

## §20. Li Compatibility of Erbium Oxide as a MHD Coating Material for Liquid Lithium Breeder Blanket

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Liquid lithium (Li) is a candidate tritium breeding materials in the design of fusion blanket systems. This selection is based on its high tritium breeding ratio, low density and good thermal conductivity as coolant. These properties allow designing self-cooled Li blankets without neutron multiplier, leading to compact and economical options for DEMO reactor. One of the critical issues for Li blanket concept is magneto-hydrodynamic (MHD) pressure drop which makes large pressure loss of flow. The pressure drop can be reduced by fabricating insulating coating on inner surface of the duct. Recent Li corrosion tests with insulating materials showed  $\text{Er}_2\text{O}_3$  having a good compatibility with Li.[1] However, the corrosion mechanism of  $\text{Er}_2\text{O}_3$  in liquid Li is not clear because the corrosion reaction was so small to detect. In previous studies, we showed  $\text{Er}_2\text{O}_3$  react with Li and forms slight amount of  $\text{LiErO}_2$ . [2] Investigation of reaction mechanism will help evaluating corrosion rate via forming  $\text{LiErO}_2$  and controlling the corrosion. In the present study the corrosion tests with various O concentrations in Li were carried out. At first, oxygen supplier and absorber were added to observe the change in corrosion behavior. Then the detailed corrosion sensitivity of  $\text{Er}_2\text{O}_3$  to O concentration was investigated.

Corrosion tests were carried out using type 316 stainless steel capsule as a crucible. 15 g of Li, an  $\text{Er}_2\text{O}_3$  specimen was packed in the capsule under Ar atmosphere. Test temperature was 873 K for all tests and the test durations were 500 - 2000 h. Reaction rate to form  $\text{LiErO}_2$  can be affected by concentration of elements included in  $\text{LiErO}_2$ . So, we changed concentration of O and Er activity in the Li to investigate the reaction mechanism. O activity can increase by adding a material which can be easily reduced by Li. In this study we used  $\text{Fe}_2\text{O}_3$  powder as O supplier. In the same way, the O concentration can be lower by adding a metal whose oxide is stable in Li. Er or Ca was employed as the O absorber in Li.

To investigate the corrosion mechanism, we carried out three experiments and compare the corrosion rate with previous study. The three tests are with additive of 0.1g of  $\text{Fe}_2\text{O}_3$  powder, 2g of Er powder, and 2 g of Ca granule. Test temperature was 873 K and test duration was 1000 h. After the tests, specimen with  $\text{Fe}_2\text{O}_3$  broke during the cleaning. Other specimens did not break in the cleaning process. Small particles with 100 to 500 nm diameter were covered large  $\text{Er}_2\text{O}_3$  grain with about 10  $\mu\text{m}$  in diameter for specimen without additives and with Er. Specimen with  $\text{Fe}_2\text{O}_3$  has lot of  $\text{LiErO}_2$  on the surface compared to other specimens.  $\text{LiErO}_2$  on the  $\text{Er}_2\text{O}_3$  grain surface or at inter

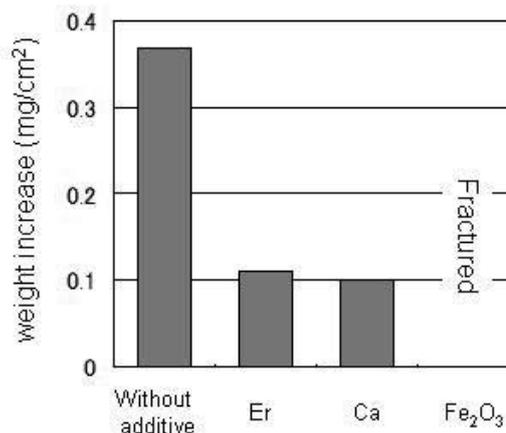
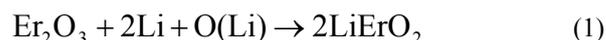


Fig.1. Weight increase of corrosion specimen with additives. Specimen with Er and Ca

granule region can weaken the bonding of  $\text{Er}_2\text{O}_3$  grains. This might be a cause of specimen fracture. For the specimen of Er or Ca added tests, they showed smaller corrosion, compared to the non-additive test. Figure 1 shows weight gain in these tests. The previous study showed larger corrosion result in larger weight gain,[2] when the specimen did not break. Surface SEM images of Er added test show lower amount of  $\text{LiErO}_2$  than that of the non-additive one. A specimen with Ca test showed same tendency with the Er added test in SEM observation and weight increase. From these result, we found reaction rate of forming  $\text{LiErO}_2$  depends on O concentration in Li. A corrosion test with higher O concentration showed larger amount of  $\text{LiErO}_2$ . The reaction rate seems to be independent from the Er concentration in Li. This results leads to a reaction below.



This formula corresponds to the reaction rate dependence on O concentration and agrees with the weight change of the corroded specimens that higher corrosion shows larger weight increase. If the  $\text{LiErO}_2$  formed by reaction above remains on the specimen, it would be the cause of mass gain. Mass gain of 0.1 mg means  $3 \times 10^{-6}$  mol  $\text{Er}_2\text{O}_3$  reacted in Li, which is equivalent to about 1.5  $\mu\text{m}$  coating thickness.

In this study, we investigated the corrosion of bulk  $\text{Er}_2\text{O}_3$  with Li under various O concentrations and propose a corrosion reaction of  $\text{Er}_2\text{O}_3$  in liquid lithium, which gives a basis to predict life-time of the corrosion protection ability of erbia coatings.

- 1) B. Pint, et al., J. Nucl. Mater., **307-311**(2002)1344.
- 2) M. Nagura, A. Suzuki, et al., Fus. Eng. Des., In Press.