§12. An Experimental Study to Recover Tritium by Yttrium from IFMIF Li Loop

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Liquid Li is proposed as a flowing target to generate neutron for the International Fusion Materials Irradiation Facility (IFMIF). Fast D^+ ion beam hits the flowing Li target to generate fast neutrons by a D-Li stripping reaction. At the same time, tritium is generated in the Li target, and its rate is estimated 7g/year. In order to operate IFMIF continuously and safely, tritium should be recovered from the flowing Li, Yttrium is considered the most effective material to remove tritium from Li. The target concentration for the tritium recovery is 1 ppm in Li.

Fig. 1 shows a comparison in equilibrium H_2 pressure among the Li hydride (a chain line), the Y hydride (an upper solid line), the α-phase Y (a lower solid line) and the α-phase Li (a dashed line). As seen in the figure, the dissociation plateau pressure of the Y hydride is lower than that of the Li hydride. The tritium recovery in IFMIF will be performed under the condition where Y particles are in the hydride phase and the tritium concentration in Li is 1 wppm. Then, we need to operate the Y bed at 250 °C from the crossover between the equilibrium pressure of YH_2 and that of the α-phase Li. This operation temperature of 250 °C was targeted at the previous design for the IFMIF Y trap.

We experimented the recovery of H_2 from Li by Y plates in the present NIFS collaboration study. **Fig. 2** shows examples of the H_2 absorption rate for the Y-H_2 system and the Li-Y-H_2 system. The H_2 absorption rate for the Li-Y-H_2 system is almost the same as that for the Y-H_2 system at 400 °C. Therefore, the Y plate at temperatures higher than 400 °C assures us to recover H_2 from liquid Li as well as from a gaseous Ar-H_2 mixture. However, the absorption rate heavily dropped at temperatures lower than 350 °C. Therefore, we cannot expect sufficient H_2 absorption there.

In the actual Y hot trap, it will be operated at flowing conditions. Then liquid Li flows through an Y particle bed. Since the tritium mass transfer rate is limited by diffusion through the Li boundary layer or the Y inside, the hydrogen concentration inside the Y bed changes from the Y hydride to the α-phase. The region where the concentration changes from the lower concentration to the higher one is called a breakthrough curve in the terminology of the chemical engineering field. Then, the H_2 absorption temperature can be relieved (can be raised). If the α-phase condition is equal to $YH_{0.006}$, the absorption temperature can be operated even at 500 °C as seen in Fig. 1. In this temperature, most of the Y particle bed is in the hydride phase and the rest in the mass-transfer zone is the α-phase region.

In order to improve the H_2 absorption performance at lower temperatures, we tested HF acid treatment. Usually, Y surfaces are covered with an Y oxide.

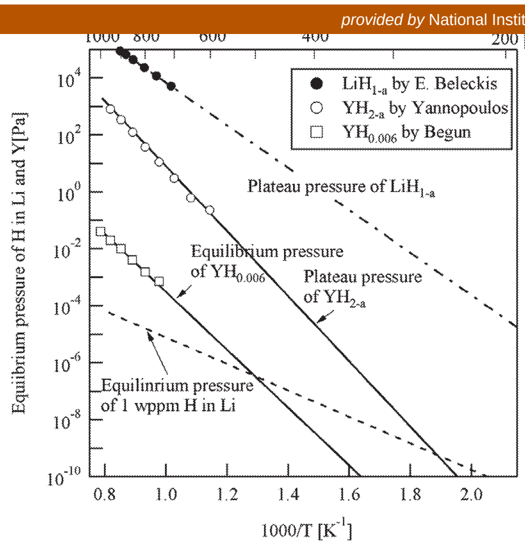

Fig. 1 Tritium recovery condition for INMIF Li loop

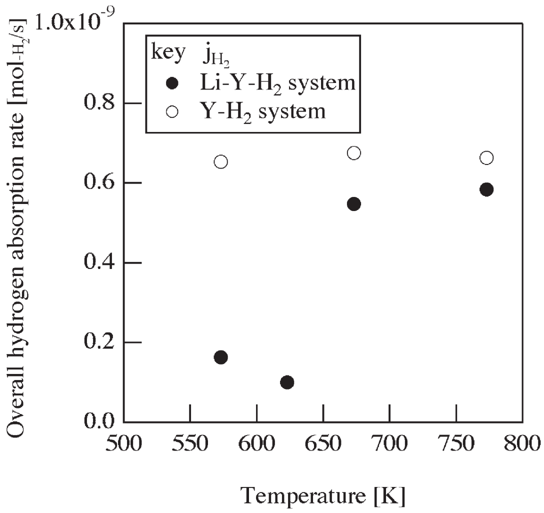

Fig. 2 Hydrogen recovery rate for Li-Y-H_2 system

Thermodynamic consideration predicts that the oxide can be removed by the HF treatment as follows:

$$Y_2O_3 + 6HF = 2YF_3 + 3H_2O$$

We can also expect that YF_3 formed on the surfaces is resolved in liquid Li. Therefore a fresh metal layer will be disposed on the Y surfaces. Thus we expect hydrogen recovery by an Y bed down to 1 ppm at 500 °C. Now, we initiated the HF treatment experiment.

Another problem is to desorb tritium from Y. We need to heat it up until at least 850 °C to recover tritium from the Y bed. This temperature is not so low. We need to develop another effective desorption method for tritium recovery from Y.

References

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