Preliminary Beam Irradiation Test for RI Production Targets at KOMAC

Sang-pil Yoon*, Hyeok-jung Kwon, Han-sung Kim, Yong-sub Cho, Kyung-tae Seol, Young-gi Song, Dae-il Kim, Myung-hwan Jung, Kye-ryung Kim,Yi-sub Min
KOMAC, Korea Atomic Energy Institute
**Corresponding author: spyun@kaeri.re.kr*

1. Introduction

Korea multi-purpose Accelerator Complex (KOMAC) is operating 20 MeV and 100 meV proton beamlines to provide proton beams to users. 2016. February, The new beamline and target irradiation facility has been constructed for the production of therapeutic radio-isotope. Sr-82 and Cu-67 were selected as the target isotope in this facility, they are promising isotope for the PET imaging and cancer therapy [1].

For the facility commissioning, the irradiation test for the prototype-target was conducted to confirm the feasibility of radio-isotope production, the proto-type targets are made of RbCl pellet and the natural Zn metal for Sr-82 and Cu-67 production respectively, In this paper, an introduction to the RI production targetry system and the results of the preliminary beam irradiation test are discussed.

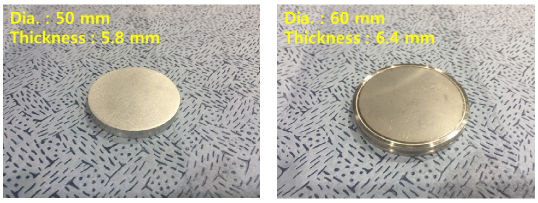
2. Methods and Results

2.1 Proto-type Target Preparation

To design RI target, we have derived the optimum thickness of target materials considering the beam energy loss by the beam window, cooling water and target claddings through SRIM calculation [2].

For the Sr-82 and Cu-67, the pressed RbCl pellet and Zn metal disc was prepared. These target materials have natural abundance and they are encapsulated in stainless steel cladding with o.d. of 60 mm and i.d. of 50 mm with 0.3 mm window for the proton irradiation. To prevent the leakage of the radioactive species inside target claddings, the cladding is fabricated by laser welding. After the target cladding fabrication, the leakage test have been conducted by using the penetration test. Figure 1 shows the fabricated proto-type target claddings after welding process.

(a) RbCl pellet and its target cladding



(b) Zn disc and its target cladding

Fig.1 The proto-type target for Sr-82 / Cu-67 production

2.2 Targetry System

The RI targets are mounted inside the target holder for their supporting and cooling. The cooling water are incoming from the bottom side of target holder and flow out through the upper side. Inside of target holder, there is cooling water gap between two targets. For the beam irradiation, the target holder can be inserted into the target transport system and withdrawn by remote handling inside the hot-cell. Figure 2 describes the prepared target holder.

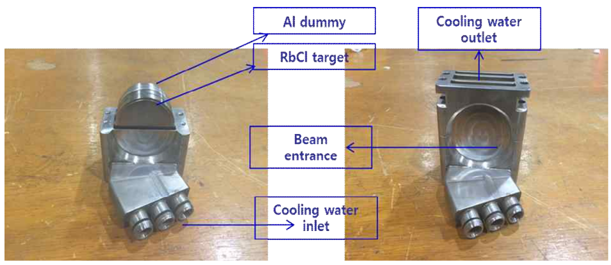


Fig.2 The fabrication of target holder

For the transportation of target carrier from the hot-cell to the target irradiation chamber, target carrier is driven by the electric AC servo motor with chain and sprocket system thorough the target transport pipe. The oscillations of target carrier during its motion are controlled by constraining by two guide rail which attached inside of transport pipe which is filled by deionized water for the prompt neutron shielding during the beam irradiation. Therefore, All parts and structural materials are made of the stainless steel to prevent the corrosion of the target transport equipment. Figure 5 and Figure 6 describes the inside of the target irradiation chamber and the target transport system.

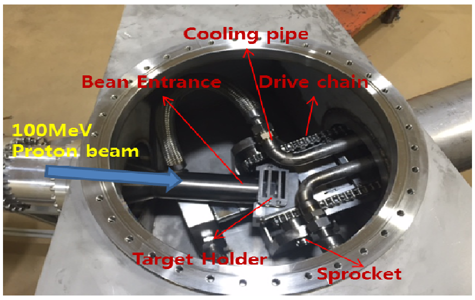


Fig. 3. Inside of target irradiation chamber

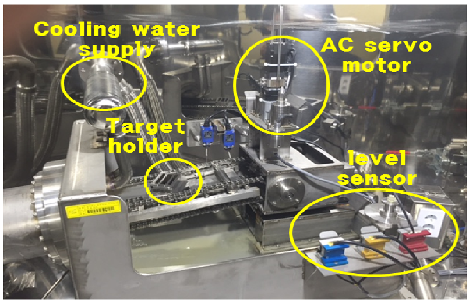


Fig. 4. Target transport system

For the heat removal from the target, which is induced by proton beam irradiation, we have prepared independent cooling system. the flow rates of coolant are max. 190 L/min (63.3L/min per one cooling channel) and the coolant was selected the de-ionized water to prevent the corrosion inside target transport system. The cooling system consists of air-cooled chiller, water purification filter and de-ionized water product apparatus and All component are integrated at one SKID. These targetry systems can be remotely monitored and controlled by EPICS control system. Figure 5 and 6 shows the installation of targetry system at KOMAC.

