mixture of Ti chips, heavy water, deuterated polypropilenium and LiD. The implication of their experiment is hard to evaluate.

FRONTIERS OF COLD FUSION

The only clear-cut experiment performed so far in regard to the fracture-induced fusion is that of Dickinson et al. (1990), in which they observed emissions of photons, electrons and D^+ ions during the fracture of TiD_x, and a fairly large charge imbalance between the two cracked pieces of the sampie. Although the energy of emitted D^+ ions was not determined in their experiment, there appears to be a possibility that it can be of the order of 10keV which is necessary to yield measurable fusion rates.

Our measurement have been performed to detect neutron emission attributable to d-d nuclear fusion accompany fracture of deuterium-loaded materials using a ball mill specially designed for this purpose.

2. Experimental Details

The deuterium and hydrogen loading of specimens were performed in a Sieverts-type apparatus. The specimens used are listed in Table 1.

Table 1. Samples

Sample	Shape;Size	Quantity
$TiD_{1.0}$	block;2～10 mm	400 g
$TiD_{1.9}$	block;2～10 mm	500 g
$YD_{2.9}$	block;2～10 mm	81 g
$Ti_{086}Al_{01}V_{004}D_{1.1}$	fragment;5～10 mm	260 g
$Ti_{086}Al_{01}V_{004}H_{1.1}$	fragment;5～10 mm	223 g
$Ti_{086}Al_{01}V_{004}D_{1.1}$	fragment;5～10 mm	177 g
$TiD_{1.3}$	plate;1mm thick	171 g
$TiH_{1.7}$	plate;1mm thick	177 g
$YBa_2Cu_3O_{7-x}D_{0.8}$	block;2～10 mm	147 g
$YBa_2Cu_3O_{7-x}H_{1.0}$	block;2～10 mm	147 g

The electrical resistivity of the specimens varies widely: $\sim 10^{-6}\Omega\cdot m$ for Ti and Ti-alloy deuterides, $\sim$ 1 $\Omega\cdot m$ for $YD_{2.6}$, and $\sim 10^{2}\Omega\cdot m$ for the deuterides of $YBa_2Cu_3O_{7-x}$.

These samples were crushed in the ball mill (21cm in diameter, 13cm in width) to about 10μm in average size(Rosin-Rammler distribution) in a vacuum or 1 atm. of D_2 gas for 25～120 minutes at room temperature. The ball mill was surrounded by a polyethylene moderator (3cm thick), in which an array of 4～12 ^3He detectors (25mm in diameter, 15cm in active length) was located, and the whole assembly was shielded from outside radiation by borated water of 50 cm thickness.

Signals were counted by CAMAC scalers, and recorded in a microcomputer every 5 min. The signal-counting efficiency was measured by using ^{252}Cf neutron sources, to be 0.3 and 4% for four and twelve detectors.

Measurements were made to check possible noises arising from the rotation of the ball mill by comparing background counts during the on- and off-time of the empty ball-mill oper-ation. No difference was found.

It must be emphasised that the present experiment allows the use of much larger quantities of samples, and produces much larger area of freshly cracked surface, than any experiments reported so far.

3. Experimental Results

Each run of measurements consisted of neutron counting during the on- and off-period of the ball-mill operation consecutively.

Typical time-variations of neutron count rates are shown in figure 1 for $TiD_{1.0}$, $YBa_2Cu_3O_{7-x}D_{0.8}$ and $YBa_2Cu_3O_{7-x}H_{1.0}$.

No difference in the count rates of on- and off-periods can be observed in any of these runs.

