Preliminary Calculation Results for the Sr-82 Production

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1. Introduction

The radionuclide ^{82}Sr is a parent nuclide of ^{82}Rb and has a half-life of 25 days. The production technology of ^{82}Sr using RbCl target was developed by Dr. L.F. Mausner at BLIP (Brookhaven National Laboratory) in 1986 [1]. The ^{82}Sr had been produced by the irradiation of molybdenum with 800 MeV protons at Los Alamos Meson Physics Facility [2-3]. From 1980's the RbCl target has been used for ^{82}Sr production instead of Mo.

A 100-MeV proton linear accelerator has been constructed at the end of 2012 and the target irradiation facility for RI production was established in 2016 at the KOMAC (Korea Multi-purpose Accelerator Complex) in Gyeongju. Radio-nuclides which can be produced by high-energy proton beam irradiation, such as ^{67}Cu, ^{82}Sr, etc. are main nuclides interested in by KOMAC. In this paper, some calculation results for ^{82}Sr using 100-MeV proton accelerator are presented.

2. Methods and Results

2.1 Specific Activity of ^{82}Sr

The specific activity of purified ^{82}Sr is ≥ 25 mCi/mg according to Sr-82 fact sheet provided by Nordion [4]. It is known that Sr-83, Sr-84, Sr-85 and Sr-86 are coproduced by the proton beam in the target during the irradiation for ^{82}Sr production using RbCl target, as shown in Fig.1. And the specific activity is calculated by the following equation.

Specific activity = activity(Sr-82)/total mass(Sr).

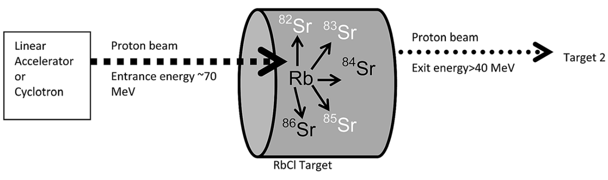

Fig. 1. ^{82}Sr production: a proton beam from a linear accelerator or cyclotron is used to irradiate a rubidium chloride target, and the Rb is converted to ^{82}Sr by the following nuclear reactions ^{85}Rb(p,4n) or ^{87}Rb(p,6n). Analysis of the purified ^{82}Sr indicates ^{83}Sr, ^{84}Sr, ^{85}Sr and ^{86}Sr are coproduced by the proton beam in the target [5].

2.2 SRIM Code Simulation for Target Design

The cross-section of the nuclear reaction ^{nat}Rb(p,x)^{82}Sr is shown in Fig.2. As shown in the figure, the cross-section value is in the range of 30~100 mbarn for 45~70 MeV proton beam. To minimize the co-produced radioisotopes of strontium, the proton energy to the target has to be controlled in the range of 50~68 MeV [1].

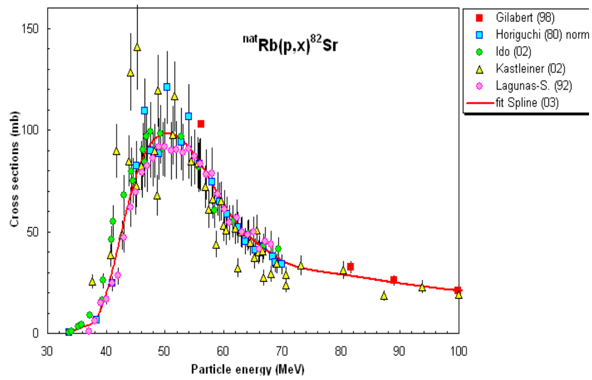

Fig. 2. Nuclear cross-section of ^{nat}Rb(p,x)^{82}Sr.

The proton energy reached to the RbCl target was calculated using SRIM code [6]. The calculation results are shown in Fig.3. The proton beam energy from accelerator is 103 MeV and it is passing through the beam window, cooling water, target window, and RbCl target material. The calculation results are summarized in Table.1. As shown in table 1, the incident energy to RbCl target is 67.23 MeV and extraction energy from the target is 52.30 MeV.

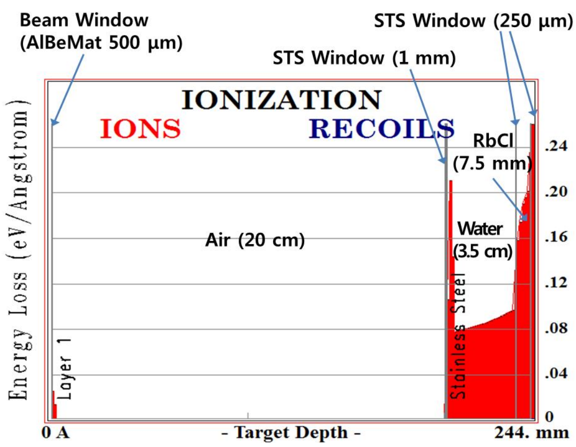

Fig. 3. SRIM code calculation results: energy loss profile in depth.

Table 1. SRIM code calculation results

Comp.	Material	Thickness	Density [g/cm^3]	Extraction Energy [MeV]
Beam Window	AlBeMat	500 μm	2.07	102.42
Air Gap	Air	20 cm	0.001	102.26
Window	STS	1 mm	8.0	98.21
Cooling Water	H_2O	3.5 cm	1.0	68.53
Target Window	STS	250 μm	8.0	67.23
Target	RbCl	7.5 mm	2.8	52.30
Target Window	STS	250 μm	8.0	50.68

2.3 MCNPX Code Simulation for Irradiation Condition Optimization

For the optimization of irradiation condition, we calculated the ^{82}Sr production yield with various irradiation and target conditions. The calculation results are summarized in Table 2. The target thickness and diameter are 2 mm and 5 cm, the proton beam current is 100 μA, and the irradiation time is 6 hours. The ^{82}Sr activity @ EOB is 9.2E+8 Bq with 50 MeV proton beam incidence.

Table 1. MCNPX code calculation results

Incident Proton Beam Energy [MeV]	Sr-82 Activity @ EOB [Bq]	Sr-83 Activity @ EOB [Bq]	Sr-85 Activity @ EOB [Bq]
30	-	1.94E+10	5.83E+08
40	3.71E+8	3.27E+10	4.51E+8
50	9.20E+08	1.28E+10	2.67E+08
70	3.59E+08	8.49E+09	1.45E+08
80	2.92E+08	5.44E+09	1.06E+08
90	2.49E+08	6.01E+09	1.12E+08
100	2.32E+08	5.26E+09	8.66E+07

3. Conclusions

For the target design and optimization of irradiation conditions, we conducted some calculation using SRIM code and MCNPX code. As a result, we can found out that we can optimized the irradiation conditions by using SRIM code and MCNPX code. After optimization of the irradiation condition on the basis of the ^{82}Sr production yields calculated by MCNPX code simulation, the proton beam energy reached to the target can be calculated by SRIM code simulation.

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