Study of solid target preparation for developing I-124, Pd-103, Cu-64 radioisotopes based cyclotron

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1. Introduction

The decay characteristics of I-124, Pd-103 and Cu-64 radioisotopes produced by cyclotron have considered useful agents for diagnostic imaging or therapy. Numbers of radioisotopes used in medical applications or promised for development are produced with solid targets [1]. The aims of developing solid targets are to obtain large quantities of radionuclides from accelerators. The scope of the study is to develop optimized target system and chemical procedures of these radioisotopes. In order to increase the availability of the radionuclides, the investigation for the design of the solid target and different procedures yielding efficient production of high specific activity will be carrying. In this work, we will present the issue of the primary target design concept.

2. Methods and Results

At KIRAMS, interesting radionuclides of positron emitters for PET images and gamma ray emitters for SPECT are produced via various (p,xn) reactions with the high current proton cyclotron (IBA) installed at 2002. Several different targets have been developed to enhance the production yield for specific radionuclides: gas targets employed for C-11, F-18 and I-123 radionuclides (Nordion), a liquid target used only for the F-18 nuclide, and solid targets (IBA) prepared for the production of Ga-67 and Tl-201 nuclides. Our research is involved with the development of high current solid targets for medical radioisotope production and optimization of production procedure and quality control of radiotherapeutical radionuclides and radiophermaceuticals. The quality and yield of products are evaluated by proton energies, target thickness, bombarding time, and growth time. Radionuclidic impurities are determined by gamma-spectrometer with high purity Germanium (HPGe) detector and the yields are read by ion chamber.

The following parameters are considered to develop the solid targets, which produce large quantities of radioisotopes with high purity:

(i) Target construction (selection of target material and beam energy from the cross-section data of the specific nuclear reaction)
(ii) Design of Targetry (Heat transfer in solid, melting temperature of target material, target thickness, cooling, electroplating). The cooling of the target is important at high production beam intensities, that is critical in the design. A dense, smooth and homogeneous target layer on plate is being able to tolerate with high beam currents without losing or burning enriched material.
(iii) Beam irradiation condition (bombardment time and beam current, growing time after irradiation)
(iv) Separation and recycle of target materials
(v) Extraction of radionuclides
(vi) Form of seeds or radiopharmaceuticals

Figure 1 shows the typical process of the radionuclide production with cyclotron at KIRAMS.

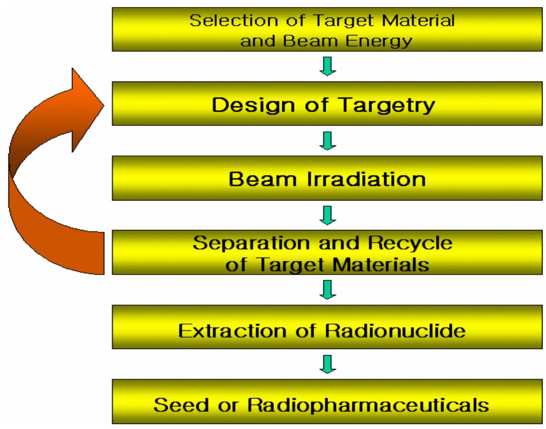

Fig. 1 The Process of radionuclide production based on cyclotron.

2.1 Development of I-124 radioisotope

Radioisotope I-124 (23 % positron emission, half-life 4.2 days) is considered to use in diagnostic PET imaging with monoclonal antibodies and also has potential for therapy. The production of I-124 radionuclide is limited to solid target up to now.

The production yield of iodine radionuclide I-124 by solid target irradiation strongly depends on the type of target material as summarized in table 1. The solid target for producing I-124 is composed of tellurium oxide, which placed on Pt backing plate by electroplating method and pressed in order to obtain a uniform layer. With the target material of enriched Te-125, the yield of I-124 production is expected 5 times higher than that from enriched Te-124 from the cross-section data.

Table 1 The comparison of yield of I-124 from different target materials.

