§5. Hydrogen and Hydrocarbon Combustion in Atmospheric Pressure Plasma

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One of the critical issues for nuclear fusion reactors is that tritium and tritiated carbon are recovered in the reactor building. Using the present method, a tritium removal system removes tritium from a gas by cracking the tritium containing components on a heated precious metal catalyst. The tritium combines with oxygen in the air stream to form tritiated water. Then, a molecular sieve bed removes the tritiated water contained in the air stream. Although this system offers adequate efficiency, a high-pressure drop, the use of a large amount of precious metals, and inefficient heating occur when the processing throughput is quite large. On the other hand, plasma combustion is expected to solve these problems since hydrogen and oxygen radicals are easily generated by high-energy electron and ion impacts in the plasma.

So far, we have done hydrogen combustion experiments using an atmospheric pressure plasma and found hydrogen conversion efficiency raises with increasing input power and has reached over 80% at 100W for input microwave power [1, 2]. Furthermore, we have clarified that input energy density is one of key parameters for combustion processes in atmospheric pressure plasma. It has been also found that neutral gas temperature in the plasma is much higher than the outside temperature of plasma. The high neutral gas temperature would affect to the combustion reaction [3].

In this study, we focus on hydrocarbon combustion in atmospheric pressure plasma generated by a 2.45 GHz microwave discharge as shown in Fig. 1. Instead of hydrogen, small amounts of methane and oxygen were mixed in the operational argon gas during discharge. A quadrupole mass spectrometer (QMS) was used primarily to measure time evolution of gas composition during discharge. To clarify the details of combustion, visible light emissions from the plasma were also observed by a spectrometer through a biconvex lens and an optical fiber. Gas temperature in the plasma flame was planned to evaluate using the spectrum profile of OH emission.

Figure 2 shows the change of gas composition measured by the QMS during discharge for several input microwave power with Ar: 2.26 L/min (83.7 vol%), O_2: 0.40 L/min (14.8 vol%) and CH_4: 0.04 L/min (1.4 vol%). Increasing with input microwave power, not only decomposition and oxidation of CH_4, additional chemical compounds is also observed. Because of the difficulty about distinction between mass spectra, which have same mass to charge ratio, we are preparing a gas chromatography measurement. In the next step, we will attempt to evaluate methane combustion efficiency and the detail of the reaction based on quantitative measurements by the gas chromatography and optical emission spectroscopy.

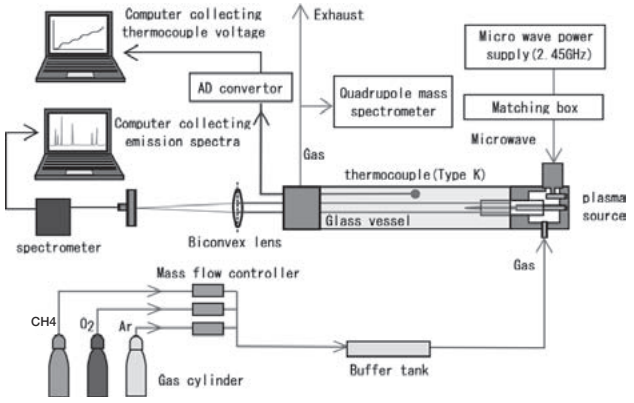

Fig. 1. Schematic of the experimental setup for hydrocarbon combustion in atmospheric pressure plasma.

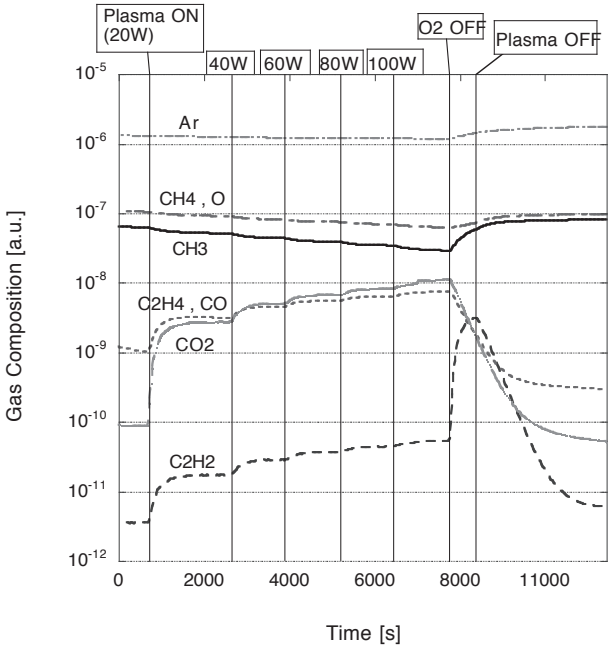

Fig. 2. Time evolution of gas composition measured by the QMS during discharge for several input microwave power with Ar: 2.26 L/min (83.7 vol%), O_2: 0.40 L/min (14.8 vol%) and CH_4: 0.04 L/min (1.4 vol%).

1) Akahane, K., Ezumi, N. et al.: Fusion Sci. Technol. **60** (2011) 1343.
2) Ezumi, N., Akahane, K. *et al*., Plasma and Fusion Research, **7**, (2012) 2401075.
3) Yoshida, T., Ezumi, N. *et al*., 10th International Conference on Tritium Science and Technology (Tritium 2013) Nice, France, 21 – 25 October 2013, 3-53. *Submitted to Fusion Sci. and Technol*.