# §35. Compatibility and Mass Transfer Study for Liquid Breeder Blanket System

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Self cooled Liquid breeder blanket system is considered as advanced blanket system for possibility for reprocessing and simple structure. However, the corrosion of structural or coating material is critical issue for these blanket system development. In this study, purification of Flibe ($LiF$-$BeF_2$ molten salt) and corrosion test of Li was carried out for development of Flibe or Li blanket system.

Flibe blanket system has low chemical reactivity with air and it is free from MHD pressure drop for high electrical resistivity. Reduced Activated Ferritic Steels (RAF Steels), such as JLF-1 is considered as structural material for its compatibility with Flibe. To carry out corrosion study of these materials, pure Flibe is necessary which without the elements contained in candidate structural material. Presence of these elements will affect the corrosion rate. Oxygen also affects the corrosion test, since oxidation is one of the most important reactions in corrosion. These elements can be eliminated by chemical and mechanical processes. In previous study, 50 g of Flibe was purified by the chemical and mechanical process. However large scale purification is desired for further corrosion tests. In present study, 300 g of Flibe was purified for the first step to fabricate mass purification system.

At first the reagent of $BeF_2$ and LiF were prepared and packed into purification pod in vacuum grove box which atmosphere is He. The reagents are dehydrated by vacuum pumping. Next, the reagents were melted and fluoridated with 10% HF gas. The gas was generated from reacting $H_2$ with NiF powder. From this process, oxides like BeO, $Fe_2O_3$ or $Cr_2O_3$ become fluorides like $BeF_2$, $FeF_3$ or $CrF_3$. For the final step, these fluorides were reduced by $H_2$ gas. These metal fluorides become metal and were segregated in the cooling process. Figure 1 shows crushed Flibe after cooling. Metal impurities are condensed in gas-Flibe interface and the interface became black. ICP analysis shows that Ni was segregated efficiently in black part. Fe and Cr are considered to be segregated as Ni by prolonging the reduction process.

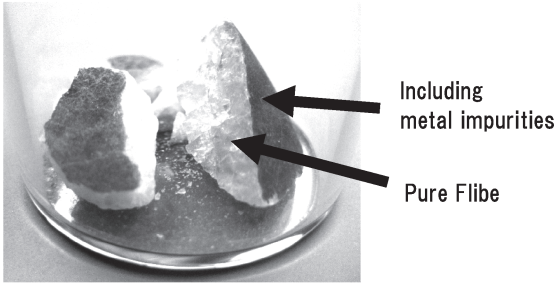


**Fig.1. Crushed Flibe after cooling. White part is pure Flibe without Ni. Metal impurities are segregated in gas-Flibe interface.**

Liquid Li blanket system has high tritium breeding ratio and good heat exchangeability. Fabrication of insulating coating inside the duct is proposed to reduce the Magneto hydrodynamic (MHD) pressure drop. $Er_2O_3$ is promising material for chemical stability. Although reaction of $Er_2O_3$ with Li is minimal, corrosion behavior of $Er_2O_3$ in Li must be clear to evaluate the duration of coating. In this study $Er_2O_3$ were immersed in liquid Li under static and flowing condition. Corrosion behavior of $Er_2O_3$ in the Li became clear.

Sintered $Er_2O_3$ tablets were immersed as specimen. For static test, capsule made by type 316 stainless steel was used as crucible. For flowing test natural convective Li loop which is made by 316 stainless steels is constructed. Test temperature was up to 600 $^0$C for both tests. After immersion, specimen was analyzed with Scanning Electron Microscopy (SEM), X-ray diffraction (XRD) spectrometry and weight measurement. These analyses showed that the $Er_2O_3$ increase its weight in Li. Figure 2 indicates the relation of weight increase with the test temperature in static condition. Corrosion products are observed in SEM images and it causes the weight increase. Diffraction patterns appeared in the XRD spectrum of the specimen on which corrosion products are observed by SEM observation. Corrosion product is considered as $LiErO_2$ from the XRD pattern. In the flowing test, almost same corrosion behavior was observed. Mass transfer, which happens sometime for other materials corrosion in such flowing condition, was not detected. Therefore production of $LiErO_2$ will be a problem in practical use of $Er_2O_3$ in Li blanket system.

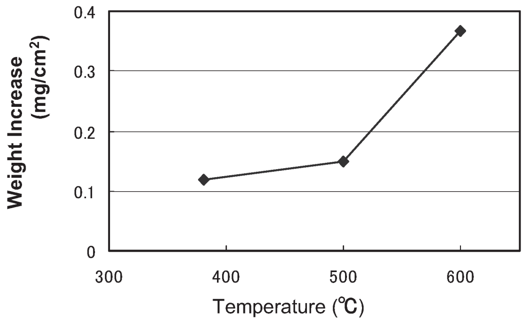


**Fig.2 Weight increase of Er2O3 tablet in static Li.**

For summary, purification of 300 g Flibe and corrosion test of $Er_2O_3$ in Li were carried out. For Flibe purification, Ni in Flibe was segregated efficiently. Fe and Cr can be removed by prolonging the reduction process. From $Er_2O_3$ corrosion test, corrosion behavior becomes clear that $LiErO_2$ forms in Li. The formation of $LiErO_2$ must be suppressed.

1) Nagura, M., et al. Fusion Sci. Tech. **52**, (2007) 630