

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

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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 and cryogenic pressure swing adsorption as technologies of hydrogen isotope separation. The purposes of study are development of high-efficient adsorbent and catalyst applied to the above technologies, 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 University and modified in this year. The apparatus was composed of mainly two liquid phase chemical exchange columns. One column, which was made of Pyrex glass tube, was operated at lower temperature and lower pressure. The other column, which was made of stainless steel tube, was operated at higher temperature and higher pressure. Both columns were 25 mm internal diameter and 1 m in length. The columns were filled in 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 %. The tritium concentrations in the samples were measured by a liquid scintillation spectrometer (Aloka, LSC5100). Tritium concentrations in the product and waste streams with time variation are plotted in Fig. 1. It is confirmed that tritiated water can be separated by the apparatus as significantly distinguishable. The separation factors obtained by the experiments and calculations are summarized also in Fig. 1. The values obtained by calculations sufficiently correspond with the experimental values. The fact indicates the validity of the model and the calculation code.

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. A number of silane coupling agents was tested for hydrophobic treatment of the beads. Among them a catalyst treated with decyltrimethoxysilane (Shin-Etsu Silicones, KBM-3103, LS-5258) provided superior performance in hydrophobicity and isotope separation. The catalyst performance for hydrogen atom exchange between water vapor and hydrogen gas was measured with tritiated water of 1 MBq/kg, and the overall mass transfer coefficient was obtained as $49 \pm 2 \text{ s}^{-1}$.

Taguchi has been developing a Pt-catalyst with a DVB polymer support from a standpoint that the pore size and pore structure of the support must be controlled adequately for upgrade of catalytic performance. The macro-pore size of the DVB support was well controlled by the fraction of dimethylpolysiloxane. According to the TEM observation most of the Pt particles seemed to exist in the micro-pores, for that reason the Pt particles unable to perform effectively. A technique to reduce the micro-pore volume is currently under development.

Detailed performance evaluation of various catalysts was experimentally conducted by Munakata. The mass transfer process in the catalyst bed was also examined theoretically.

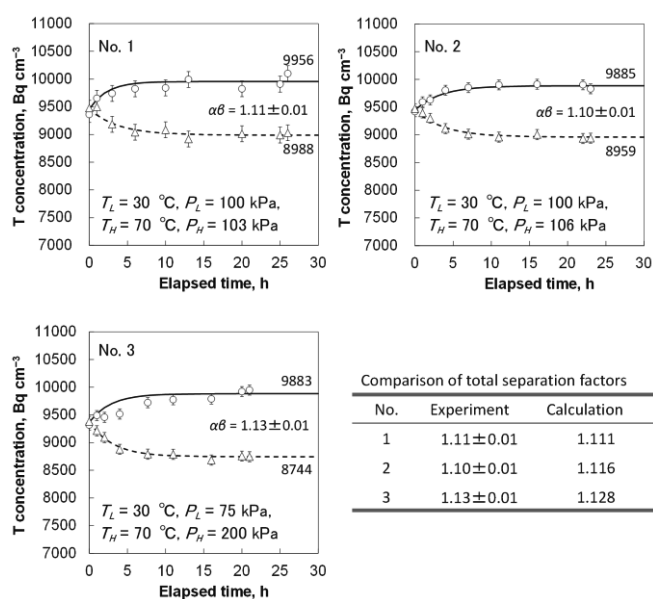


Fig. 1 Hydrogen isotope separation by DTDP-CE