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Measurement of Strontium-82 Specific Activity Using ICP-MS

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1. Introduction

Strontium-82 (Sr-82) is the parent nucleus of Rubidium-82 (Rb-82), and is used to manufacture Rb-82 generators by being adsorbed on a hydrated tin oxide adsorbent column. The Rb-82 generator is used to manufacture the Rb-82 infusion systems which is used for myocardial perfusion imaging using PET. Worldwide, two Rb-82 infusion systems, CardioGen-82 and Ruby-Fill, have been approved by the U.S. Food and Drug Administration (FDA) and are used for heart disease diagnosis in the United States and Europe.

In Korea, the Korea Multi-purpose Accelerator Complex (KOMAC) of the Korea Atomic Energy Research Institute has been able to produce Sr-82 using a 100 MeV proton accelerator since last year, and the production is at the level of several mCi. The quality of the produced Sr-82 is evaluated using gamma nuclide analysis using an HPGe detector, Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), and Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).[1] The quality is mainly evaluated through chemical and radiochemical purity and specific activity measurements. In this paper, we will discuss the specific radioactivity measurement of produced Sr-82 using HPGe gamma nuclide analysis and ICP-MS.

2. Methods and Results

In this section, we describe the production of Sr-82, gamma nuclide analysis of separated and purified Sr-82, sample preparation for ICP-MS analysis, and the results.

2.1 Sr-82 Production

Sr-82 is obtained by irradiating Rubidium Chloride (RbCl) with a high-energy proton beam generated from a high-energy linear accelerator and then purifying it using an ion exchange chromatography column. The target irradiated with the proton beam is dissolved in a buffer solution and then passed through a column containing Chelex-100 resin to separate Strontium isotopes from the solution. Sr-82 is obtained by passing a 6 M HCl solution through a column to elute adsorbed strontium. The eluted Sr-82 solution is concentrated using a rotary evaporator and then dissolved using a 0.1 M HCl solution to obtain a high-purity Sr-82 solution.

2.2 HPGe Gamma Nuclide Analysis

Gamma nuclide analysis was performed on the Sr-82 solution produced using the HPGe detector. Fig. 1 shows the gamma spectrum of a 1 mL Sr-82 solution sample measured for 3000 seconds using an HPGe detector. The measured Sr-85 and Sr-82 radioactivity concentrations were 980 and 1499 Bq, respectively. The sample for ICP-MS was diluted in 250 mL of 0.1M HCl solution so that it was 10 Bq/g or less, which is the allowable radioactivity concentration value for exemption.

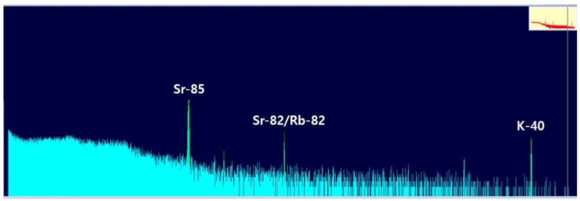

Fig. 1. HPGe gamma spectrum for Sr-82 solution.

2.3 ICP-MS

The output of the detector model is input to the cable model. The cable is modeled using the code PSpice and includes the cable characteristics of capacitance, resistance, characteristic impedance, and length. Although the effect of cable on the shape of the output signal of a detector is usually negligible, in our application to high-rate counting, its effect is significant. For our application, we found a distributed parameter model was necessary for accurate modeling of the cable.

2.3 Preamplifier Model

ICP-MS and ICP-OES analyzes were performed using Sr-82 solutions diluted below the allowable radioactivity concentration for exemption. The radiation shielding high-resolution ICP-MS and ICP-OES devices owned and operated by the Chemical Analysis Department of the Korea Atomic Energy Research Institute were used, and a picture of the device is shown in Fig. 2. ICP-MS can measure each strontium isotope and the detection limit is up to 0.1 ppb. ICP-OES can measure the total amount of strontium, but the detection limit of detection is several tens of ppb, which is relatively high compared to ICP-MS. The Chemical Analysis Department did not have permission to use strontium and rubidium radioactive isotopes, so the radioactive concentration of the Sr-82 sample was diluted below the allowable range for exemption from permission for analysis.

Fig. 2. Pictures of ICP-MS and ICP-OES equipment used for analysis.

The results of ICP-MS and ICP-OES analysis are shown in Tables 1 and 2. As can be seen from the two analysis results, ICP-OES has a relatively high detection limit compared to ICP-MS, so it was not possible to obtain the concentrations of strontium and rubidium, which are contained in very low concentrations in the sample. On the other hand, the concentrations of strontium stable isotopes other than Sr-84 could be obtained through ICP-MS analysis.

Table I: ICP-MS Analysis Result

	Concentration [ng/mL]
Sr-84	< 0.67
Sr-86	0.45
Sr-87	1.7
Sr-88	0.44

Table 2: ICP-OES Analysis Result

	Concentration [μg/mL]
Sr	< 0.02
Rb	< 0.02

2.4 Specific Activity

The specific activity of Sr-82 was calculated using the nuclide analysis results using the HPGe detector and the ICP-MS analysis results. The radioactive concentrations of Sr-85 and Sr-82 are converted based on the time of completion of separation and purification in consideration of the half-life, and the amount of strontium stable isotopes is obtained by converting into mass based on the concentration obtained through ICP-MS analysis. The specific radioactivity obtained through these calculations was 25.9 mCi/mg, which satisfied the production quality standard of > 25 mCi/mg for Sr-82 production facilities in the US and Canada.

3. Conclusions

We successfully developed a technology to produce Sr-82 using an ion exchange chromatography process after irradiating a high-energy proton beam to an RbCl target using a 100 MeV linear proton accelerator of the Korea Multi-purpose Accelerator Complex of the Korea Atomic Energy Research Institute.

In order to evaluate the quality of the Sr-82 production process, the specific activity was obtained using ICP-MS, and the result was 25.9 mCi/mg, which satisfied the global standard of > 25 mCi/mg.

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