§14. Compatibility of Structural Materials with FLIBE Molten Salt

Tanaka, S., Terai, T., Nishimura, H. (Dept. Quantum Eng. & Systems Sci., Univ. of Tokyo),
Sagara, A., Motojima, O.

A molten salt mixture of LiF-BeF_2 (FLIBE) is considered as a candidate for tritium breeding material in a liquid blanket system. It has favorable characteristics as follows:

1) chemical stability, and
2) lower electric conductivity than liquid metals (which results in the lower MHD pressure drop).

As for FLIBE, however, essential properties such as the behavior of tritium in it and its corrosion behavior against structural materials are still very poorly provided and more experimental data are strongly required.

Then, the compatibility of FLIBE with candidate materials for structure is one of the most critical issues for system design. As a fundamental research, this work aims to elucidate the process and the mechanism of the corrosion under static conditions at high temperature by both experimental and theoretical studies.

The corrosion behavior of FLIBE against structural materials has been studied for, e.g. Ni-based alloys, which has been practically utilized for the core container of Molten Salt Reactor Experiment (MSRE). For molten salt corrosion, in general impurities in the system tend to play an important role. As for FLIBE blanket system, HF, H_2O and O_2 would be generated under neutron irradiation, and their chemical behaviors should be investigated thoroughly. Ferritic steel (JLF-1) and V-based alloy are supposed to be used as structural materials in FFHR, but no experimental study is so far found for these materials. Moreover, almost nothing is known about the compatibility of these materials with FLIBE under a metallic-beryllium-coexisting system, which causes a highly complex redox condition.

Up to the present, the corrosion of JLF-1 (Fe-9Cr-2W) and V-4Cr-4Ti, which are candidate structural materials for FFHR blanket system, has been investigated in contact with molten Flibe by thermodynamic calculation. It has been suggested that metal oxides such as Cr_2O_3, $FeCr_2O_4$ and VO might be stable in Flibe, and that the corrosion by HF existing in Flibe might not occur if these oxides performed as protective scales on the surface. However, kinetic data on stability of these oxide layers are required to judge whether they can survive in contact with molten Flibe or not. Thus, we carried out dipping experiments on the corrosion of candidate materials in Flibe to consider the compatibility.

All experiments were carried out in Ar atmosphere containing 1% O_2, and 82 ppm HF for 30 days. Nickel crucibles were used as containers, in each of which a test specimen was put with Flibe at 823K. After being kept at the temperature for prescribed time, the specimen was taken out of the molten fluoride, and fluoride remnant was dissolved in molten LiCl-KCl eutectic salt, which was flushed finally. Retrieved specimens were analyzed by Rutherford backscattering spectroscopy (RBS) and X-ray photoelectron spectroscopy (XPS). X-ray diffractometry (XRD) was also applied for the confirmation of phases in the specimens.

As ferritic steels, at first, SUS430(Fe-18Cr), typical ferritic steel specimens were dipped in Flibe and it was clarified that Cr contributes to avoid the corrosion. JLF-1 specimens were also dipped under several kinds of atmosphere such as; 1) trace amounts of both HF and O_2 contained, 2) O_2 mainly contained, 3) HF mainly contained. Under each atmosphere, the specimens were stable and it was clarified that oxide films can work as a protective scale against corrosion.

From all results, it was concluded that the compatibility of JLF-1 with Flibe is not severe. For the judgment whether JLF-1 can be utilized as the structural material of a blanket system or not, more experiments are required in the following points;

1) corrosion behavior in longer-term dipping ,
2) corrosion behavior under neutron irradiation, and
3) stability of oxide in flowing Flibe

As for V-4Cr-4Ti, on the other hand, the corrosion by HF or O_2 was less severe than the case of pure V. However, the material is enough delicate against the corrosive species, which are generated by nuclear transmutation. Therefore, it is important for this material to be separately placed from these corrosive species. The following concrete methods are proposed;

1) to coat the surface with a stable material, and
2) to add scavenger materials such as Be metal into Flibe.