

§15. Analysis of Tritium Fluoride Behavior and Tritium Recovery in a Molten Salt Flibe Blanket

Fukada, S. (Kyushu Univ.),
Sagara, A.

1. Purpose of the present study

The present study is to clarify the behavior of tritium in Flibe as a self-cooled liquid blanket of a fusion reactor, *e.g.*, FFHR-2, quantitatively. In order to avoid the generation of corrosive TF, Flibe is maintained under reduction condition to transform TF to T₂ to keep a faster reaction rate compared with a residence time in a self-cooled blanket. The most important thing is to clarify whether or not the redox control of Flibe can be achieved by Be rods inserted in an external blanket loop within a limited contact time. The dissolution rate of a Be rod and the TF reduction reaction rate of Be + 2TF = BeF₂ + T₂ in Flibe were experimentally determined under the JUPITER-II collaboration work. Close agreement was obtained between experiment and our simplified complete-mixing model. Especially, the reaction between Be and F⁻ ion immediately after the contact was found to be limited by diffusion of F⁻ ion in Flibe. The behavior of tritium generated in a Flibe fuel cycle was simulated under a Flibe flow condition of FFHR-2.

2. Amounts and rates of H₂, HF and Be dissolved in Flibe

The experiment clarified that the saturation solubilities of H₂ and HF in Flibe obey the Henry rule, and their absorption rates are linear. Their values were determined as follows: $K_{\text{Henry,H}_2} = 1.24 \times 10^{-3}$ mol-H₂/m³Pa and $k_{\text{abs,H}_2 A_g} = 1 \times 10^{-5}$ m³/s for H₂ absorption, and $K_{\text{Henry,HF}} = 6.61 \times 10^{-2}$ mol-HF/m³Pa and $k_{\text{abs,HF} A_g} = 1 \times 10^{-7}$ m³/s for HF absorption. The $K_{\text{Henry,H}_2}$ value determined here agreed with our data determined by the D₂ permeability through Flibe. However, the values of $K_{\text{Henry,H}_2}$ and $K_{\text{Henry,HF}}$ were about ten times higher than those which ORNL researchers reported previously. This is considered because the chemical form of hydrogen atoms in Flibe is strongly affected by the redox-control condition. A proper (*i.e.* not so fast and not so late) Be dissolution rate is a key for redox control. The dissolution rate of Be in Flibe was correlated to a linear equation of rate constant $k_{\text{dis,Be} A_{\text{Be}}} = 8.9 \times 10^{-8}$ (Be/Li₂BeF₄)/s. The saturated concentration of Be, $x_{\text{Be,sat}}$ was estimated 2.7×10^{-4} in molar ratio of Be/Li₂BeF₄. When the galvanic-coupling effect is present, $x_{\text{Be,sat}}$ became around 6×10^{-3} .

3. Conversion of HF to H₂ by Be dissolved in Flibe

Fig. 1 shows variations of the HF concentration in the gas phase with time immediately after or during the Be immersion into Flibe. Drastic change of the HF concentration was observed regardless of different HF concentrations and immersion periods. Several things were noticed from the figure. (i) The decrease in y_{HF} was continued for a certain time even when Be was withdrawn from the Flibe. (ii) The initial decrease in rate was correlated to the relation of $y_{\text{HF}}/y_{\text{HF,in}} = kt^{-n}$ regardless of different conditions of $y_{\text{HF,in}}$ and t_{Be} . (iii) Since the residence

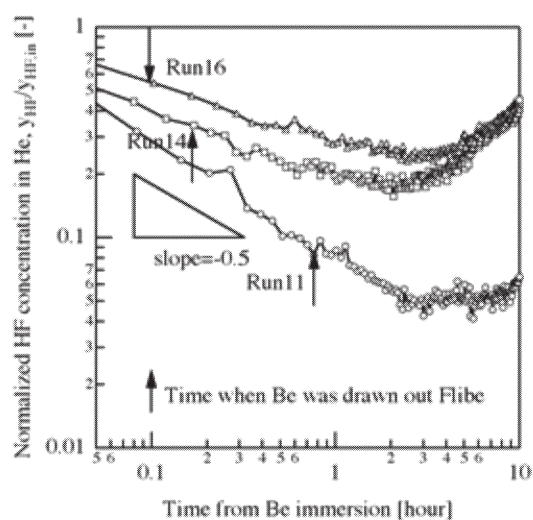


Fig. 1 Initial HF reaction rate

time of gas supplied to the Flibe reservoir was less than 0.1 hour, the variations of y_{HF} with time was independent of the residence time. The value of index n was around 0.5. The Be concentration was almost constant immediately after the Be withdrawal. This implies that the reaction of Be and HF is controlled by diffusion of F⁻ ion in the Flibe molten salt.

Fig. 2 shows estimated values of the TF concentration in a Flibe blanket of a fusion reactor. When its fusion power is 1 GW, the tritium generation rate to maintain a steady-state tritium burning is 1.6 MCi/day. Since the partial pressure of TF generated in a self-cooled fusion blanket to maintain a steady-state fusion power of 1 GW is around 10 Pa. Consequently, the expected rate of the TF to T₂ transformation became sufficiently fast to keep x_{TF} low. Then, the high transformation ratio of T₂/TF at the blanket outlet is expected. The present study proved that the redox control by Be can be achieved even under the TF concentration expected in the FFHR-2 Flibe blanket.

[Our achievements in 2006]

[1] S. Fukada, et al., Proc. ICFRM-12 (2007)

[2] S. Fukada, et al., Proc. TOFE-17 (2007)

[3] S. Fukada, et al., J. Nucl. Mater., 358 (2006) 235

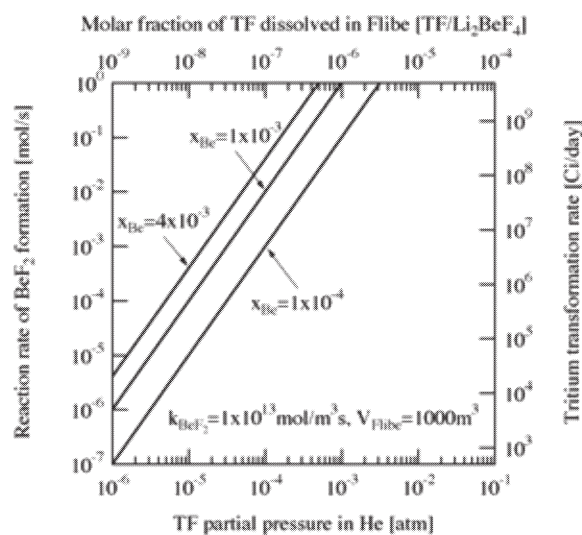


Fig. 2 Estimated TF concentration in Flibe blanket