Preparation of no-carrier-added ^{85}Sr using the ^{nat}Rb(d,x)^{85}Sr reaction

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Since 2007, we have distributed purified radioisotopes such as ^{65}Zn, ^{88}Y, and ^{109}Cd produced at the RIKEN AVF cyclotron to the general public.[1] After the Fukushima Dai-ichi Nuclear Power Plant accident in 2011, distribution of ^{85}Sr solutions having high specific radioactivity was required to develop analysis techniques for discharged radio-strontium. In response to these demands, we intended to produce ^{85}Sr via the ^{nat}Rb(d,x)^{85}Sr reaction using a 24-MeV deuteron beam from the RIKEN AVF cyclotron. We also studied a chemical separation procedure to obtain a purified ^{85}Sr solution using a no-carrier-added technique. In the previous study,[2] we successfully produced a ^{85}Sr solution having high radionuclidic purity. To estimate specific radioactivity, however, chemical purity should be estimated carefully. In the present study, we therefore evaluated chemical impurities in the prepared solution and assessed the applicability of the ^{nat}Rb(d,xn)^{85}Sr reaction and the no-carrier-added technique to the larger-scale production of the ^{85}Sr solution for distribution.

The ^{85}Sr isotope used in this work was produced by irradiating a RbCl disk (Sigma-Aldrich; chemical purity: > 99.99%; thickness: 500 mg cm^{-2}) of natural isotopic abundance with 24-MeV deuterons. The average beam intensity was 159 nA. The irradiation time was 17 min. ^{85}Sr was chemically separated in accordance with the scheme using a two-step chromatographic separation technique that we had reported.[2] The chemical impurities in 5.0 mL of this purified solution was evaluated using ICP-MS (Agilent Technologies; Model 7700) for a control sample, which was treated using the same procedure as that for the irradiated sample.

The production yield of ^{85}Sr was estimated to be approximately 3.90 MBq·μA^{-1} h^{-1} under the present experimental condition. The chemical yield reached as high as 94%. As shown in Table 1, the Rb target material was successfully removed and the decontamination factor of Rb reached 10^6. The strontium content required for the determination of specific radioactivity was measured to be 0.1 ppm (equivalent to 614 ng) in this analysis. However, the Sr impurities originate from not only the environment but also nuclear reactions. To estimate stable Sr isotopes produced by nuclear reactions, we calculated the expected Sr impurities by comparing the production yield obtained in the present experiment with that simulated by the TALYS code.[3]

Fig. 1 shows the simulated cross sections of ^{85}Sr and other stable Sr isotopes. The production yield of ^{85}Sr was 4.37 MBq·μA^{-1} h^{-1}. To estimate the production yields for other Sr isotopes, the calculated production yields for the stable Sr isotopes were normalized by the calculated rate for ^{85}Sr and the one obtained in the present experiment. As a result, the amount of Sr impurities from irradiation to be 346 ng under 3μA irradiation for 24 h.

The amount of Sr isotopes produced by the nuclear reaction depends on the deuteron beam dose. To apply the present technique to a larger-scale production, we estimated the expected specific radioactivity for the distribution shown in Fig. 2. According to the present result, the purified ^{85}Sr solution having a high specific radioactivity of 124 MBq μg^{-1} could be produced under 3μA irradiation for 24 h using the present chemical separation scheme. We are planning to launch the purified ^{85}Sr solution with a high specific radioactivity prepared using these studied techniques in response to customers' request.

Table 1. Measured principal chemical impurities in the ^{85}Sr solution after the purification process.

Element	Na	Al	Si	S	K
Concentration (ppm)	12.8	4.6	19.5	110.0	4.2
Element	Ca	Ba	Rb	Sr	
Concentration (ppm)	231.8	19.8	0.1	0.1	

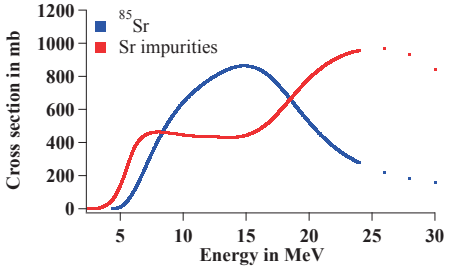

Fig 1. Cross sections for ^{85}Sr and other stable Sr isotopes calculated using the TALYS code.

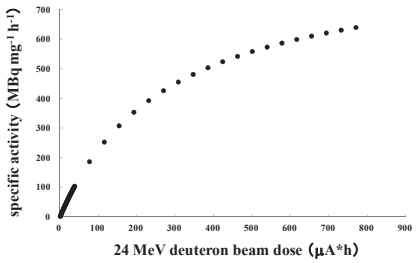

Fig 2. Calculated specific radioactivity for distribution of the purified ^{85}Sr solution as a function of the deuteron beam dose.

References

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