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

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Introduction: Tritium is a fuel for fusion reactors. However, there are no natural sources in the earth. So, tritium is produced by the ^{6}Li(n, T)^{4}He reaction during D-T fusion operation. Flibe ($2LiF+BeF_2$) is one of the most promising liquid blanket materials, because of lower tritium solubility, stable at higher temperature, less reactivity with oxygen, low electric conductivity (small MHD effect) and so on. Disadvantages of Flibe are generation of corrosive TF and higher melting temperature. Previously there were several experiments for tritium recovery from Flibe. However, there are few experiments based on the analysis of tritium diffusion through Flibe and isotopic exchange with H_2. In this study, tritium was generated in Flibe by the neutron irradiation in a fission reactor. Experimental tritium elution curves from Flibe are fitted by numerical analysis that takes into consideration of diffusion and isotopic exchange.

Experiment and Analysis: A mixture of 2LiF and BeF_2 was melted in a Mo crucible under He atmosphere. Around 1 g Flibe sphere particle was placed in a capsule made of polyethylene and was irradiated in a fission reactor under a neutron flux of 2.75×10^{13} n/cm^{2}s and temperature of 50^{o}C. The irradiated Flibe was placed in another Mo crucible in a Ni reaction tube and was heated by an electric furnace from the room temperature to 800^{o}C under Ar purge condition. The outlet tritium concentration was detected by an ionization chamber.

The diffusion equation of the Flibe particle is as follows:

$$\frac{\partial q_T}{\partial t} = \frac{D_T}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial q_T}{\partial r}\right)$$

The initial and boundary conditions are

$$t = 0 \rightarrow q_T = q_{T,0}$$

$$r = 0 \rightarrow \frac{\partial q_T}{\partial r} = 0$$

$$r = a \rightarrow j_{HT} = -D_T\frac{\partial q_T}{\partial r} = k_{exc,H_2}\left(q_T c_{H_2} - \frac{q_H c_{HT}}{K_{H_2-HT}}\right)$$

The effluent tritium concentration in the Ni reaction tube, c_T ($=c_{HT}$) , is described by the equation:

$$V\frac{dc_T}{dt} = 4\pi a^2 j_T - Wc_T + Wc_{T,in}$$

When the equilibrium relation in T concentration between Flibe surface (q_T) and gaseous HT (c_{HT}) is described by the Henry relation and the c_{H2} and q_H values are much larger than the c_{HT} and q_T ones, the equilibrium relation becomes linear. Then, the analytical solution is obtained by the following equation.

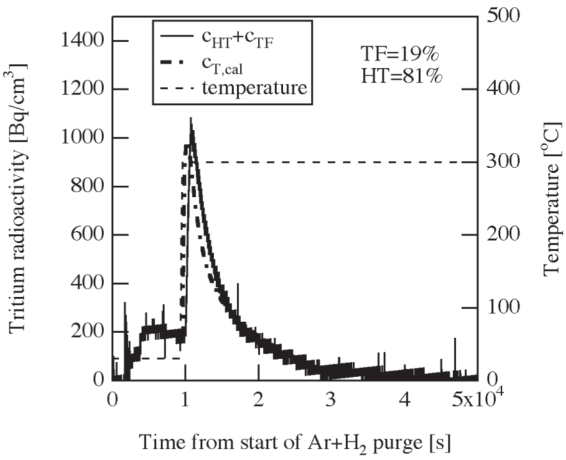

Fig.1 Experiment and calculation of tritium release from neutron-irradiated Flibe

$$c_T = \frac{4\pi a^2 k_T' q_{T,0}}{V}\sum_{n=1}^{\infty}\left[\frac{2\frac{k_T' a}{D_T}}{p_n^2 - \frac{k_T' a}{D_T}\left(1-\frac{k_T' a}{D_T}\right)}\right]\left[\frac{\exp\left(-\frac{p_n^2 D_T}{a^2}t\right)-\exp\left(-\frac{W}{V}t\right)}{\frac{W}{V}-\frac{p_n^2 D_T}{a^2}}\right]$$

Results and Discussion:

Fig. 1 shows an example of the experiment and calculation of tritium effluent curve from Flibe at 300^{o}C. The temperature is maintained at constant after the start of heating. There is a small time lag after the start of heating, but the experimental tritium effluent curve could be fitted to the numerical one. The diffusion coefficient obtained here and our previous data are correlated in Fig. 2

Reference: S. Fukada et al., J. Nucl. Mater., 367(2007)1190

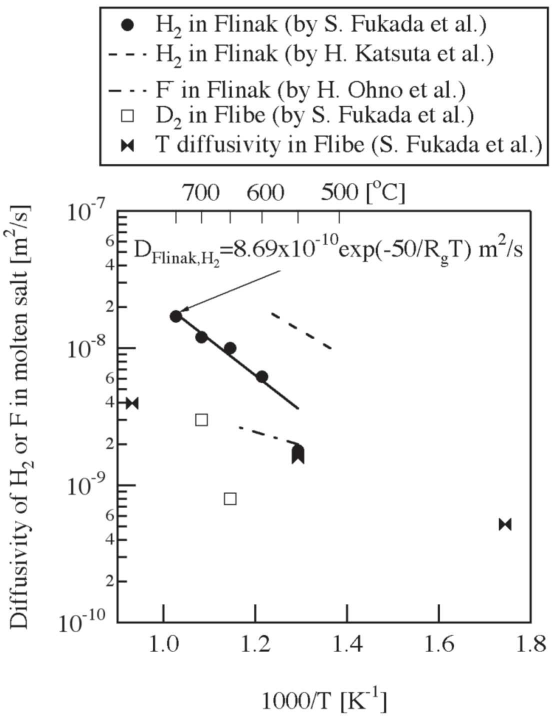

Fig. 2 Tritium diffusivity in Flibe