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A-FNS金属リチウム中軽水素濃度分析法の開発
Development of method to measure hydrogen concentration in metallic lithium for A-FNS

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Introduction

For IFMIF relevant fusion neutron sources such as A-FNS and IFMIF/DONES (FNSs), it is necessary not only to monitor the tritium concentration but also to measure the concentration of all hydrogen isotopes in lithium. While the method to measure deuterium and tritium concentration in lithium have been well-developed, that for hydrogen has not been developed, and has been set as one of the R&D tasks in the IFMIF/EVEDA project during 2021 to 2025 [1,2] for early realization of FNSs.

In the present study, therefore, the method to measure the hydrogen concentration in metallic lithium was developed based on the heavy water dissolution method.

Theory

The heavy water dissolution method was adopted for the measurement of hydrogen concentration in metallic lithium. Since it is considered that hydrogen impurity in lithium would be the chemical form of hydride ion, the following chemical reactions are to be induced by heavy water introduction with metallic lithium including hydrogen impurity.

$LiH_x + D_2O \rightarrow LiOD + 1/2(1\text{-}x)D_2 + xHD$ (1)

From this chemical reaction formula, it could be found that the number of D atom released as D_2 and HD is comparable to that reacted Li, and that the hydrogen concentration in lithium could be delivered from the ratio between D_2 and HD.

Experimental

The metallic lithium sample used in the present study was that sampled from the EVEDA Lithium Test Loop (ELTL) after the cold trap operation at 523 K, since the hydrogen concentration could be predicted as 0.13a% from the hydrogen solubility. 99.96% of pure heavy water fabricated by Merck KGaA was used. The gas generated by the reaction of the lithium and the heavy water described above was measured by a gas chromatograph system GC-2014AT fabricated by Shimadzu Co. Ltd., where specially designed column for hydrogen isotope separation, OGO-SP fabricated by Shinwa Chemical Industries Ltd. was used.

Results and discussion

Figure 1 shows a gas chromatogram of the gas generated by the chemical reaction between the lithium and the heavy water described above. From the peak area ratio of the HD and D_2 in Fig. 1, the hydrogen concentration in the lithium sample used in the present study was estimated to be 0.14 ± 0.02appm, consistent with the predicted value of 0.13a%. From this result, it is considered that the present developed method for the measurement of hydrogen concentration in lithium would be available, while the accuracy of this method is to be improved for FNSs to be measurable for 80appm of hydrogen concentration in lithium.

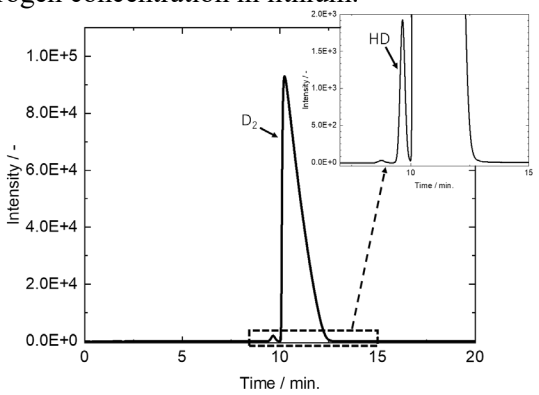

Fig. 1. A gas chromatogram of reacted gas.

Summary

In the present study, the method to measure the hydrogen concentration in lithium was considered based on the heavy water dissolution method and experimentally verified using the lithium sample from ELTL after the cold trap operation at 523 K, indicating the availability of the present method, while there is still open room for improvement of the accuracy.

References

[1] E. Wakai et al, Nucl. Mater. Energy 9(2016)278.
[2] J. Knaster et al, Nucl. Fusion 57 (2017) 102016.