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Performance investigation of hydrogen production from ammonia by plasma membrane reactor

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Ammonia has a number of favorable characteristics that stem from its molecular structure, the primary characteristic being its high hydrogen storage capacity of 17.6 wt%. Its secondary merit is that it is carbon-free at its end uses, although CO_2 emitted during the production of ammonia depends on the energy source. Therefore, ammonia is the most promising hydrogen carrier among all hydrogen-containing compounds.

A dielectric barrier discharge (DBD) plasma is appropriate for ammonia decomposition because the electric load to plasma reactors can be quickly controlled by adjusting either the output voltage or the duty cycle, which can respond well to variations in gas volume. Furthermore, ammonia is expected to be completely decomposed by sufficient electron energy in the plasma without the need for heating.

The aim of the present research was to develop an efficient method for using pulsed plasma to produce hydrogen from ammonia. An efficient method for producing hydrogen was developed on the basis of the mechanisms of ammonia decomposition in plasma. To achieve this aim, we precisely designed the advanced plasma reactor shown in Figure 1.

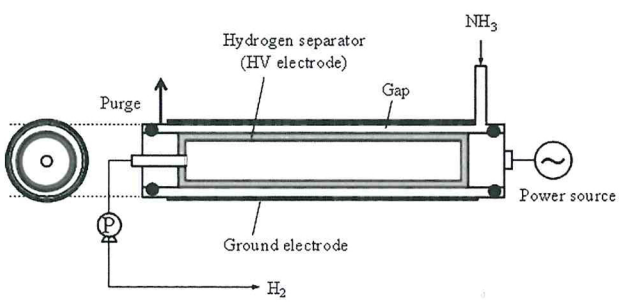

Figure 1: Configuration of the plasma membrane reactor.

In this plasma reactor, the original hydrogen separation membrane was used as a high-voltage electrode. We expected the H radicals generated by ammonia decomposition in the plasma to rapidly diffuse through the membrane, thereby inhibiting ammonia recombination.

Hydrogen production experiments were conducted using 100% ammonia gas at a flow rate of 1.0 L/min in the advanced plasma reactor shown in Figure 1. The ammonia was completely converted into pure hydrogen at an applied voltage of 9 kV (total power consumption of the high-voltage power source was 200 W). The energy efficiency was 65.3%.