Development of Plasma Membrane Reactor for Hydrogen Production from Ammonia

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An on-site hydrogen production system is desired by semiconductor industries and by manufacturers of fuel cell power generators to reduce the hydrogen cost. Ammonia is a promising raw material for hydrogen production because it may solve several problems related to hydrogen transportation and storage. Hydrogen can be effectively produced from ammonia via catalytic thermal decomposition; however, the resulting residual ammonia negatively influences the fuel cells.

Therefore, a high-purity hydrogen production system comprising a catalytic decomposition reactor (CR) and a plasma membrane reactor (PMR) has been developed herein. The catalytic reactor containing 10% Ni/Al_2O_3 catalyst achieves ammonia conversion to hydrogen at an efficiency of 99.5%. The product gas containing unreacted ammonia was introduced into the 42-mm-diameter and 400-mm-long PMR, wherein the residual ammonia was decomposed by the electron energy in the dielectric barrier discharge plasma. The produced hydrogen was simultaneously separated by the hydrogen separation membrane in the reactor, thus obtaining hydrogen at a purity of 99.999% at the output of the PMR.

The optimal operating conditions to maximize the hydrogen production flow rate were investigated. The residual ammonia concentration, gas differential pressure, applied voltage of the plasma, and plasma state influenced the flow rate. It found that the rate-controlling step in the pure hydrogen production was the adsorption of H radicals on the surface of the membrane. A pure hydrogen flow rate of about 200 L/h was achieved with the current operating conditions (Fig. 1). The flow rate can be further increased by improving the plasma state.

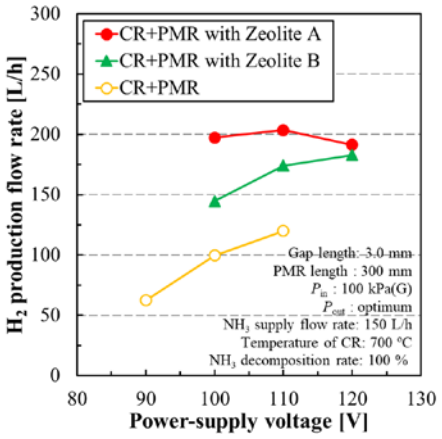

Fig. 1 Hydrogen production by the PMR.