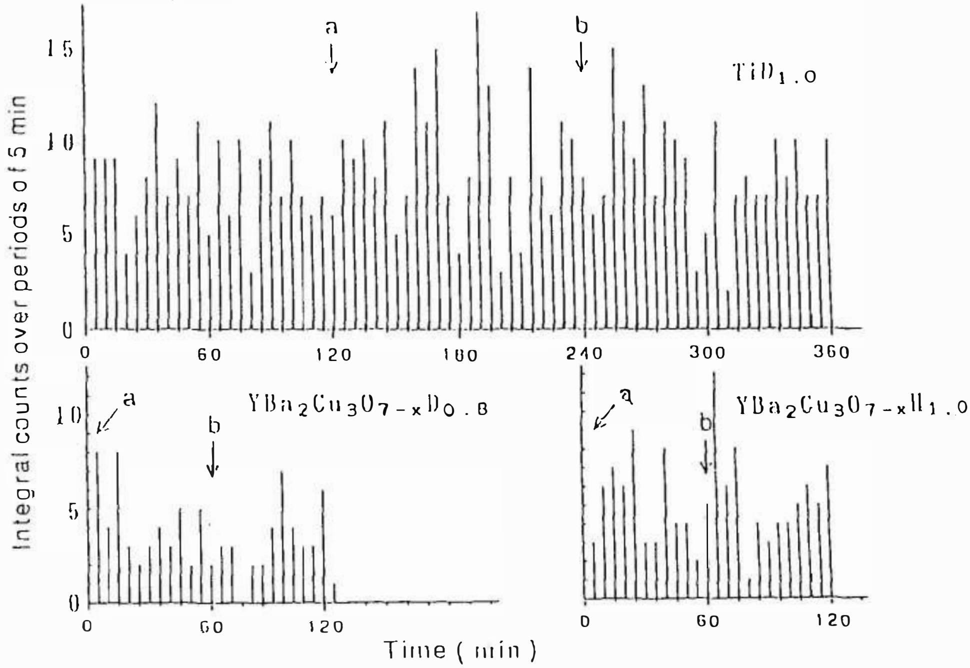

Figure 1. Time-variation of neutron count rates.
Arrow a: start, and b:stop of the crushing operation.

The average count rates observed for all the samples are listed in Table 2. Difference in the count rates during the on- and off-periods cannot be said to be meaningful.

Table 2. Count Rates(count/5min$\pm\sigma$) and Duration

Sample	Crusing on	Crushing off
	Counts; Duration	Counts; Duration
$TiD_{1.0}$	9.2±0.6; 120 min.	8.3±0.6; 120 min.
$TiD_{1.9}$	8.2±0.6; 120 min.	8.9±0.6; 120 min.
$YD_{2.9}$	8.8±1.3; 25 min.	7.8±1.2; 25 min.
$Ti_{0.86}Al_{0.1}V_{0.04}D_{1.1}$	6.5±0.5; 120 min.	2.5±0.3; 120 min.
$Ti_{0.86}Al_{0.1}V_{0.04}H_{1.1}$	3.1±0.3; 60 min.	2.9±0.2; 60 min.
$Ti_{0.86}Al_{0.1}V_{0.04}D_{1.1}$	4.3±0.6; 60 min.	5.2±0.7; 60 min.
$TiD_{1.3}$	5.6±0.7; 60 min.	6.0±0.7; 60 min.
$TiH_{1.7}$	4.8±0.7; 50 min.	4.1±0.6; 50 min.
$YBa_2Cu_3O_{7-x}D_{0.8}$	4.1±0.6; 60 min.	3.2±0.5; 60 min.
$YBa_2Cu_3O_{7-x}H_{1.0}$	5.0±0.6; 60 min.	5.4±0.7; 60 min.

4. Discussion

Let us start with a crude estimation of D-D fusion rates by assuming appropriate values. Let n_1 be the density of D^+ ions on unit surface of crack, δ the fraction of D^+ ions emitted and accelerated across the crack surfaces, λ the fusion reactions per one accelerated D^+ ion and dS/dt the rate of generation of fresh crack surface, then the total rate of D-D fusion is given by $\lambda_{tot} = n_1 \delta \lambda$ (dS/dt) s^{-1}, which becomes $4\times 10^3 \delta$ for experimented conditions of $TiD_{1.9}$. If we assume $\delta \simeq 10^{-5}$, and a voltage of 10kV across the crack gap of 10μm, we obtain λ_{tot} equal to the background counts. These values appear quite reasonable. Absence of any observable neutron emission suggests that some of these values were overestimated.

Admittedly, the efficiency of acceleration of D^+ ions depends critically the time of decay of the voltage across the crack surfaces. The present experiment is believed to have coverd a wide range of the decay time because, other things being equal, if should be proportional of the electrical resistivity.

Thus, the negative results of the present experiment,in spite of greatly enhanced sensitivities, put a rather stringent limit on the occurrence probability of the fracture-induced fusion.

5. References

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