Current Status of RFT-30 Cyclotron and Recent Progress in Radioisotope Production

Eun Je Lee, Young Bae Kong, Ho Seung Song, Min Goo Hur,
Jun Young Lee, Pyeong Seok Choi, Seung Dae Yang, Jeong Hoon Park*
Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute,
29 Geumgu-gil, Jeongeup-si, Jeollabuk-do 580-185, Republic of Korea
**Corresponding author: parkjh@kaeri.re.kr*

1. Introduction

RFT-30 cyclotron has been developed not only for the production of radioisotopes (RIs) and their applications, but also for proton beam utilization to various research fields including material science, bio science, and so on.

RFT-30 cyclotron has been regularly operated since 2013, and research on the production of radioisotopes has been performed using this cyclotron. ^{18}F, which is the most widely-used positron emitter, has been produced regularly since 2015. In 2018, mass-production of ^{89}Zr is successfully achieved. In addition, long-term proton irradiation for the production of ^{68}Ge, which is one of the typical generator RIs, was also performed. Recently, we are also trying to perform the test production of ^{64}Cu, ^{57}Co, and ^{44}Sc.

2. Methods and Results

2.1 Target Materials

For the production of ^{18}F, enriched Oxygen-18 water ($H_2{}^{18}O$) was used as a target material. For the production of ^{89}Zr and ^{68}Ge, natural Y (^{89}Y: 100%) and Ga (^{69}Ga: 60.1%, ^{71}Ga: 39.9%) were used respectively.

For the test production of ^{64}Cu and ^{57}Co, natural Ni electroplated on a Cu plate was used. In addition, $CaCO_3$ was used as a target material for the test production of ^{44}Sc.

2.2 Proton Irradiation Condition

Target materials were installed at the automatic target change system of the beamline 1-1 (Fig. 1), and then irradiated with a proton beam generated from RFT-30 cyclotron of Korea Atomic Energy Research Institute (KAERI). Proton beam energy was initially 21.8 or 29.4 MeV, and controlled by adjusting the thickness of degrader material (Al or Cu) before the proton beam was incident on the targets. Average beam current was 30~40 μA and irradiation time was changed to control the total dose. Metal targets were water-cooled during the proton irradiation process. Irradiated targets were automatically detached and transported to the hot cells, and then chemical processes were performed there.

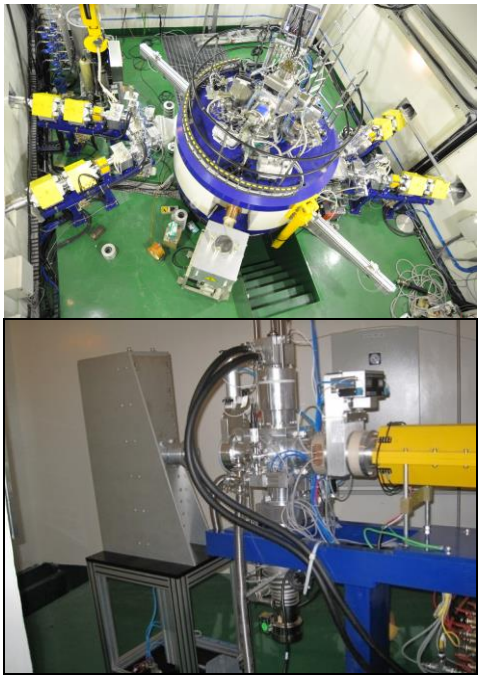

Fig. 1. Photo of RFT-30 cyclotron and the beamline 1-1 for the production of PET RIs.

2.3 Production of RIs

RIs were produced via the nuclear reactions induced by the proton irradiation listed below. Target and product nuclides can be seen in Fig. 2.