Nuclear reaction	Optimum energy range [MeV]	Thick Target yield of ^{124}I [GBq/uAh]	Calculated impurity (%)	
			^{125}I	^{126}I
^{124}Te(p,n)	13 → 9	20	< 0.1	< 0.1
^{124}Te(d,2n)	16 → 6	24	not determined	not determined
^{125}Te(p,2n)	22 → 14	111	0.89	-

2.2 Target fabrication for Pd-103 seeds

Pd-103 is increasingly used in brachytherapy seeds. For the simple production of Pd-103 seeds, Rh wires are placed on the Cu plate and irradiated directly by 18 MeV proton beam using the nuclear reaction of Rh-103(p,n)Pd-103. The direct irradiation of Rh wires is designed in order to avoid a complicate chemical process for the separating and extracting target materials. The wires have appropriate dimensions to be put into the titanium tubes for brachytherapy seeds. Figure 2 shows the proposed schematic diagram for the target station. Rh wires (7 x 0.5 mm) are assembled in a 7 degrees target to beam system. The stopping power of Rh is sufficient to degrade 18 MeV to 5 MeV in 0.5 mm of Rh in 7 degrees beam/target geometry. Increased of incident energy above 18 MeV for production of Pd is not acceptable due to two major reasons: the contamination of Rh-102m, Rh-102g, Rh-101g and negligible additional yield with higher energies. Cooling is carried by direct contact of the backing with water.

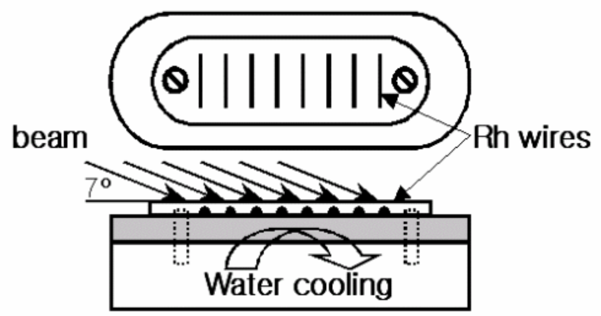

Figure 2. The proposed Rh-wires target system.

The disadvantage of the direct method is necessarily needed to rotate the wires during irradiation to obtain a more or less homogeneous Pd-103 distribution. Also the apparent activity is lower than real activity due to the self-shielding effect.

Alternative production of Pd-103, we will discuss electroplating of Rh to Cu plate and recovery of rhodium from irradiated target fragments. With this method, a electroplated layer with a thickness of 50um is obtained as shown in figure 3.

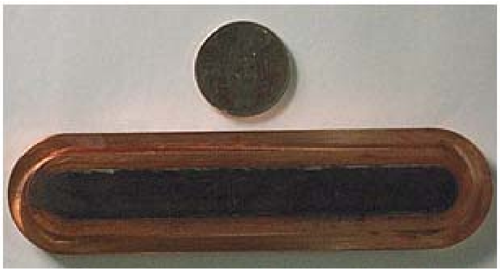

Fig. 3 The Rh-103 electroplated on Cu plate

2.3 Production of Cu-64 radioisotopes

Copper-64 is considered as a useful radiotracer for positron emission tomography (PET) as well as a promising radiotherapy agent for the treatment for cancer. For the production of Cu-64 radionuclide, Ni-64(p,n)Cu-64 nuclear reaction was employed with 12 MeV proton energy [2]. The enrich Ni-64 target material will be electroplated on a gold disk and the efficiency of plating will be investigated. In addition to, a recycling technique for the target materials will be developed.

3. Conclusion

We have studied to develop high power solid targets for producing useful radioisotopes of I-124, Pd-103, and Cu-63. From the nuclear cross-section data for the specific reaction, the optimized beam energies and target materials are selected. The target materials will be coated to Cu plate (Pt or Au backing plates) by electroplating method. The optimized condition for the electroplating is still under investigating in order to have a uniform film on the Cu plate. Metallic target deposited on a solid substrate by electroplating could be designed to capable of high currents. It is expected that the new system will exhibit improvements in both performance and reliability.

REFERENCES

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