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Development of Copper-based Adsorbent for the Separation and Recovery of Gaseous Iodine from Fission Mo-99 Production

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1. Introduction

Technetium-99m (Tc-99m) is one of the most important medical isotopes, which has been widely used in the diagnostic imaging technology. It can be easily extracted from the molybdenum-99 (Mo-99), the mother nuclide of Tc-99m, using a generator.

In general, Mo-99 has been produced by nuclear fission of U-235 because of its high specific activity. During the Fission Mo-99 process, however, radioactive iodine gas can be inevitably released as the impurity by considerable. [1] Thus, it is necessary to collect the gaseous iodine from the off-gas stream.

For the gaseous iodine trapping, common operation using the column with sold adsorbent has been generally utilized. And the various materials such as silver or carbon-based materials have been used as effective adsorbents. In this research, we proposed and developed the copper-based adsorbent which has advantages in cost-effectiveness and high affinity with iodine.

2. Methods and Results

2.1 Preparation of adsorbent and column module

Adsorbent for the column operation was based on the commercial copper powder. Copper has been attracted as the promising adsorbent for trapping gaseous iodine due to its reliable performance and cost-effectiveness. However, copper particulates which reacted to the gaseous iodine tend to agglomerate themselves, thus have a critical problem in that it can cause a gas flow blockage on the column operation. In order to prevent the copper particulates agglomeration, we introduced oxide-type ceramic material as the spacer. Adsorbent was simply prepared by mixing mechanically the copper powder and ceramic materials. The column was assembled from 8-cm sections of 6.2-mm OD glass tube. As-prepared adsorbent was filled into the column, which was supported by the plug of glass wool. Assembled column was attached to the custom-made equipment for the iodine gas analysis.

2.2 Separation and recovery process

Entire process for the performance analysis is shown as below. (see Fig. 1) Gaseous iodine was generated by the sublimation of solid iodine in a well-sealed glass reactor at about 80℃ temperature. Then, produced iodine gas flowed into the adsorbent-filled column with the nitrogen carrier gas in constant flow mode. After saturated adsorption, the gaseous iodine passed through the column, which did not adsorbed by the adsorbent, was collected by dissolving in ethanol. In this experiment, all the parts except the ethanol-containing vial were maintained with 80℃ temperature.

In recovery process, the I_2-adsorbed column was heated to 350℃ temperature, thus the desorbed iodine gas was flowed into the ethanol-containing vial with carrier gas.

Concentration of iodine dissolved in ethanol was measured via UV-Visible spectrometer specialized at analysis of iodine (EMWUS-PA, EMWUS, Korea).

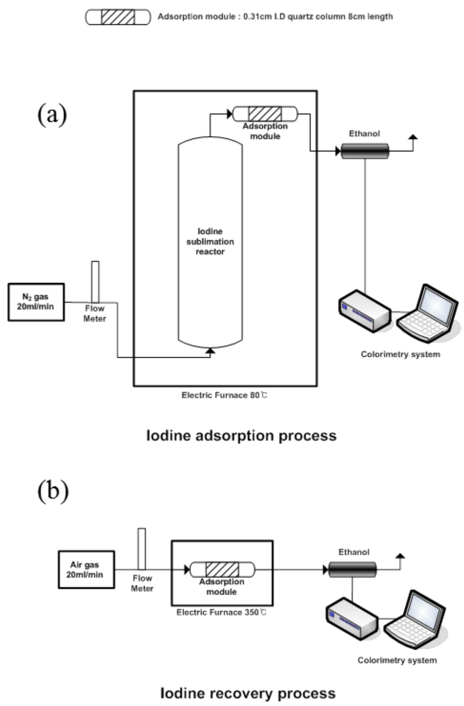

Fig. 1. Process diagram for the investigation of (a) separation and (b) recovery performance with developed column filling material.

2.3 Efficiency evaluation of the prepared adsorbent

As a result of experiments, prepared copper-ceramic composite adsorbent showed the high adsorption efficiency at 80℃ temperature and the adsorption capacity was 195 mg I_2/g adsorbent. Moreover the copper-ceramic composite adsorbent did not form the agglomerates and the gas passed smoothly through the column without flow blockage, while the adsorbent made with only copper powder plugged up the column with large agglomerates and hindered the gas flow through the column. Recovery of gaseous iodine from the adsorbent was performed successfully, and the efficiency was measured near 92%.

3. Conclusions

In here, we proposed and developed the copper-ceramic composite adsorbent for the collection of gaseous iodine. Micron-size copper particles were utilized as adsorbent material, and oxide-type ceramic material were introduced to prevent the gas flow blockage induced by the agglomeration between iodine-reacted copper particles. It is very simple to prepare and showed high efficiencies to the separation and recovery of gaseous iodine at the column process.

REFERENCES

[1] R. Muenze, G. J. Beyer, R. Ross, G. Wagner, D. Novotny, E. Franke, M. Jehangir, S. Pervez, and A. Mushtaq, The Fission-Based ^{99}Mo Production Process ROMOL-99 and Its Application to PINSTECH Islamabad, Science and Technology of Nuclear Installations, Vol. 2013, p. Article ID 932546, 2013.