1) ^{18}O(p, n)^{18}F
2) ^{89}Y(p, n)^{89}Zr
3) ^{nat}Ga(p, xn)^{68}Ge
4) ^{64}Ni(p, n)^{64}Cu
5) ^{58}Ni(p, 2n)^{57}Cu → ^{57}Ni → ^{57}Co
6) ^{44}Ca(p, n)^{44}Sc

^{18}F is produced routinely or by request and we provide ^{18}F-labelling experiment service to users. For ^{89}Zr, because it has a half-life of 3.3 days which is well matched to the circulation half-lives of antibodies, intensive research on ^{89}Zr has been performed [1]. After the production of ^{89}Zr using RFT-30 cyclotron, it was delivered to several hospitals and research institutes as a form of zirconium oxalate or chloride for research purpose. ^{68}Ge has a relatively long half-life of ~270 days and produces daughter RI, ^{68}Ga. Therefore experiments using ^{68}Ga can be performed for several

months without daily-production of ^{68}Ge if ^{68}Ge/^{68}Ga generator is provided [2]. We have performed sufficient proton irradiation of 2,150 μAh, and the target is being cooled for the elimination of short-lived impurities. The measured radioactivity of ^{68}Ge is ~80 mCi. Test production of ^{64}Cu, ^{57}Co, and ^{44}Sc were performed using natural Ni and $CaCO_3$ targets. After the production, separation experiment was also performed. For the mass production of them, proton irradiation experiment of enriched targets will be carried out later.

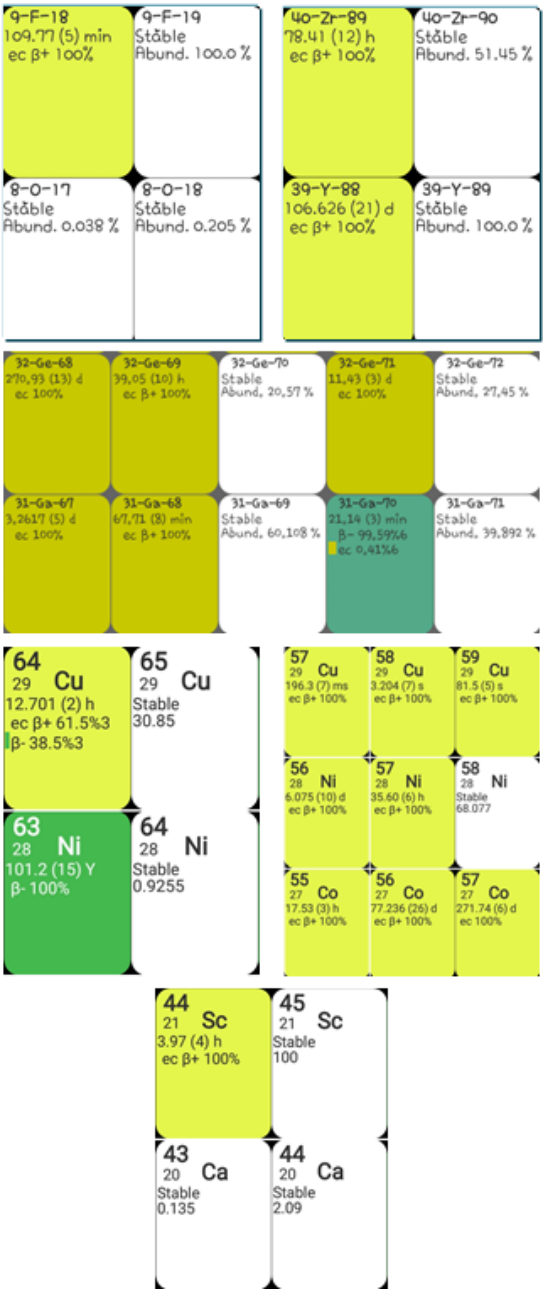

Fig. 2. Target and product nuclides [3].

3. Conclusions

In this research, various positron-emitting RIs including ^{18}F, ^{89}Zr, ^{68}Ge, ^{64}Cu, ^{57}Co, and ^{44}Sc were successfully produced using RFT-30 cyclotron at KAERI. We are trying to optimize irradiation conditions for RI production and following processes after the irradiation. Produced RIs can be used for the user service as well as for our own research purpose. In the future, research on the production of other useful RIs and the performance improvement for mass-production will be carried out.

REFERENCES

[1] Y. Zhang, H. Hong, and W. Cai, PET Tracers Based on Zirconium-89, Current Radiopharmaceuticals, Vol.4, p.131, 2011.
[2] F. Rösch, Past, present and future of ^{68}Ge/^{68}Ga generators, Applied Radiation and Isotopes, Vol.76, p.24, 2013.
[3] Isotope Browser, IAEA Nuclear Data Section