Variation of impurity gas in recovered helium gas for liquid-helium supply and recovery system

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We use recovered helium gas for liquid-helium supply system.[1)] Gas-holder E was damaged and contaminated by air in 2023. This holder recovers the helium gas from Nanoscience Joint Laboratory, Chemistry and Materials Physics Bldg., and the Emergent Matter Research Facilities. All recovery lines from these buildings were reconnected to Gas-holder A including those from Cooperation Center. Starting October 7, helium gas was recovered through these arrangements.

After the rearrangement, concentrations of N_2 and O_2 reduced. However, the concentrations of H_2, CO_2, and CO did not reduce, instead, they fluctuated randomly. The impurities N_2 and O_2 were attributed to the invaded air. The cause of the fluctuations in H_2, CO_2, and CO concentrations remains unidentified. Additionally, the fluctuation patterns of N_2 and O_2 concentrations were quite different from those of H_2, CO_2, and CO. The variation of impurity gas in 2023 was shown in Fig. 1. The right axis shows the concentration of N_2 and O_2, while the left axis shows the concentration of H_2, CO_2, and CO.

Black line and blue line in Fig. 1 show the concentration of N_2 and O_2, respectively. The fluctuation of N_2 concentration was mostly between 1600 ppm to 1800 ppm and that of O_2 was between 1200 ppm to 1500 ppm before the rearrangement. N_2 concentration reduced gradually to about 400 ppm in December. On the other hand, O_2 concentration reduced rapidly and fell to about 200 ppm in December.

Red line in Fig. 1 shows the H_2 concentration. The concentration of H_2 fluctuated significantly almost every day in 2023. After rearrangement, the concentration of H_2 did not reduce but increase and fluctuated significantly between 0.2 ppm to 2.4 ppm. Hence, we could reveal that H_2 impurity intermixed into the helium gas by the quite different process of N_2 and O_2. However, the liquid helium supply and recovery system was not damaged by H_2 impurity.

The gray line in Fig. 1 shows CO_2 concentration. CO_2 was observed almost every day from March to October fluctuating between approximately 0.1 ppm to 1 ppm and reaching to 14 ppm in July. However, CO_2 can be eliminated immediately from the system because the melting point is much higher than N_2, O_2, and H_2.

The green line in Fig. 1 shows the change of CO concentration. From October, CO was observed every day. However, the concentration was at most 0.01 ppm. Therefore, CO dose not pose a problem.

In 2023, we did not encounter any serious issues in the liquid helium supply and recovery system operations. However, we discovered damage to Gas-holder E and air contamination in the recovered helium gas. Therefore, repairing this holder as soon as possible is essential. The H_2 concentration in 2023 increase 2–3 times compared 2021 and 2022, making countermeasures against H_2 impurity is a more pressing concern. Preventing impurity gases will remain a crucial subject for ensuring safety operations.

Reference

1) M. Nakamura *et al.*, RIKEN Accel. Prog. Rep. **56**, 215 (2023).

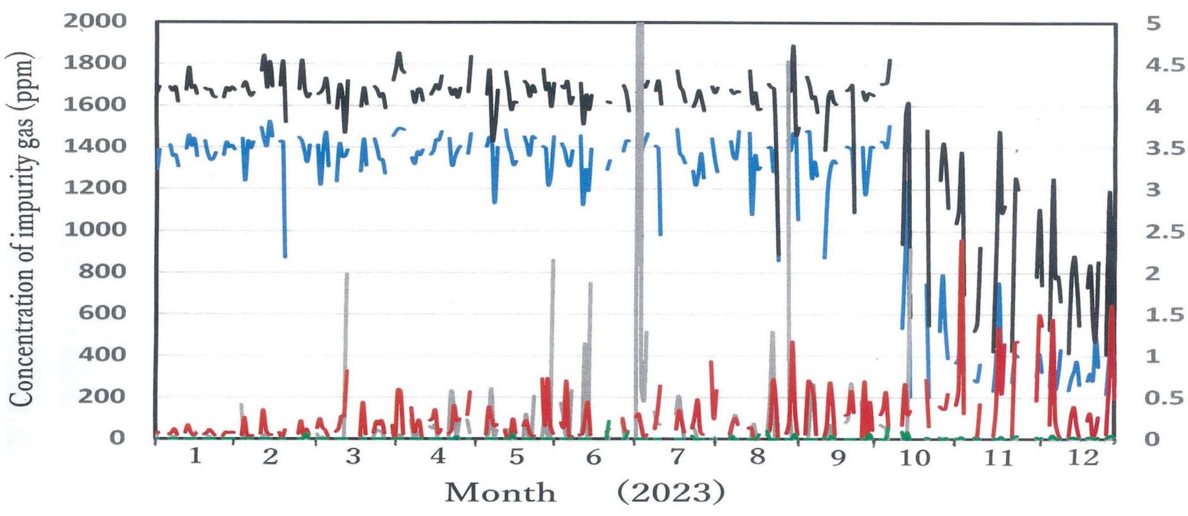

Fig. 1. Impurity concentration in recovered helium gas in 2022.

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DOI:10.34448/RIKEN.APR.57-045