Anormalous conversion rates of liquid Ortho- to Para-D_2 by Irradiation

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Since the last year, we continued a basic study[1] on the liquid deuterium (D_2) converter aiming at construction of high intensity UCN source, i.e., study on conversion of the ortho- (I=0, 2) to para-D_2 (I = 1) due to the radiation exposure, where I is a total nuclear of the deuterium. We employed Bremsstrahlung gamma-rays produced by the 33-MeV electron beam incident on a 30-mm thick Ta target as an irradiation source. The ortho fraction of D_2 was measured by using the Raman spectroscopy[2]. The reduction of ortho D2 fraction was observed as a function of radiation dose in unit of Gy. The results of the measurement are shown in Fig. 1, where not only the experimental results but also the theoretical results are plotted. Data denoted by an open triangle, open circle, and x are, respectively, taken with

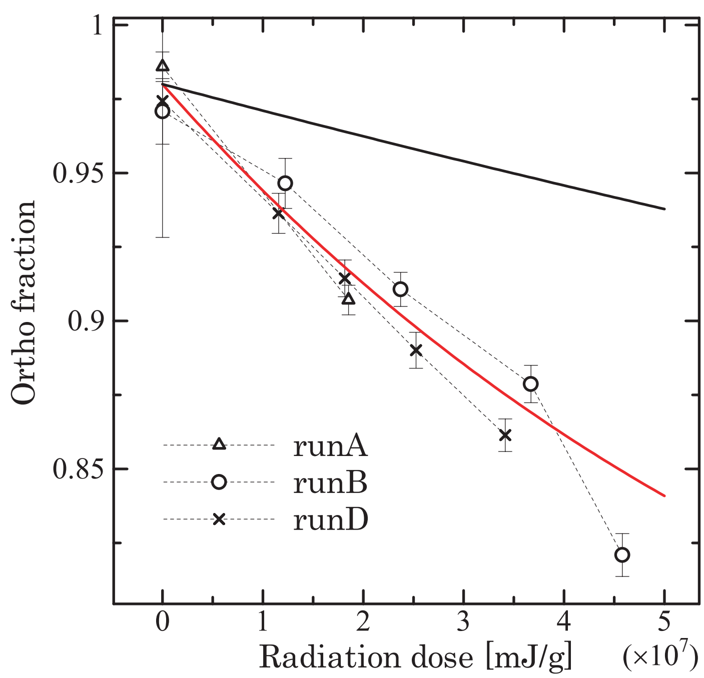

Figure 1: The ortho fractions are plotted against the radiation dose. See the text and ref. [5] for further detail.

a 33-MeV electron beam intensity of 170, 39, and 63 A. The data seem to linearly decrease according as the increase of radiation dose, where seem no dependence on the electron beam intensity. This behavior strongly suggests that the catalyzing effect is less important. The empirically deduced molecular breakup coefficient (conversion rate), k is

$$k = (1.37 \pm 0.44) \times 10^{-5} P \quad g/J \tag{1}$$

where P is a radiation dose measured in unit of W/g. The solid curve is the result of the theoretical calculations assuming the above k value. On the other hand, we can obtain the k value theoretically, in which ionization and recombination processes induced by irradiation are treated based on a simple model[3, 4, 5] The model calculation predicts;

$$k = (2.89 \pm 0.20) \times 10^{-6} P \quad g/J \tag{2}$$

The dotted curve in Fig. 1 is the theoretical result with the above k value. It is quite interesting that the value obtained by the model calculation is about 5 times less than the empirical value presently obtained. This unexpected enhancement of the conversion rate cleared in this work suggests the presence of unknown conversion processes from ortho- to para- D_2.

References

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