§31. Design Support and Sophistication of Trapping and Recovery System for Low-concentration Gaseous Tritium

Munakata, K., Hara, K., Wada, K., Wajima, T. (Akita Univ.),
Kotoh, K. (Kyushu Univ.),
Sugiyama, K. (Nagoya Univ.),
Uda, T., Tanaka, M.

LHD is known for its magnetic field confinement system called ‘heliotron’, which was uniquely developed in Japan. With LHD, NIFS places greater importance on the research in the generation and confinement of high-temperature high-density plasmas and the analysis of LHD experiments as well as the extensive theoretical and simulation science research by using the supercomputer. In the near future D-D experiments are planned, and thus it is necessary to establish a system that can recover tritium in the downstream of the exhaust pumping system of plasma and in the purge gases produced during the cleaning of the first wall of the device. In this study, the authors will obtain chemical engineering data that can be used for detailed design, optimization of operation, prediction of malfunction and so forth. Moreover, the authors will present more sophisticated systems for the recovery of low-concentration tritium in the exhaust systems of LHD.

In the first year of the LHD research, the authors carried out extensive search in terms of candidate catalysts and adsorbents. However, it was found that catalysts or adsorbents studied in the past have not been produced and are not available at present. Thus, the authors selected catalysts and adsorbents that are used in general industries and are produced by credible prestigious and credible industrial companies. The authors have procured 4 kg of DASH520 catalyst (N. E. Chemcat Co.) and 100 kg of MS5A (Union Showa Co.).

In the experiments, the catalysts were charged in a reactor made of quartz. The temperature of the reactor was varied in the range of 0 to 80 °C. The argon gas containing hydrogen (0.1 %) and oxygen (20%) was introduced to the reactor. The concentration of hydrogen at inlet and outlet stream of the reactor was measured with a mass spectrometer. The flow rate (10,000 1/h of space velocity) was controlled with conventional mass flow controller. The catalysts were reduced under the stream of hydrogen at the temperature of 350 °C before the experiments.

The experimental adsorption isotherms of water vapor on the MS5A adsorbent and the catalysts were taken by using high-performance measurement apparatus for adsorption amounts, BELSORP-max, manufactured by BEL JAPAN, Inc.

Figure 1 shows the conversions mass transfer capacitance of oxidation of hydrogen over the DASH520 catalysts as a function of reciprocal temperature. In terms of the mass transfer capacitance, K_F [m³/s], the following equation was obtained.

$$K_F = 6.7\times10^{C}\exp[-37000/(RT)] \qquad (1)$$

The performance of the catalyst for oxidation of hydrogen was found to be moderate among the catalyst tested up to now.

Figure 2 shows the adsorption isotherms of water vapor on the MS5A adsorbent as functions of partial pressures of water vapor at the temperatures of 10, 30 and 50 °C. The adsorption capacity increases with decreasing temperature, and asymptotic behavior is observed for the isotherms. These experimental adsorption isotherms are to be analyzed using several adsorption isotherm models and the results will be incorporated into a numerical simulation program. Furthermore, the experimental adsorption isotherms water vapor on the DASH520 catalyst was also taken using BELSORP-max. The adsorption amount of water vapor on the substrate of the DASH520 catalyst is found to be smaller than that of the MS5A adsorbents by one order of magnitude.

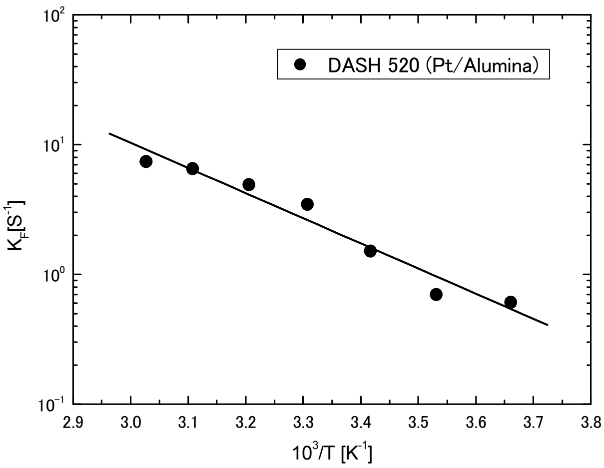

Fig.1 Mass transfer capacitance of oxidation of hydrogen over DASH520 catalyst

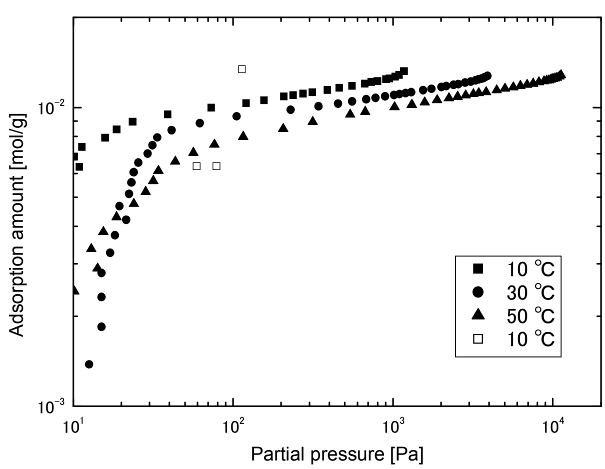

Fig.2 Adsorption isotherms of water vapor