§24. Development of Hydrogen Isotope Separation Technologies for DEMO Fuel Cycle

Sugiyama, T., Takada, A., Morita, Y. (Nagoya Univ.), Kotoh, K. (Kyushu Univ.), Munakata, K., Nakamura, A. (Akita Univ.), Taguchi, A. (Univ. Toyama), Kawano, T., Tanaka, M., Akata, N.

Detritiation of huge amount of tritiated water and safety improvement by reducing the tritium inventory are still important developing challenges for DEMO fuel cycle. In the present study, we adopted water-hydrogen chemical exchange as a technology of hydrogen isotope separation. The purposes of study are development of high-efficient catalyst applied to the technology, and development of devices for hydrogen isotope separation with its high-efficient operating procedures.

i) Water-hydrogen chemical exchange

An experimental apparatus for water detritiation, named 'Dual Temperature Dual Pressure Catalytic Exchange (DTDP-CE)', was built in the isotope separation laboratory at Nagoya University¹). The apparatus was composed of mainly two liquid phase chemical exchange columns having internal diameter of 25 mm and length of 1 m. The columns were filled, in a random manner, with Kogel catalysts (Ganz Chemical, 4.0-6.7 mm spherical, 1.0 wt%-Pt) and Dixon gauze rings (TO-TOKU Engineering, 6 mm outer diameter, 6 mm high, austenitic steel). The catalyst packing ratio was selected to be 30 %.

Effects of some operating parameters, such as pressure, temperature, cut, and flow ratio, on separation factors of the DTDP-CE apparatus were investigated by the analysis code based on the 'Channeling stage model'^{1,2}. As shown in Fig. 1 for a representative example, separation factors increased with gas-liquid flow ratio and reached plateaus around where the ratio was 2^{3} . From a safety viewpoint, a small flow rate of hydrogen gas is preferable. Consequently, the optimum value of gas-liquid flow ratio was found to be 2 for the present case.

ii) Pt catalyst for DTDP-CE

Developing targets of a Pt-catalyst for DTDP-CE are improvement in heat resistance and lasting hydrophobicity under pressurized condition. A Pt-catalyst has been developed using porous silica beads (Fuji silysia chemical Ltd., CARiACT Q-50) as a support. From the previous year a number of silane coupling agents was tested for hydrophobic treatment of the beads. As shown in Fig. 2, the overall mass transfer coefficient *k* increased with the alkyl chain length of the silane coupling agents. A catalyst treated with hexadecyltrimethoxysilane (C16) provided superior performance in hydrophobicity and isotope separation⁴). The catalyst performance for hydrogen atom exchange between water vapor and hydrogen gas was measured with tritiated water of 1 MBq/kg. Reaction efficiency kept constant over 30 hours under the condition of saturated water vapor at 1 atm, 343 K. The overall mass transfer coefficient of C16 was obtained as $84 \pm 5 \text{ s}^{-1}$.



Fig. 1 Effect of hydrogen flow rate on separation factors of the DTDP-CE apparatus.



Fig. 2 Reaction rate constant for various length of alkyl chain of silane coupling agents.

- 1) T. Sugiyama et al., Fusion Eng. Des., 98-99 (2015) 1876.
- 2) T. Sugiyama et al., Fusion Sci. Tech., 60 (2011) 1323.
- 3) T. Sugiyama et al., ITC-25, P1-79 (2015).
- 4) Y. Morita et al., ITC-25, P1-80 (2015).