

§ 9. Hydrogen Isotope Separation by Hydrogen-Water Chemical Exchange Reaction under Reduced Pressure

Yamamoto, I., Enokida, Y., Kobayashi, N., Abe, Y., Shiozaki, T. (Nagoya Univ.), Sugiyama, T., Asakura, Y., Uda, T.

When we carry out the LHD deuterium experiments, large amount of tritiated drainage will be discharged by the experiments. The tritium concentration of the drainage, however, is very low and we want reduce the volume of the drainage by means of isotope separation (i.e., tritium enrichment), and have adopted hydrogen-water chemical exchange method to the system of isotope separation for the LHD deuterium experiments.

The equilibrium constant of the isotopic exchange reaction, which is a measure of degree of separation, becomes larger when the temperature decreases. Then the lowering the process temperature will improve separative performances of the process, but, at the same time, will deteriorate the performances because partial pressure, which is a measure of throughput, of water decreases. As a method for lowering the process temperature without reducing the steam partial pressure, we newly devised the method to decompress inside of the separation column. In this paper, the experiments with this method are reported.

i) Experimental apparatus

Schematic drawings of the experimental apparatus newly constructed are shown in Figure 1. In the separation column of 25 mm inner diameter and of 90 cm total length Kogel catalyst (made of Showa engineering, 4.0~6.7 mm particle size, platinum-supported quantity 0.8 w-%) and Dixon Gauze Ring (6 mm diameter, 6 mm height) were alternately filled. Heights of each layer are 5, 15 cm, respectively. The natural hydrogen gas which moisturized by the humidifier was supplied from the lower of the column. The distilled water was made to flow from the upper part of the column, and the same quantity of water was discharged from the lower of the column. Degree of vacuum in the separation column was controlled in constant value using scroll type vacuum pump and vacuum control unit.

ii) Experiments under reduced pressure

Separation experiments were carried out at 70 °C under the atmospheric pressure (101.3 kPa) and 40 °C under reduced pressure (12.1 kPa). Flow rates of hydrogen gas and water are 2.0 NL/min and 4.1 g/min, respectively. Flow rates of water vapor become 0.44 g/min at 101.3 kPa and 1.8

g/min at 12.1 kPa. Reflux liquid and hydrogen gas from the upper part of the column and effluent liquid from the lower of the column were sampled in every 1 hour. The isotopic ratio of the hydrogen in the sample was measured by mass spectrometer for the stable isotopic ratio measurement.

Separation factor a_T was defined with isotopic ratio of HD to H_2 , R_{HD/H_2} , as

$$a_T = R_{HD/H_2}(\text{top of the column}) / R_{HD/H_2}(\text{bottom of the column}).$$

The comparison of result at 101.3 kPa and that of at 12 kPa is summarized at Table 1. The value calculated with the theoretical plate model was also described. Clarified point is summarized in the following.

- (1) Process temperature could be lowered without reducing the water vapor proportion by decompressing the column, and it could obtain more large separation.
- (2) From the comparison with the calculated value, it was proven that the equipment sufficiently demonstrated the performance under reduced pressure.

Tab. 1 Comparison in different operating pressure

Operating pressure [kPa]	101.3	12.1
Equilibrium temperature [°C]	70	40
Ratio of molar flow rate Hydrogen : Vapor : Liquid	1 : 0.27 : 2.6	1 : 1.12 : 2.6
a_T (Experimental) [-]	3.31	4.10
a_T (Estimated) [-]	2.56	3.77

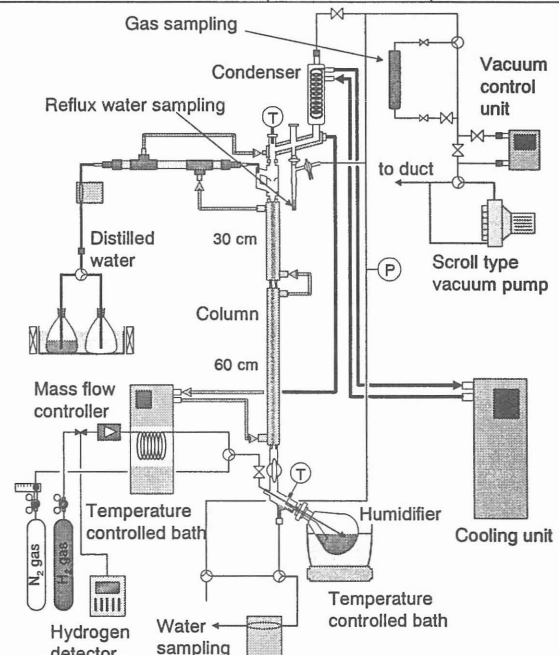


Fig. 1 Schematic drawings of experimental apparatus

Reference

- 1) Abe, Y., *et al.*: Proc. AESJ Spring Meeting 2003 (in Japanese), Part I, E-19, Sasebo, March (2003).