§26. Integrated Experimental Process Study for Removal of Tritium and Impurities from Liquid Lithium — I

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Liquid Li is proposed as a flowing target for a high-energy neutron generator of IFMIF. Since radioactive T is generated by a nuclear reaction and its solubility in Li is quite high, T monitoring and its removal are one of the most important issues for IFMIF target. Furthermore, T concentration monitor is indispensable not only for the target Li loop, but also for further experiment on yttrium which will be used as gettering material for hydrogen isotopes in IFMIF. In addition, N impurity in Li must be reduced to low level not only because it enhances corrosion for tubing materials, but because it promotes nitriding on the surface of Y. As for N getter, Fe–Ti alloy has been shown to be effective, whose most effective composition and micro structure have to be clarified for valid system design. In this report, we describe recent progress on the impurity removal system, focusing on composition dependence of Fe-Ti alloys and improvement of a hydrogen monitor.

Nitrogen gettering by Fe-2.5Ti alloy was performed with 20 g of lithium in a pure iron gastight crucible at 600℃ under high purity Ar atmosphere. The change of nitrogen concentration is shown in figure 1 along with a similar experimental result using Fe-7.5Ti alloy and 25 g of lithium performed in FY2006 [1]. Fitting the temporal changes of nitrogen concentration and fitting those of past results [2] in which Fe-5Ti and Fe-10Ti were used, nitrogen gettering coefficients for each titanium concentration were estimated, which is shown in figure 2. Regarding nitrogen diffusion in getter alloys as a rate limiting step, square root of time is used for calculation following parabolic low. Nitrogen gettering coefficient is proportional to titanium concentration up to about 5at% and seems to saturate above the concentration. [3]

Since only 7.5 and 10at% Fe-Ti alloys had precipitation of Fe_2Ti intermetallic phase in α iron, the saturation of nitrogen gettering coefficient occur almost simultaneously with the precipitation of Fe_2Ti that is saturation of titanium concentration in α iron. Considering this point, titanium in solution in α iron will be responsible for the nitrogen gettering of Fe-Ti alloy and Fe_2Ti will have little contribution. Thus thermal treatment to enrich titanium concentration in α iron phase may enhance nitrogen gettering coefficient.

Hydrogen permeation monitor for concentration measurement has been improved increasing permeation area and lithium inventory, changing heating method and attaching a mass analyzer (QMS). Iron was chosen as permeation wall material due to its compatibility with lithium, large hydrogen diffusion coefficient for high responsiveness and little surface degradation. Schematic view around permeation wall is shown in figure 3.

The improved permeation device shows well hydrogen permeation which fits theoretical value very well as shown in figure 4. [4] Additionally, 20wppm of deuterium in lithium could be observed as HD and D_2 (m/z = 3 and 4, respectively) even at 450℃ with QMS.

Furthermore, immersing yttrium plate in lithium in the device, hydrogen gettering was observed as a decrease of hydrogen permeation at 600℃

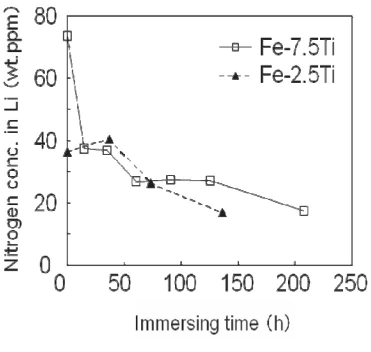

Fig.1: Nitrogen gettering by Fe-Ti alloy

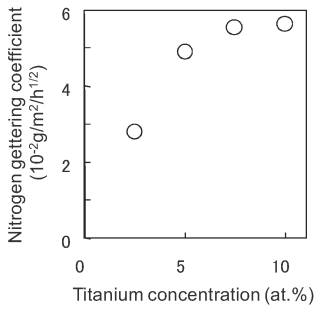

Fig.2: Nitrogen gettering coefficient of Fe-Ti alloy

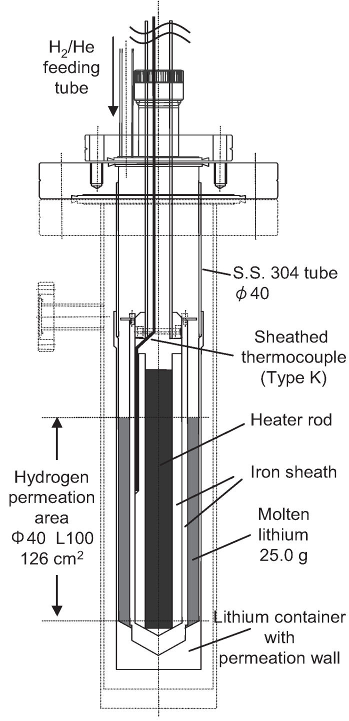

Fig.3: Schematic of hydrogen permeation wall

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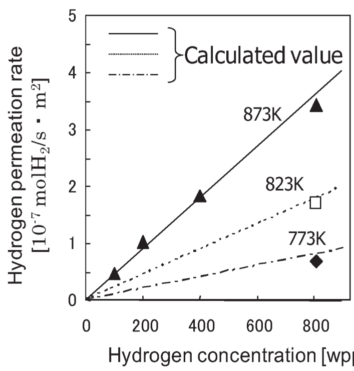

Fig.4: Hydrogen permeation and concentration in lithium

[1] J. Yagi et al., SOFT2006, Dec2006
[2] S. Hirakane et al., Fusion Eng. Des. 81 (2006) 665–670
[3] J. Yagi et al., J. Nucl. Mater., under review.
[4] J. Yagi et al., ICFRM-13, Dec2007