§4. Hydrogen Solubility in Ti Powder Mixed FLiNaK

Yagi, J., Sagara, A., Tanaka, T., Muroga, T.

Molten salts are practical liquid breeding material for fusion reactor owing to the inertness against air and water, low electric conductivity, relatively light density, good compatibility with structure materials. However its very low hydrogen isotopes solubility, which will result in high equilibrium tritium pressure and large tritium permeation leakage in the actual fusion reactor, is the severest concern.

Considering this, mixing a little hydrogen soluble metal powder (such as Ti, Zr) with molten salt has been proposed. It is expected to results in higher effective hydrogen solubility, no significant change in electric resistivity, negligible change in nuclear behavior (=TBR), and improved compatibility with structure materials when fluoric acid (=TF) is generated

In this work, effective hydrogen solubility into the FLiNaK/Ti powder mixture was investigated. Experimental setup is shown in Fig.1. Absorbed hydrogen by H_2/Ar gas bubbling in the mixture was swept by pure Ar gas bubbling and quantified using mass analyzer.

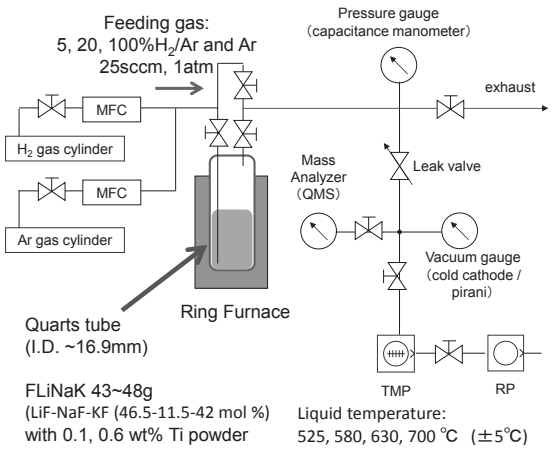

Fig.1. Experimental setup.

As shown in Fig.2, only 0.1wt% of titanium powder in FLiNaK showed significant hydrogen absorbing capability. The ratio of absorbed hydrogen to titanium powder was calculated and shown in Fig.3. Hydrogen solubility seems to increase almost linear to the square root of hydrogen partial pressure (Sirvert's law). In contrast, molten salt mixture with 0.6 wt% Ti powder did not show significant hydrogen absorption and desorption when the mixture was exposed to air for a minute at 800 K. Contamination of the Ti powder surface would suppress the hydrogen transfer between molten salt and Ti powder. This is consistent with the SEM analysis result -oxygen was detected in where titanium was detected-.

Based on the hydrogen absorbing result by 0.1 wt.%Ti at 973 K and considering the similar hydrogen

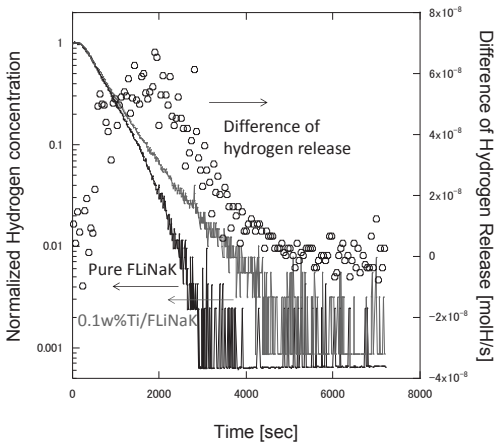

Fig.2. An example of hydrogen release behavior
Ti/FLiNaK: 0.1wt%, temp.: 700C,
feeding gas 5%H2/Ar →Ar

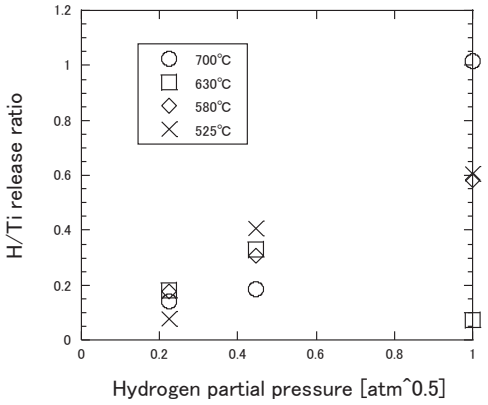

Fig.3. hydrogen solubility in Ti powder mixture

absorption by Ti powder happen even in molten salt FLiBe, tritium inventory was estimated for the FFHR-2 type reactor made of 700 ton of V-alloy (V-4Cr-4Ti). The result is shown in Table 1. Addition of Ti powder to FLiBe drastically decreases the tritium inventory to the V-alloy structure material to the acceptable level.

These results were presented in a conference (SOFT2014, Spain) and to be published in a journal [1].

1) J. Yagi et al., Fusion Engineering and Design, to be published (2015).

Table 1. Tritium inventory estimation in fusion reactor

	T in FLiBe (mixture)			T inventory in	
	C [appm]	[wppb]	Equilibrium T_2 pressure [atm]	V-alloy [kg]	FLiBe [kg]
pure FLiBe	1	30	1	1700	13
	0.1	3	0.1	520	1.3
	0.01	0.3	0.01	170	0.13
0.1w%Ti-FLiBe	1	30	6×10^{-7}	1.3	13
	0.1	3	6×10^{-9}	0.13	1.3
	0.01	0.3	6×10^{-11}	0.013	0.13