Fig. 5. Installation status in the target room

Fig. 6. Installation in the processing room

2.3 Preliminary Beam irradiation test

For the beam commissioning of the new RI production targetry system and the preliminary irradiation of proto-type target, the low flux irradiation test was conducted. Table 1 describes the irradiation test conditions.

Table 1. irradiation test conditions

Peak current	0.2 mA
Pulse width	100 usec
repetition	1 Hz
Flux density	7.4E+6 #/cm^2-pulse
Irradiation dose	2.5E+10 protons

For the identification of Sr-82 and Cu-67 production, we have measured the characterized gamma emission spectrum from the irradiated RbCl and Zn target by using the HPGe(High Purity Germanium) gamma spectroscopy system after proton beam irradiation. For the detection, the target claddings didn't separate from target material due to the absence of isotope separation and purification facility. The experimental set-up and the decay characteristics of Sr-82 and Rb-82 were described by Figure 7 and Table 2.

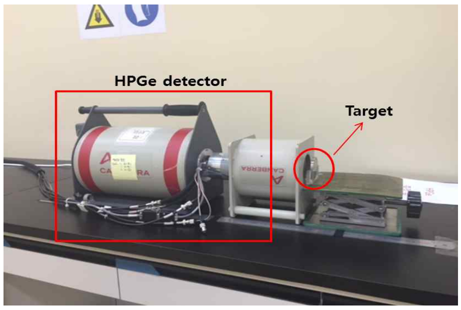


Fig. 7. Experimental set-up for gamma spectroscopy

Table 2. decay data of Sr-82 and Cu-67

	Sr-82	Cu-67
Decay mode	Electron capture	Beta (-)
Half life	25.5 day	2.58 day
Daughter	Rb-82	Zn-67 (stable)
Main gamma	From Rb-82 - 511 keV (192%) (positron annihil.) - 776.5 keV (13%)	- 91 keV (7%) - 93.3 keV (16%) - 184.6 keV (48.7%)

Figure 8 and 9 shows the measured gamma spectrum from the irradiated RbCl and Zn targets.

Through the HPGe gamma spectroscopy, because we didn't separate the target from the claddings, the unwanted gamma peaks emitted from the cladding material were measured. Among them, we could obtain 511 keV and 776.5 keV gamma emissions, which is the typical gamma spectrum from Sr-82/Rb-82.

And also, we could obtain 91 keV, 93.3 keV, 184.6 keV gamma emissions, which is the typical gamma spectrum from Cu-67. These measured gamma spectrum shows the production of Sr-82 and Cu-67 by 100 MeV proton beam irradiation.

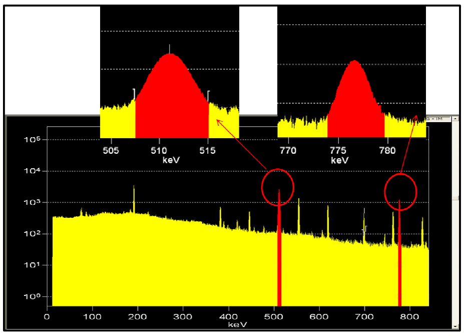


Fig. 8. The gamma spectrum from RbCl target

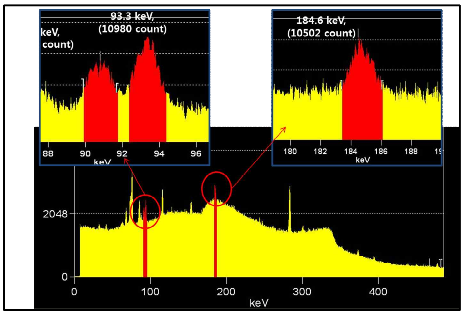


Fig. 9. The gamma spectrum from Zn target

3. Conclusions

We have completed to the construction of the RI production targetry system for the Sr-82 and Cu-67 production. And then, the low-flux beam irradiation tests for proto-type RI target have been conducted. As a result of the beam irradiation tests, we could obtain the evidence of Sr-82 and Cu-67 production, have confirmed the feasibility of Sr-82 and Cu-67 production at KOMAC RI production facility.

Acknowledgements

This work was supported by the Ministry of Science, ICT & Future Planning of the Korean Government

REFERENCES

[1] F.M. Nortier et al, Transactions of the American Nuclear Society and European Nuclear Society, TANSAO 89 1-920 p.77, 2003

[2] J. F. Ziegler, J. P. Biersack, "SRIM-2000, 40: The Stopping and Range of Ions in Matter", IBM-Research, Yorktown, NY 2000.