The 1st Radioisotope Separation Experiment for the Sr-82 Production in KOMAC

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1. Introduction

Production of radioisotopes such as Sr-82, Cu-67, Ge-68, etc. is one of KOMAC's major accelerator applications.[1] The construction of target irradiation facilities for the production of radio-isotopes at KOMAC using 100-MeV linac was completed in 2016, and chemical process facilities were completed in March of this year and licensed.[1-2]

The 1st radioisotope separation and purification experiment using a target contained radioactive nuclides produced by the proton beam irradiation was carried out successfully. The target is RbCl in the form of pellet with a diameter of 3 cm and a thickness of 7.5 mm for the Sr-82 production. The operating conditions of the proton accelerator beamline for target irradiation were energy 100 MeV, peak current 1 mA, pulse width 200 usec, repetition rate 2 Hz, and irradiation time was 1 to 2 hours. The Sr-82 is the parent nuclide of Rb-82 used for the diagnosis of myocardial infraction, and it is manufactured and supplied to users in the form of a Sr-82/Rb-82 generator.

KOMAC has been developing Sr-82 production technology using a high-energy proton accelerator since 2019. The separation and purification process of Sr-82 has been developed using stable isotope compounds such as RbCl or $SrCl_2$ until the approval of the RI production facility. The process procedure was developed by referring to the research results of foreign research institutes such as BNL and ARROMAX, [3] and detailed conditions were determined by reflecting the ICP-MS analysis results for each stage of the process. In this paper, we will deal with the first separation and purification experiment in which the separation and purification process developed so far is applied to an irradiated target.

2. Methods and Results

2.1 Equipment Installation in the RI Hood

In order to handle the irradiated target, the devices necessary for the separation and purification process were installed in the RI hood. As shown in Figure 1, the minimum essential devices necessary for the process were installed in consideration of the space constraints in the RI hood. Columns filled with Chelex-100 resin, bottles containing essential reagents such as PH 9.5 buffer, 0.1-M HCl, 6-M HCl, and distilled water, and a vacuum rotary evaporator for concentrating the separated and purified Sr-82 solution were installed in the RI hood. The vacuum rotary evaporator is based on a chemical-resistant vacuum pump that can be used for evaporating strong acid solutions such as 6-M HCl, and is configured to minimize the leakage of HCl solution and radionuclides using a chiller.

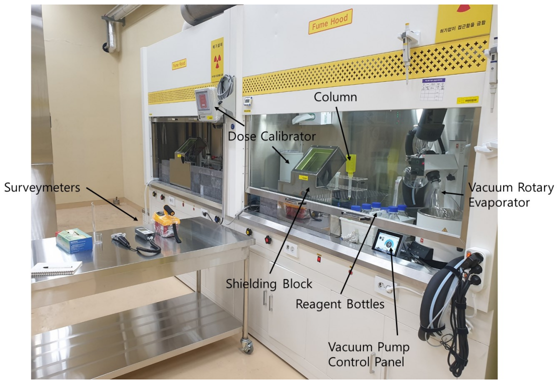

Fig. 1. RI hood for separation and purification process for Sr-82 production.

2.2 Separation and Purification Process

The separation and purification process applied in this experiment was developed with reference to the procedure developed by BNL, and as mentioned above, the effectiveness was confirmed using stable isotope compounds. ARRONAX has reported that Sr-82 of the desired purity can be obtained only by the process using Chelex-100 instead of the resin process in several steps. Therefore, in this experiment, the process was simplified by using only Chelex-100 resin based on the BNL process.

