§19. Hydrogen and Heat Simultaneous Transport through Molten Salt Flinabe

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Molten salt Flibe ($2LiF+BeF_2$ mixture) has promising properties as a tritium breeder or self-coolant for helical-type fusion reactor of FFHR, which are high TBR, low tritium solubility resulting in easy tritium recovery, low electric conductivity leading to small MHD effect, low vapor pressure and less reactivity with H_2O or O_2. Disadvantages, on the other hand, are higher melting temperature (459ºC) and corrosive TF generation after neutron irradiation. The latter will be resolved by means of conversion to T_2 using the redox-control reaction with Be, which is described as $Be+2TF=BeF_2+T_2$. Although it was reported that the first disadvantage might be mitigated by using a new candidate of Flinabe ($LiF+NaF+BeF_2$ mixture) in place of Flibe, there were less experimental trial or information on interaction with T_2 or hydrogen isotopes. In the present study, H transfer properties such as solubility, diffusivity and permeability of Flinabe are experimentally determined using a tertiary cylindrical tube system set up in our laboratory this year.

Flinabe was melted in a Ni crucible to perform H_2 permeation experiment using the new molten salt. An equi-molar mixture of $LiF+NaF+BeF_2$ was melted around at 300-400ºC and purified using 1000ppm HF+inert gas mixture. The reaction progress as time elapsing is shown in Fig. 1. The following reaction may occur in the molten salt including BeO impurities:

$BeO+2HF=BeF_2+H_2O$

HF introduced at earlier time is consumed by the above reaction and the area amounts to 3.05×10^{-6} mol, which corresponds to 4 ppm impurity. Judging from the thermodynamic data of each component appearing in the above reaction, it is considered that BeO is not present in the purified Flinabe.

A tertiary cylindrical tubes system composed of monel-400 Ni-Cu alloy and sus316 alloy is set up. H_2-Ar gas mixture or pure H_2 is supplied in the inside cylindrical tube, and H_2 permeates through the dual cylindrical tube of the middle part. Finally H_2 permeates in the outer cylindrical tube and permeated H_2 is purged out by Ar. The H_2 concentration in Ar purge is detected by gas chromatography. At the same time transient H_2 diffusion behavior is analyzed solving the transient diffusion equation. As seen in Fig. 2, good fitting is obtained between calculations and transient experimental effluent curves, and the comparison gives a set of diffusivity and solubility. After confirming the steady-state permeation rate, the experiment is terminated, the H_2 gas line is changed to Ar purge line and then experiment is moved into the next condition.

As seen in Fig. 3, the steady-state H_2 permeation rate is in proportion to the up-stream H_2 pressure, and therefore H_2 is present as the molecular form in the molten salt and diffuses inside Flinabe. The absolute value of H_2 permeability is the maximum position among Flibe, Flinak and Fnabe. The permeability and diffusivity is closely related with viscosity of each molten salt. Experiment is now continued.

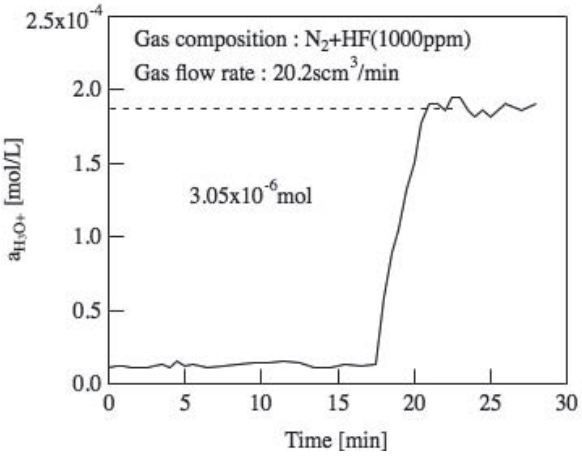

Fig. 1 Experiment to remove O from Flinabe using HF

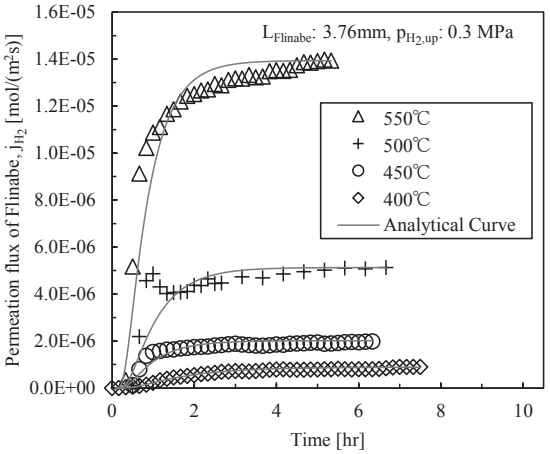

Fig. 2 Transient H_2 permeation curve of experiment and calculation for Flinabe

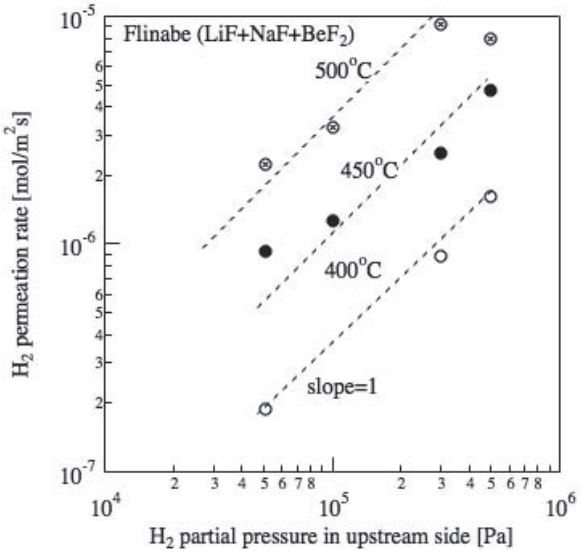

Fig. 3 Steady-state H_2 permeation rate as a function of the upstream H_2 partial pressure