Analysis of radioisotope production according to the position of the IP-15 rig in the research reactor(HANARO)

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1. Introduction

For the production of radioactive isotopes, the radioactive concentration was measured after neutron irradiation using research reactor(HANARO) of the Korea Atomic Energy Research Institute. Thermal neutron flux is 1.81E+14 $n \cdot cm^{-2} \cdot s^{-1}$ and IP-15 irradiation hole was used, which can load up to 4 targets.

In this study, two identical targets were manufactured and load into IP-15 rig, and radioactive concentrations of the two targets were compared and analyzed.

Yb_2O_3 raw material was used as the experimental target and it is used for NCA(no-carrier added) ^{177}Lu production.

In these days, Therapeutic radionuclides such as ^{177}Lu are emerging as an important factor for treatment of the malignant tumor such as breast, prostate, colon. Its demand is also increasing because of its high theranostics potential [1].

^{177}Lu production methods include direct production using ^{176}Lu and indirect production using ^{176}Yb. Direct production using ^{176}Lu can produce a large amount of ^{177}Lu with a 2100(b) cross-section, but ^{176}Yb has a relatively small 2.4(b) cross-section, so it is one of the most difficult radionuclides to separate [2].

Also, the Preparation of ^{177}Lu from the ytterbium target is more widely studied in related fields and Yb_2O_3 target is suitable for producing the NCA(no-carrier added) ^{177}Lu by using a few mg of enriched Yb target similar to the methods reported in the literature [3, 4].

For this reason, it is expected to play an important role in NCA ^{177}Lu production using IP-15 rig irradiation hole in HANARO reactor.

2. Experimental and measurement

2.1 Manufacture of target container

The target container made for neutron irradiation (Fig. 1.) was made of a quartz ampoule that can contain raw materials and an external container that wraps It.

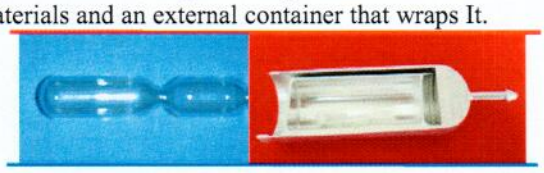


Fig. 1. Target ampoule for neutron irradiation

In particular, the target container containing raw materials is made of a quartz ampoule with excellent mechanical strength and chemical resistance, and is shaped like a peanut with an upper of 35 mm, a lower part of 45 mm, and thickness of 1.0 mm.

The target container for neutron irradiation surrounding the quartz ampoule was composed inner and outer aluminium and was manufactured using high-purity Al-1050 [5].

2.2 Neutron irradiation and analysis

The target material used for neutron irradiation is Yb_2O_3 and the amount of target material (Table. 1.) is 30 mg each. Two targets were produced. The target is used to separate the NCA ^{177}Lu from ^{177}Yb and ^{177}Lu radioactive concentration is measured.

Measurement equipment was used with CRC-15R(CAPINTEC).

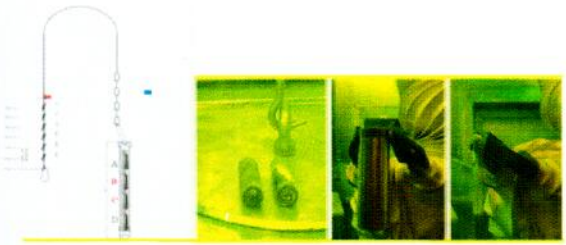


Fig. 2. Target position (B, C) and irradiated quartz ampoule

The study loaded two targets(B, C) to the IP-15 rig and compared the difference in radioactive concentration for each location according to the same neutron irradiation time (Table. 2.).

Table 1. ^{176}Yb raw material concentration

Description	Isotope	^{176}Yb
	Enrichment	99.48%
	Element weight	30 mg
	Form	Oxide(Yb_2O_3)
Isotope Distribution	Isotope ^{175}Yb	^{176}Yb
Content(%)	0.52	99.48

The average thermal neutron flux is 1.81E+14 $n \cdot cm^{-2} \cdot s^{-1}$, neutron irradiation time is 6 days, and Cooling time is 19 hr. and move the irradiation target to the production facility.

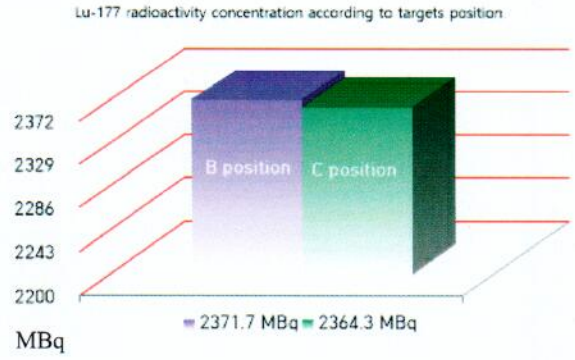
In order to measure the radioactive concentration, the irradiated quartz ampoule (Fig. 2.) is prepared after cutting the target container of the irradiation target using the cutting machine in the hot cell.

For analysis of ^{177}Lu production, the irradiated quartz ampoules measured, and ^{177}Lu productions (Table. 2.) were measured as 2371.7 MBq at B position and 2364.3 MBq at C position.

Table 2. ^{177}Lu Production efficiency comparison

Measurement of ^{177}Lu					
Neutron irradiation hole	Target position	Flux ($n \cdot cm^{-2} \cdot s^{-1}$)	Irradiation time (d)	Cooling time (hr)	Measurement of ^{177}Lu (MBq)①
IP-15	B	1.81E+14	6.0	19	2371.7
	C	1.81E+14	6.0	19	2364.3

① ^{177}Lu final radioactivity concentration.
※ Use of CRC-15R(CAPINTEC)



3. Conclusions

In this study, IP-15 rig was used to produce radionuclides for research and the amount of radioisope produced according to the position of the targets in the IP-15 rig was analyzed.

IP-15 rig contains two neutron irradiated targets and it was thought that there would be a lot of difference in radioactive concentration according to the irradiated targets position. but, as a result of actual confirmation, it was confirmed that there was almost no difference in radioactive concentration at B and C position.

As a result of study, it will be an important index when conducting themal neutron irradiation not only IP-15 rig but also IP-4, IP-5 rig. It is also likely to play an important role in the production of NCA(no-carrier added) ^{177}Lu.

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