§7. Study on Purification and Compatibility of Structural Materials with Molten Salt Breeder

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A mixture of LiF-BeF_2, Flibe, is considered as a candidate material for tritium breeding in a fusion liquid blanket. It has favorable characteristics such as high chemical stability and low electric conductivity. The liquid blanket system using Flibe is applied to the conceptual design for Force-Free Helical Reactor, FFHR. In this design, ferritic steel (*e.g.* Fe-9Cr-2W, JLF-1) and vanadium-based alloy (*e.g.* V-4Cr-4Ti) are candidate materials for the blanket structure.

Flibe itself has higher chemical stability as a fluoride than those of ordinary structural metals, which would be used for fusion reactors, and has almost no reactivity with structural materials. In the blanket operation condition, however, Flibe generates H(mainly as tritium), O, F, He, etc. by nuclear transmutation, and corrosive species such as HF should have a strong influence. Therefore, it is very important to investigate the compatibility of structural materials with Flibe containing the corrosive species. Up to the present, we have investigated the corrosion behavior by thermodynamic calculation and some preliminary experiments.

Recent thermodynamic data base systems enable us to calculate complex chemical equilibrium. In this work, a thermodynamic data base system, MALT2 and the *gem* code, which are attached to MALT2, were utilized for the calculation of chemical equilibrium for Flibe-structural material systems. By finding out the existing and emerging species and the phase equilibrium in the complex chemical systems at a certain temperature, we can estimate the possibility of the corrosion and get information for prevention of the corrosion. In this segment, corrosion behaviors of Fe-9Cr-2W in Flibe containing some amount of impurities are clarified by the thermodynamic calculations using the MALT2 code.

By this calculation, it was found that chromium was selectively attacked as is expected, and it is depleted under the condition of 10000ppm-T generation. Then, Fe is fluorinated to evaporate as FeF_3. On the other hand, Cr_2O_3 can coexist in the system, and it might function as a protective layer. Hydrogen atmosphere simply results in reducing the attack on Fe, with decreasing the partial pressure of FeF_3. Addition of metallic Be has a positive effect of preventing corrosion.

To clarify the effect of the protective scale, some preliminary dipping tests were carried out. JLF-1 (Fe-9Cr-2W) specimen was used as dipping sample. The experiments were performed with Ar or Ar/1%O_2 or Ar/82ppmHF atmosphere. Nickel crucibles were used as containers, in each of which a test specimen was put with Flibe. The crucibles were kept at 823K for 30d after Flibe was completely melted. After the specimen was taken out from Flibe, and cleansed in LiCl-KCl molten salt in order to remove the Flibe solidified on the surface. Then, LiCl-KCl sticking to the specimen was removed by ultrasonic washing in water, and finally the surface of the specimen was wiped with alcohol. In this experimental system, unknown but a very small amount of H_2O might react with BeF_2 to give a trace of HF. The corrosion behavior was investigated by weight change measurement, SEM, XRD, RBS, etc. By visual observation, any destructive corrosion was not observed on each specimen. Fig.1 and Fig.2 are photos of specimens after dipping test.

From the thermodynamic analysis and the preliminary experiment on the corrosion against structural materials, it was suggested that some kinds of oxide layers could work as a protective scale for Fe-9Cr-2W. To evaluate soundness of protective scale and corrosion rate, we are planning to adapt electrochemical method for corrosion experiment. Anodic polarization on structural material specimen will show existence of the scale and soundness of it. Result that we will obtain from this experiment will help us to evaluate compatibility of the ferritic steel specimen with Flibe quantitatively.

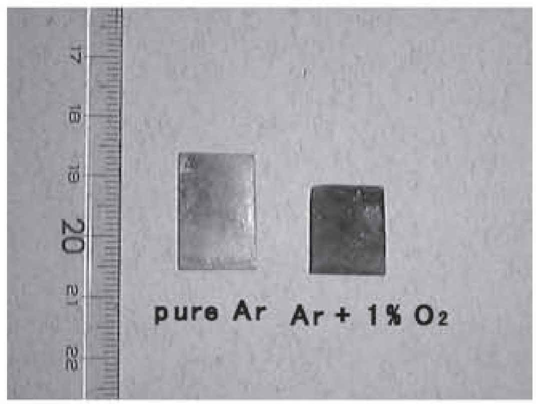

Fig.1. JLF-1 specimens after dipping tests under Ar and Ar/1%O_2 atmosphere.

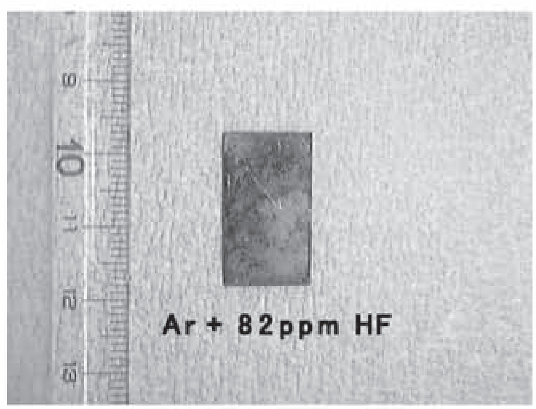

Fig.2. JLF-1 specimen after dipping test under Ar/82ppmHF atmosphere.