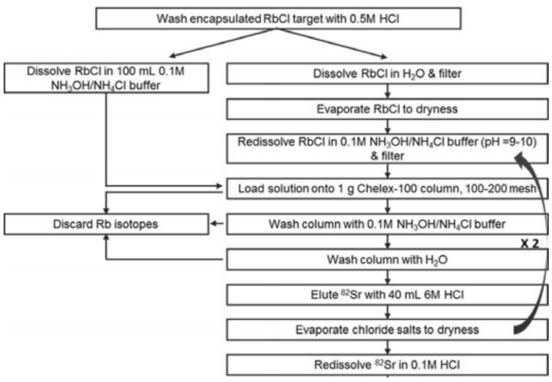

Fig. 2. Separation and purification process diagram for Sr-82 production.[3]

RbCl target was dissolved in 60 mL buffer solution, poured into a column containing 1-g Chelex-100 resin, waited for 10 minutes, and the solution was flowed at a flow rate of 1 mL/min. And after washing process using 20-mL buffer and 60-mL distilled water, 6-M HCl solution was finally flowed at a flow rate of 1 mL/min to elute Sr-82.

2.3 HPGe Gamma-ray Spectrum Measurement for Radio-Nuclide Identification

In order to confirm the separation and purification results, solutions were collected step by step and gamma-ray nuclide analysis was performed. For quantitative analysis of the radioactivity concentration of the detected nuclides, the HPGe detector was calibrated using the Eu-152 standard solution as shown in Figure 3.

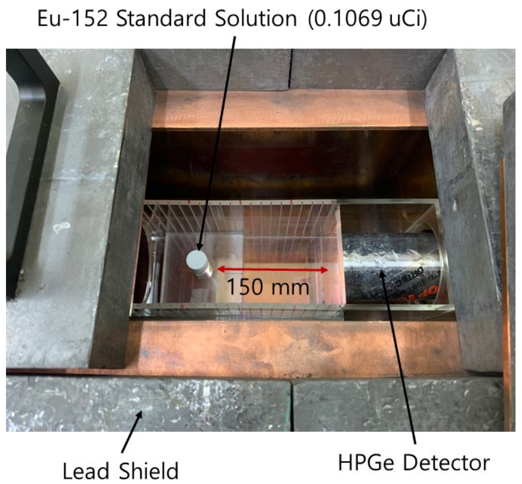

Fig. 3. HPGe detector setup for the calibration using Eu-152 standard solution.

Figure 4 and Figure 5 show the gamma-ray spectrum measurement results of the stock solution in which RbCl was dissolved and the solution after separation and purification process using an HPGe detector. As shown in the figures, it can be confirmed that gamma rays other than the 511-keV and 776.5-keV gamma rays emitted from Rb-82 disappear after the separation and purification process.

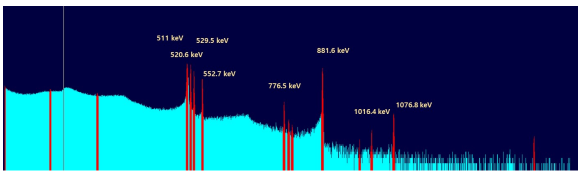

Fig. 4. Gamma-ray energy spectrum measurement result for stock solution in which RbCl target is dissolved.

The half-life of Sr-82 is 25.5 days and the half-life of Rb-82 is 70 seconds, which is very different, so that the two nuclides reach permanent equilibrium within a few minutes, and the concentration of Rb-82 becomes the same as that of Sr-82. In radionuclide analysis using the HPGe detector, the Rb-82 concentration is measured using these characteristics and the value is used as the Sr-82 concentration. As a result, it was confirmed that the Sr-82 radioisotope was well separated through the separation and purification process we developed.

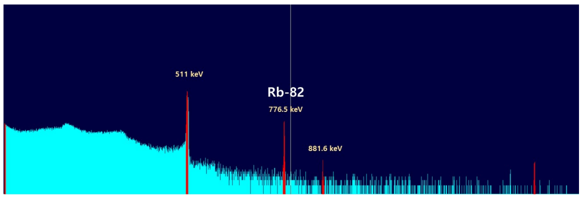

Fig. 5. Gamma-ray energy spectrum measurement result for the separated and purified solution.

3. Conclusions

The first RI separation and purification process experiment on irradiated target in KOMAC was successfully performed. Through this experiment, the effectiveness of the separation and purification process developed for the production of Sr-82 was validated. The Sr-82 obtained through this experiment is being used for the column adsorption experiment for Sr-82/Rb-82 generator development currently in progress

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