3-8 Materials Necessary for Stably Supplying Fuel Tritium to Fusion Reactors

–Development of Tritium Breeding Materials Resistant to Reduction in Hydrogen–

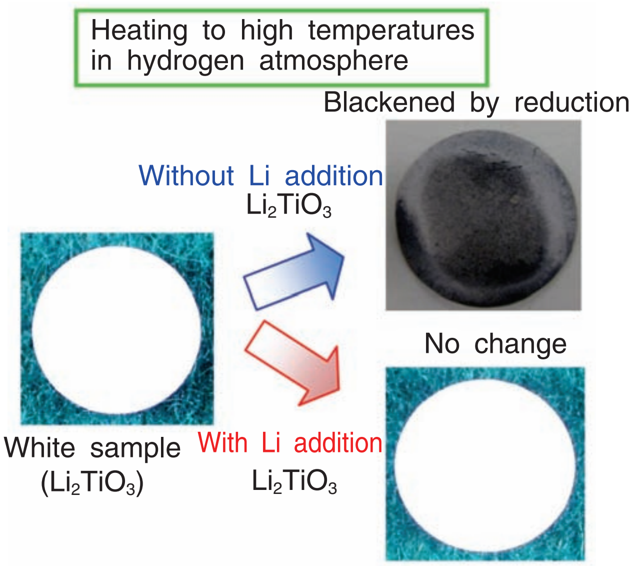

Fig.3-17 Color of Li_2TiO_3 after heating to high temperatures in hydrogen atmosphere
The color of Li_2TiO_3 without added Li changed from white to black in a hydrogen atmosphere at high temperatures. This color-change corresponds to reduction of Li_2TiO_3. In the case of Li_2TiO_3 with added Li, the color did not change, indicating that this sample was not reduced in the hydrogen atmosphere.

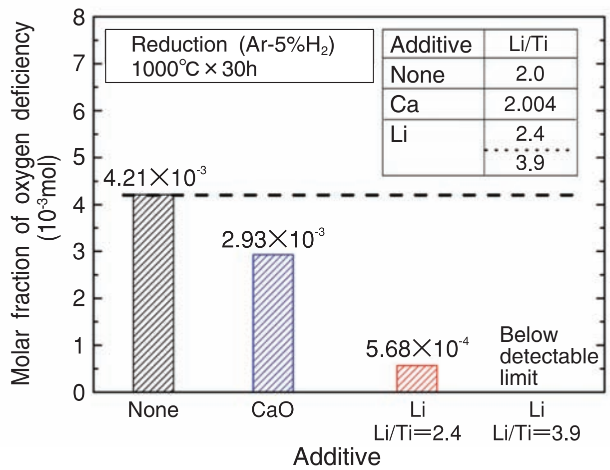

Fig.3-18 Molar fraction of oxygen deficiency of Li_2TiO_3 with different additives
Reduction of Ti in Li_2TiO_3, namely, the valence change from Ti^{4+} to Ti^{3+}, is accompanied by oxygen vacancies in the crystal structure. The Li/Ti = 3.9 sample exhibited no oxygen vacancies, which indicates clearly that it was highly resistant to reduction.

D-T fusion reactors need deuterium (D) and tritium (T) as their fuel. Since tritium does not exist in nature, it is necessary to produce tritium artificially by neutron irradiation of a lithium-filled blanket.

Lithium titanate (Li_2TiO_3) has been recognized as one of the primary candidates for tritium breeding materials because of its good tritium release and its low activation. Addition of H_2 to the inert sweep gas at the blanket has been proposed for enhancing the release of the generated tritium from the breeder material. However, Li_2TiO_3 is reduced in a H_2 atmosphere at an operating temperature above 600°C, which will lead to degradation of the tritium release characteristics. The reduction of Ti in Li_2TiO_3 from Ti^{4+} to Ti^{3+} is accompanied by mass decrease due to decrease in oxygen content of Li_2TiO_3. In a previous study, Li_2TiO_3 (Li/Ti > 2.0) to which CaO was added exhibited smaller oxygen deficiency than Li_2TiO_3 without such addition. As the next research step, development of Li_2TiO_3 with excess Li was attempted to improve its resistance to deoxidization at high temperatures.

Usually, solid state reaction of Li_2CO_3 and TiO_2 is used in the synthesis of Li_2TiO_3. However, Li addition by solid state reaction was found to be difficult. In the present study, we have developed a new process, in which Li alkoxide and Ti alkoxide are mixed to add Li_2O to Li_2TiO_3.

Fig.3-17 shows a photograph of Li_2TiO_3 samples heated in hydrogen atmosphere at high temperatures. The color of a Li_2TiO_3 sample changed black, while that of a Li_2TiO_3 sample with added Li remained white. This black discoloration indicates valence change from Ti^{4+} to Ti^{3+}, which accompanies decrease in the oxygen content of the sample.

Fig.3-18 compares the molar fraction of oxygen deficiency of the Li_2TiO_3 with added Li to Li_2TiO_3 of our previous study with added CaO. The molar fraction of oxygen deficiency increased as the molecular ratio Li/Ti decreased. The result for Li/Ti = 3.9 indicated no oxygen vacancies.

The overall results indicated that Li addition is very effective in suppressing oxygen deficiency. Thus, an advanced tritium breeding material for high temperature use in fusion reactors has been developed through successful synthesis of Li_2TiO_3 with added Li.

Reference
Hoshino, T. et al., Non-Stoichiometry and Vaporization Characteristic of $Li_{2.1}TiO_{3.05}$ in Hydrogen Atmosphere, Fusion Engineering and Design, vol.82, issues 15-24, 2007, p.2269-2273.