§4. Water Detritiation by Water-hydrogen Chemical Exchange

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Large amount of tritium will be handled in the ITER as well as future fusion reactors. It is necessary to remove tritium from exhaust gases and effluent liquids to prevent releases of tritium into the environment. Experimental studies on hydrogen isotope separation by a Combined Electrolysis Catalytic Exchange (CECE) have been carried out in order to apply it to the system of water detritiation for fusion reactors. The purpose of the present study is to demonstrate separation of tritium from hydrogen using a CECE device on the basis of the previous results for deuterium and hydrogen and to show the validity of the channeling stage model for separative analyses of a chemical exchange column.

i) Experiments

The column was a Pyrex glass tube with 25 mm internal diameter and 1 m length. Kogel catalysts (4.0-6.7 mm spherical) of 30 volumetric percent and Dixon gauze rings (6 mm outer diameter, 6 mm high) of 70 volumetric percent were mixed and filled randomly in the column so that the catalysts distributed macroscopically homogeneously. The catalyst packed ratio, 30 %, was optimal in the sense of giving maximal separation factor and was obtained by the preliminary experiments. The solid polymer electrolysis (SPE) electrolyzer was manufactured by Showa Engineering Co. Ltd. The maximum production rate of hydrogen gas was 1 m^3/h. Experiments of hydrogen-tritium isotope separation using the CECE equipment were performed at 101 kPa, 343 K. The flow rate of hydrogen gas was selected to 5, 6 and 8 L/min and feed rate of water was adjusted, respectively, as the molar flow ratio of hydrogen gas to liquid water in the column became about 1.4. A separation factor of the column was defined by the ratio of the molar fraction of HTO in the liquid water at the bottom of the column to that of HT in the hydrogen gas at the top of the column, when the molar fractions were very small compared with unity. The determination of separation factor was carried out at the steady state. The gaseous samples were converted to liquids by a reactor packed with copper oxide at 623 K. The tritium concentrations in the liquid samples were measured by a liquid scintillation spectrometer (Aloka model LSC 5100).

ii) Results and discussions

The obtained separation factors were plotted against the flow rate of hydrogen gas in Fig. 2 with predicted values by "Channeling stage model". As seen in Fig. 2 the values of separation factors predicted by the model represented very well the measured values. The separation factor increased when the flow rate of hydrogen gas decreased. The maximum value of the separation factor was 19200 when the flow rate of hydrogen gas was 5 L/min.

iii) Conclusion

Very large separation factor of hydrogen and tritium isotope separation was obtained experimentally with a random-packed trickle bed chemical exchange column of 1 m length. The value was 19200 when the flow rate of hydrogen gas was 5 L/min. The values of separation factors predicted by the channeling stage model represented very well the measured values.

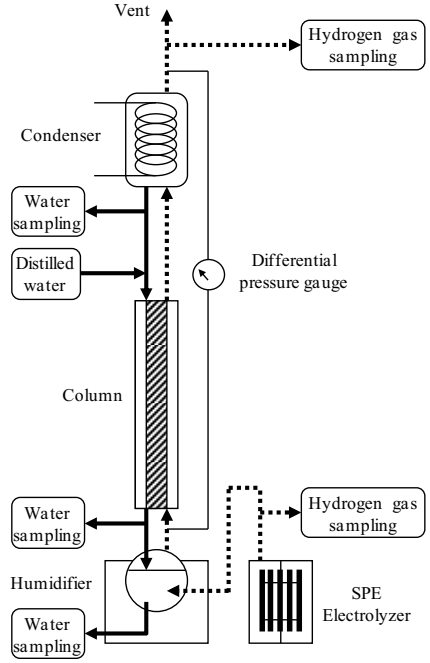

Fig. 1 Schematic drawings of a CECE device

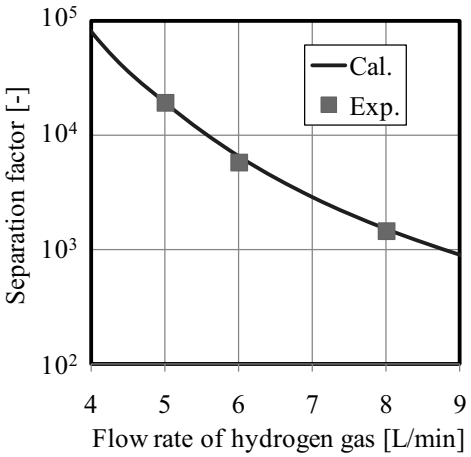

Fig. 2 Separation factor of H-T isotope separation with a random-packed trickle bed reactor

1) Sugiyama, T. *et al.*: *Fusion Sci. Technol.*, **56**[2] (2009) 861
2) Suzuki, E. *et al.*: *Proc. AESJ Fall Meeting 2009*, J56, Sendai, September (2009)
3) Suzuki, E. *et al.*: *The 7th Symposium on Isotope Science and Engineering from Basic to Applications*, P9, Yokohama, March (2009)
4) Suzuki, E. *et al.*: *Proc. AESJ Annual Meeting 2010*, M02, Ibaraki, March (2010)