§7. Development of a Tritium Gas Feed Unit for Calibration of a Tritium Monitor

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A tritium monitor with a high sensitivity has been developed at NIFS collaborating with Nagoya University in order to apply it to the safety management of the deuterium plasma experiments in LHD. The monitor should be calibrated using a tritium containing gas with very low concentration in tritium.

The purpose of the present study is to develop a tritium gas feed unit which enables us to feed the calibration gas with a constant composition in safe and for a long time.

i) Tritium gas feed unit

A schematic diagram of the apparatus is shown in Fig. 1. The reactor was a Pyrex glass tube with 25 mm I. D. and filled with a layer of Kogel catalysts (Ganz Chemical Co. Ltd., 1.0 wt%-Pt). The reactor, humidifier and trap were sunk in the thermostat baths to maintain constant temperatures. The system was initially purged with nitrogen gas to prevent hydrogen explosion. Hydrogen gas mixed with saturated deuterium/tritium vapor in a humidifier was supplied to the reactor, where heavier isotope components were transferred from the vapor to the hydrogen gas. The hydrogen gas was sampled after removal of the vapor by a cold trap at 5 ºC. Hydrogen isotope ratios in the sample were measured using a stable isotope ratio mass spectrometer (MAT252, Thermo Finnigan).

ii) Experimental results

The ratio of the height of the catalyst layer to the catalyst diameter is indicated by R_p. Experiments on hydrogen-deuterium isotope transfer were performed at 101 kPa, 343 K with various values of R_p in order to estimate the transfer efficiency, η, which is defined as follows:

$$\eta = (z - z_0) / (z_e - z_0), \qquad (1)$$

where z_0, z and z_e are the mole fraction of the heavier component in the supply gas, the sample gas and the equilibrium state, respectively.

The values of 1-η are plotted in Fig. 2, where s [cm^2] and F [cm^3/s] are the total surface area of the catalysts and the volume flow ratio of the saturated gas at 101 kPa, 292 K, respectively. In the case of $R_p > 2$, the efficiency was represented well by the following theoretical equation with the mass transfer coefficient $k_s = 4.5$ cm/s.

$$1\text{-}\eta = \exp\{-k_s (s / F)\} \qquad (2)$$

According to this equation the height of the catalyst layer was estimated at 10 cm in order to obtain a hydrogen gas with isotope equilibrium composition in the case of $F < 133$ cm^3/s.

Tritium concentration in the calibration gas was estimated by Eq. (2) as shown in Fig. 3, where 10 cm of the catalyst layer, 117 cm^3/s of hydrogen flow rate and 400 Bq/cm^3 of tritium concentration in the humidifier were applied.

iii) Conclusions

The tritium gas feed unit was developed using a technique obtained by researches on water-hydrogen chemical exchange. Because the calibration gas was generated from a tritiated water the calibration gas could be fed continuously for a long time at low cost. The required height of the catalyst layer and the relationship between temperature and the tritium concentration in the calibration gas were obtained in the present study.

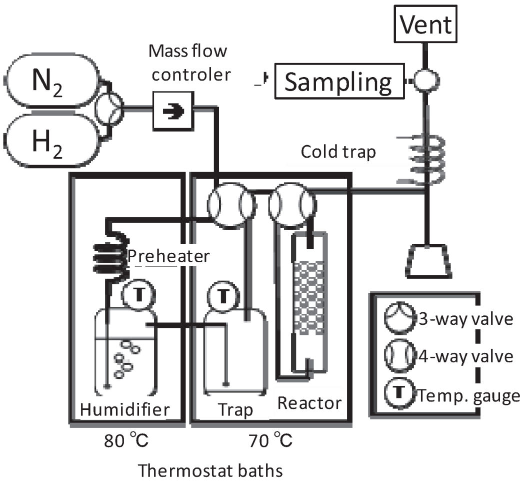

Fig. 1: Tritium gas feed unit

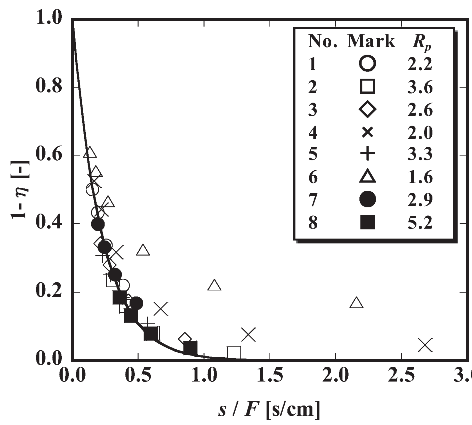

Fig. 2: Transfer efficiency of the apparatus

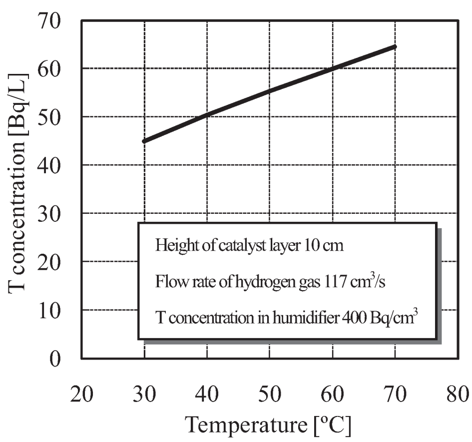

Fig. 3: Transfer efficiency of the apparatus