§28. Integrated Experimental Process Study for Removal of Tritium and Impurities from Liquid Lithium

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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 the nuclear reaction and its solubility in Li is quite high, T removal is one of the most important issues for IFMIF target. In addition, N impurity in the Li not only enhances corrosion for tubing materials, but also promotes nitriding on the surface of Y, which is considered to be T gettering material. The Li flow of the IFMIF target system will be divided into a main flow and a sub loop, where impurity concentration will be controlled. Through the sub loop, Li after the reduction of N impurity will be sent to the T hot trap system. To realize this composite impurity recovery system, it is necessary to investigate on integrated recovery process of N and T, which is consists of cold trap, N hot trap, and T hot trap. As for N getter, Fe–Ti alloy has been shown to be effective, whose temperature dependence and long term effectiveness has to be clarified for valid system design. As for T recovery, a Y particle bed is proposed as a method that can recover T down to 1 ppm. However, there was no study to prove 1 ppm T recovery by using Y. Furthermore, H concentration monitor is indispensable not only for the target Li loop, but also for further experiment on Y getter. In this report, we describe recent progress on the integrated removal system, focusing on temperature dependence and long time behavior of Fe-Ti alloys, fabrication of H monitor and efficient T recovery by Y treated by HF.

Comparing N gettering from Li in Mo crucible at 600-800^{o}C, short time gettering effectiveness was enhanced by increasing temperature. However at 800^{o}C, TiN layer was formed at the surface of the alloy to obstruct further N gettering. To observe long-term behavior of N gettering at 600^{o}C, Fe - Ti alloy (7.5 at.%Ti) absorbed N in Li with several ten wt.ppm of N for 100 hours was annealed in vacuum for 2 weeks. Both of N gettering in Li and annealing in vacuum were done at 600^{o}C. By the comparison of SEM-EDX analysis of alloys before and after vacuum annealing, the N diffusion coefficient of Fe-Ti alloy was shown to be higher than that of pure Ti more than one digit, which suggests that Fe-Ti alloy is suitable for long time usage. Purification system in IFMIF is expected to have a long effectiveness in order to achieve high operating ratio so that N gettering have to be done around 600^o C.

To fabricate H online monitor, H permeation through metal wall is selected as its principle. Considering compatibility with Li, degradation of the surface and H diffusion coefficient, pure Fe was selected as permeation window material. Li vessel (~ 40 cc) with thin wall (~ 0.75 mm, ~ 60 mm^2) made by pure Fe was annealed in vacuum pot and the pressure outside the wall was measured with ion gauge.

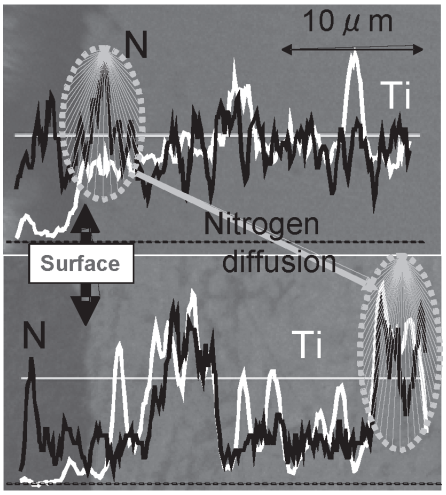

Fig.1 : Nitrogen distribution in Fe -Ti alloy
upside: after gettering in Li for 100h
downside: after gettering and 2 weeks annealing

Using the device and Li which contain 1000 wt.ppm of H, H permeation ratio at 550^{o}C was the same as calculated value with H diffusion coefficient in iron. Thus H distribution through Fe-Li interface was shown to be fast enough.

Several Li samples of 50 mg were irradiated in KUR. After the irradiation, Li was put in a Mo crucible along with a Y plate. The concentration of T generated in Li was maximally 0.03 ppm. A set of Li and Y in a Mo crucible was heated at 300 – 500^{o}C for 6 to 50 hours. After heating, the T activity left in Li without absorption and that transferred to Y after heating were analyzed. The analysis revealed the following results on T recovery by Y plates: (i) Six hours heating at 400 or 500^{o}C achieved the recovery of 1-6% of T generated in Li. The T chemical form in Li was atomic T. Its molecular form released to Ar is HT. (ii) 120 hours heating at 400 or 500^{o}C made it possible to recover more T generated in Li (around 50%). (iii) T was transferred to Y more effectively by heating operation, and its chemical form was atomic T in Y. (iv) The HF treatment affected less the T recovery rate. This may be because oxygen that is inevitably present in Li delayed the T recovery rate regardless of the HT treatment. The last result revealed that the Y trap should be set after the oxygen and nitrogen traps in the IFMIF loop.

Table 1 Tritium recovery by yttrium plate from liquid Li irradiated in KUR

Temperature	T chemical from in Li HT/(HT+HTO)	Recovery rate by Y ($T_Y/(T_Y+T_{Li})$)
500oC	0.966	0.461
400oC	0.940	0.427
300oC	0.920	0.355

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References

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