§6. A Study on Hydrogen Isotope and Carbon Behavior in Exhaust System

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Understanding of tritium behavior in the exhaust system of a fusion reactor is important from viewpoints of fuel control and tritium safety. When graphite is used as a plasma-facing material, a part of tritium would be transported to the exhaust system as hydrocarbon and carbon dust. Because carbon particles tend to adhere to material surfaces, a certain amount of tritium would be accumulated on the exhaust system with carbon. These carbon particles may be released to a working space during system maintenance. Therefore, it is necessary to comprehend the behavior of not only tritiated molecular but also carbon particles. In this work, the experimental apparatus to generate carbon particles containing tritium by plasma decomposition of tritiated methane were set up and preliminary experiment was carried out.

Fig.1 shows the experimental system that consists of input gas adjustment system, plasma discharge system and tritium measurement system. In the input gas adjustment system, tritium is added in the mixture of methane, hydrogen and helium and tritiated methane was generated in a catalyst bed. The tritiated water vapor was excluded in MS3A packed bed. Plasma is generated inside the cylindrical stainless steel chamber by supplying an RF power of 13.56Hz to the electrode which is inserted to the center of the tube. In the tritium measurement system, tritium concentration in the exhaust gas was monitored by an ionization chamber installed at the outlet of a scroll pump. Chemical form of tritium was distinguished in the triple water bubbler system. Tritium concentration in the bubbler was measured by a liquid scintillation counter. The outlet gas was sampled between the ionization chamber and the bubbler system and concentrations of H_2 and CH_4 were measured by a gas chromatograph.

Signals from the ionization chamber with (○) and without (Δ) plasma discharge are compared in Fig.2. The experimental conditions are as follows: HTO:7.4Bq/cc, HT:4.8Bq/cc, CH_3T:140Bq/cc, H_2:47ppm, CH_4:1090ppm, Gas flow rate:47cc/min, Gas pressure:590Pa, RF power: 40W. It is observed that just after plasma was turned on, tritium concentration in the outlet gas decreased sharply and was kept to be low. This is considered to be because that tritium is accumulated in the plasma chamber by co-deposition with carbon. From tritium measurement in the bubblers it was confirmed that CH_3T concentration decreased and HT concentration increased by plasma decomposition. As shown in Fig.3, it was observed that H_2 concentration increased up to 1570 ppm and CH_4 decreased to blow detection limit (< 10 ppm) during plasma discharge. Hydrogen concentration is lower than that expected from the concentration of decomposed methane. It seems that about 30% of hydrogen contained in disappeared methane is accumulated in the plasma chamber. Hereafter, mass balance of hydrogen isotopes and carbon will be investigated in detail.

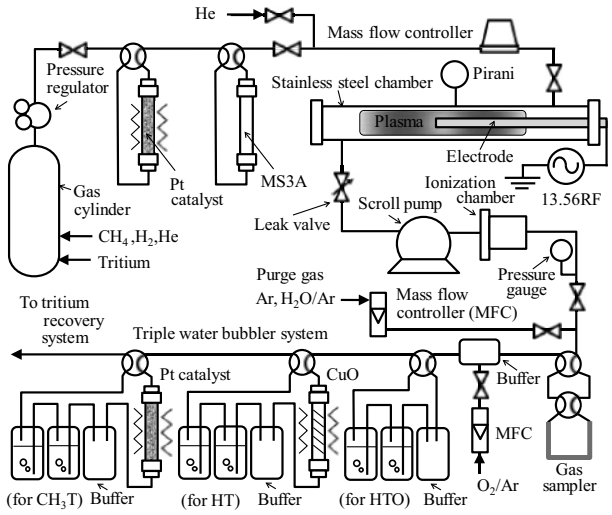

Fig.1 The experimental system for tritiated methane decomposition and formation carbon particles.

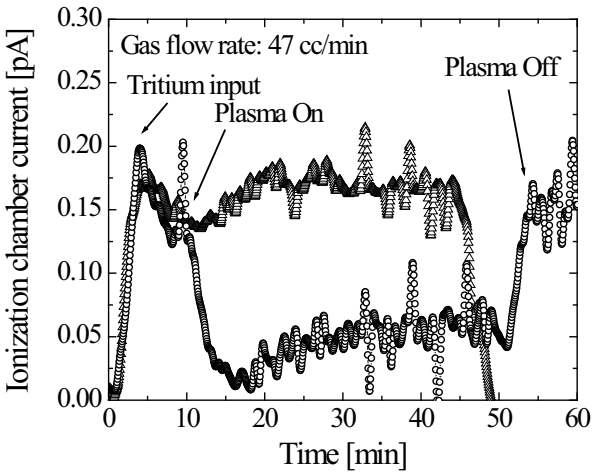

Fig.2 Signals from the ionization chamber.

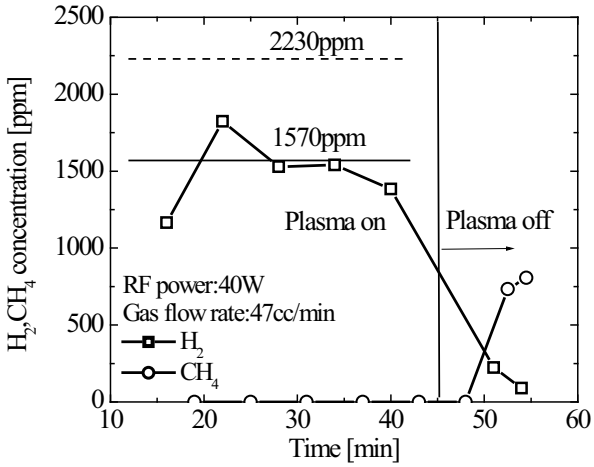

Fig.3 Changes of H_2 and CH_4 when plasma was turned off.