§89. Highly Tritiated Water Processing by Means of Electrochemical Hydrogen Pumping

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In the future fusion reactor, tritium and deuterium will be utilized as fuel gas. The tritium have to be circulated and bred by neutrons of fusion products in the fusion reactor system because the D-T burning rate will be extremely low less than 1% and tritium exists in minute quantity in nature. Also, tritium is a radioactive isotope of hydrogen. Thus, it has to handle with a special care and an expertise. Almost of hydrogen isotopes in the fuel cycle system will exits as gaseous molecules. However, a part of tritium gas will permeate through the metal wall in the reactor and the heat exchange system, etc. Then tritiated water will be generated by isotope exchange with H_2O as cooling water and the tritium removal system. Tritiated water is approximately 10000 times more biologically toxic than tritium gas. Thus, waste water processing system should be required and equipped in a fusion reactor system from the viewpoints of radiological protection, tritiated water disposal and radiation safety for public.

Various types of waste water processing techniques such as water distillation, water electrolysis, and catalytic exchange of hydrogen isotope in the water-hydrogen system etc have been developed and utilized for enrichment and separation of tritium in the nuclear plants. In this study, we propose the application of the high temperature water vapor electrolysis technique using hydrogen isotope pumping by proton conducting oxide. It has some advantages; (1) higher electrolysis efficiency than low temperature water electrolysis, (2) low tritium inventory because the system is operated in gas phase, (3) tritium gas [HT] recovery from tritiated water [HTO], etc.

The hydrogen isotope pumping system mainly consists of proton conducting oxide, potentiostat/ galvanostat, electric furnace, temperature controller, mass flow controllers and constant water bath for a bubbler. We carried out the performance tests of the one-end-closed tube made of $CaZr_{0.9}In_{0.1}O_{3-\alpha}$. The shape of the one end closed test tube was 12 mm inner diameter, 0.75 mm thickness and 200 mm length. The platinum electrode was attached on both sides of the test tube and the effective area on the cathode electrode was about 42 cm^2. In this experiment, wet argon gas containing water vapor [H_2O] of 1.2 kPa was fed to the anode compartment. Dry argon gas was fed to the cathode compartment. These flow rates were 136 cm^3/min. The test tube was heated up to 935 K by an electric furnace. Then, the constant current was passed through between the electrodes by the galvanostat. The extracted hydrogen into the cathode compartment is carried by dry argon gas. Then, the gas components in the cathode compartment were analyzed by a gas chromatograph and a chilled mirror hygrometer.

The extraction of pure hydrogen isotope gas has become a requirement for realistic applications of hydrogen isotope pumping to waste water processing. Figure 1 shows the time evolution of applied current density, voltage, hydrogen and water vapor concentrations in the cathode compartment. The experimental conditions are shown in the figure. The detection limit of hygrometer is about 35 ppm. When the current was passed through the proton conductor and hydrogen was extracted, water vapor in the cathode compartment was increased in spite of dry condition. However, the increase of water vapor was not observed when the current density was up to 2 mA/cm^2. Since the sample temperature was slightly increased after applied current, water vapor would be desorbed from the proton conductor.

To evaluate the tritium pumping performance using highly tritiated water, the experimental apparatus was moved to HRC in Univ. of Toyama as shown in Fig. 2 and water bubbler system with copper oxide reactor for tritium measurement was also constructed in the system.

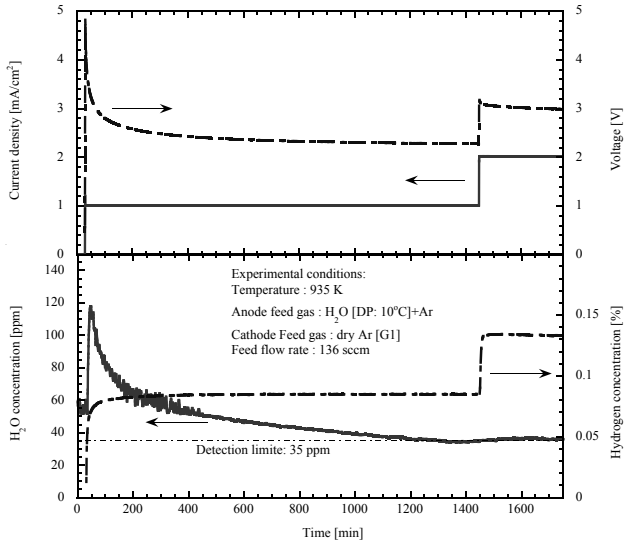

Fig. 1. Time evolution of applied current density, voltage, hydrogen and water vapor concentrations in the cathode compartment.

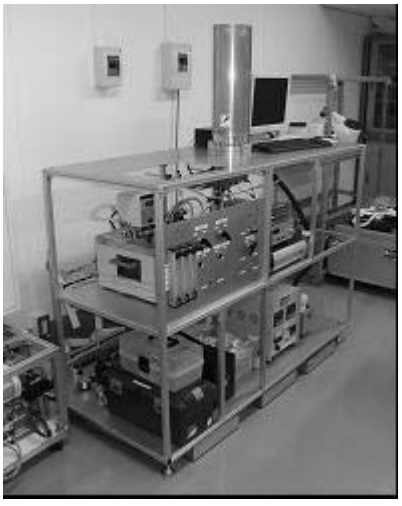

Fig. 2. A photograph of hydrogen isotope pumping system in HRC, Univ. of Toyama.