§2. 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].

Based on the previous studies, which indicated the possibility of hydrogen combustion using atmospheric pressure plasma, hydrocarbon combustion experiment has been performed. In order to clarify the combustion reaction process of tritium carbide by atmospheric pressure plasma, a gas chromatography system has been developed and combustion reaction process of methane, which is one of hydrocarbon, has been investigated using the system.

Figure 1 shows methane combustion rate in our atmospheric pressure plasma generated by a 2.45 GHz microwave discharge. Small amounts of methane and oxygen were mixed in the operational argon gas during discharge. The combustion rate increases with an increase in the discharge power. The rate reaches over 90 % at more than 60W input power. During the measurement, gas concentration measured by using the gas chromatography system is changed as shown in Fig. 2. Main component in the gas after combustion is identified as CO_2, which rises with increasing the input power. On the other hand, hydrogen molecule is drastically decreased with increase in the input power. Emission intensity of OH radical observed by a spectrometer, which corresponds to OH density, increases with increasing the power. These results indicate the importance of OH radical in the methane combustion, the same as the hydrogen one.

In the next step, we attempt to clarify the detail reaction processes as comparing the results of methane and hydrogen combustions. Thought plasma diagnostics for atmospheric pressure plasmas has some difficulties, we also try to measure electron density and temperature for realizing the detail of the reaction in the combustions.

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1) Akahane, K., Ezumi, N. et al.: Fusion Sci. Tech. **60** (2011) 1343.
2) Ezumi, N., Akahane, K. *et al*., Plasma and Fusion Research, **7**, (2012) 2401075.
3) Yoshida, T., Ezumi, N. *et al*., Fusion Sci. Tech. **67** (2015) 650.

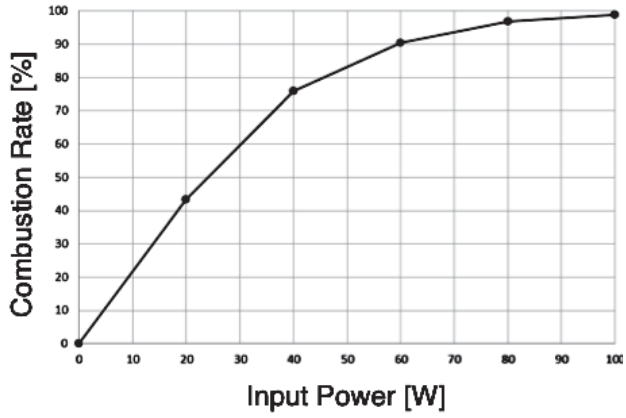

Fig. 1. Input power dependence of CH_4 combustion rate during atmospheric pressure plasma discharge on total gas flow rate 2.0 L/min (Ar: 78.0 vol%、O_2: 20.0 vol%、CH_4: 2.0 vol%).

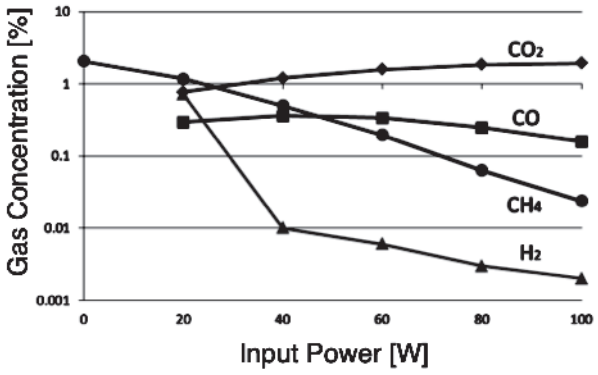

Fig.2. Gas concentration measured by the gas chromatography during atmospheric pressure plasma discharge for several input microwave power in the same condition as Fig. 1.