Hydrogen Production from Hydrocarbons by using Oxygen Permeable Membranes

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Mixed oxide-ion and electronic conductors have been widely studied for use as electrodes of solid oxide fuel cells and as oxygen permeable membranes. The oxygen permeable membranes are of interest, in view of their promising applications, such as the production of pure oxygen from air and hydrogen from hydrocarbons. To put a novel reformer using the membrane into practice for partial oxidation of hydrocarbons (MPOX reformer), we have recently developed a composite-type membrane consisting of Sm-doped CeO_2 as an oxide-ion conductor and $MnFe_2O_4$ as an electronic conductor has been developed [1, 2]. The composite of Sm-doped CeO_2 - 15 vol% $MnFe_2O_4$ (CSO-15MFO) shows a high oxygen flux density of 10 $\mu mol \cdot cm^{-2} \cdot s^{-1}$ ($\approx$ 13.4[STP]$cm^3 \cdot cm^{-2} \cdot min^{-1}$) at 1000 °C, and a thermal expansion coefficient (TEC) of 12 x 10^{-6} K^{-1} between room temperature and 1000 °C. In the first part of the talk, the fabrication and characteristics of the planar-type methane reformer using the ceria-based oxygen permeable membrane will be presented. A single module reformer with dimensions of 6 cm x 6 cm showed an oxygen flux density of 3.3 $\mu mol \cdot cm^{-2} \cdot s^{-1}$, CH_4 conversion rate of 94.1 %, CO selectivity of 85.7 %, H_2 selectivity of 92.1 %, and H_2 production volume of 360 sccm at 780 ˚C, where methane and air flow rates were 150 and 500 sccm, respectively. This reformer was also found to start up in 20 min. The advantages of the MPOX reformer in the context of exergy usage, and cation diffusion behavior that controls the durability of the membrane will be discussed. The second part of the talk will be devoted to the enhancement of oxygen permeability by using nanoparticle technologies. For example, to promote surface exchange reaction, the Langmuir-Blodgett film of PtFe nanoparticles was prepared and applied to the oxygen permeable membrane surface. In addition, the possibility of oxide-ion conductivity enhancement in ceria will be presented.

[1] H. Takamura et al., *J. Electroceramics*, 13 (2004) 613-618.

[2] H. Takamura et al., *J. Alloys Comp.*, 408-412 (2006) 1084-1089.