Experiment on hydrogen removal apparatus for helium supply and recovery system

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In the past, the liquid-helium supply and recovery system of the Wako campus have suffered severe damages from hydrogen impurities in the system.[1)] To remove this hydrogen from the recovered helium gas, we developed hydrogen removal methods utilized for our system. We found that the silver-zeolite "Ag400" made by "Molecular Products Inc." can be used as the adsorbent, and the applicability of Ag400 for hydrogen removal was confirmed.[2)] At that time, we did not install the hydrogen removal apparatus earnestly in our system. However, a new liquid-helium supply system was constructed and operated from 2017 because of the deterioration of the old system.[3)] In this system, the newly established hydrogen removal apparatus was installed beforehand. In this study, we examined the amount of hydrogen that can be adsorbed by Ag400, which had not been minutely evaluated until now.

The experimental setup consists of a hydrogen tank, a pressure gauge, a buffer tank, three switch valves, a reaction tank, a data logger, and a vacuum pump. The volume of the buffer tank is approximately 550 cc, and that of the reaction cylinder is approximately 18 cc. These parts are connected as shown in Fig. 1.

The experiment is performed by the following three steps. i) Approximately 20 g of Ag400 is filled in the reaction cylinder. Valve 1 is closed and the whole setup are evacuated. ii) Valve 2 is closed, the valve 1 is released and hydrogen gas is filled to the buffer tank; its pressure reaches 0.4 MPaG. iii) Valves 1 and 3 are closed and valve 2 is released. Hydrogen gas is supplied to the reaction cylinder and adsorption begins. The change of the pressure of the buffer tank is monitored by the pressure gauge and recorded by the data logger.

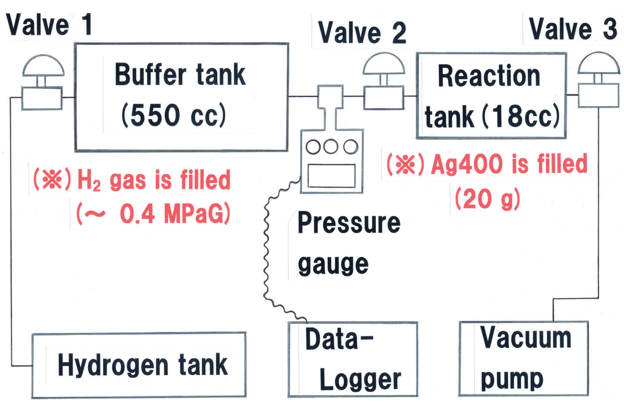

Fig. 1. Experimental setup.

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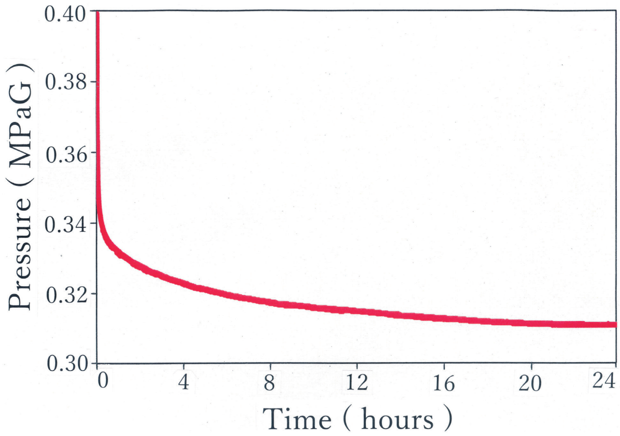

Fig. 2. Change of hydrogen pressure in the buffer tank.

The result of this experiment is shown in Fig. 2. From this figure, it can be observed that the hydrogen pressure in the buffer tank reduced rapidly from 0.4 MPaG to 0.34 MPaG in approximately 30 min after the start of the adsorption reaction. After 12 h, the pressure slowly reduced to 0.32 MPaG. Finally, the hydrogen pressure reduced to approximately 0.31 MPaG and settled at the equilibrium state. This result shows that 20 g of Ag400 can adsorb approximately 500 scc of hydrogen gas throughout the experimental process.

We use approximately 4 kg of Ag400 in the hydrogen removal apparatus in the liquid helium supply and recovery system. Hence, approximately 0.10 Nm^3 of hydrogen impurity gas can be removed by this apparatus. Usually, the concentration of hydrogen contained in recovered helium gas ranges from 0.05 ppm to 1.5 ppm in our system. Therefore, supposing that the recovered helium gas contains 0.1 ppm of hydrogen, our apparatus can purify approximately 1000,000 Nm^3 of recovered helium gas. However, the total volumes of liquid helium supplied in one year in Wako campus were from 180,000 L to 200,000 L.[3)] When all this liquid helium is vaporized, approximately 135,000 Nm^3 to 150,000 Nm^3 of helium gas is generated. In this case, we will evaluate that 4 kg of Ag400 can be used approximately 6–7 years for hydrogen removal.

In the next steps, we will evaluate other characteristics of hydrogen removal apparatus containing Ag400.

References

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