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Production of ^{103}Pd Radioisotope by Using Cyclotron

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1. Introduction

The production of various radioisotopes has been beneficial to both diagnostic and therapeutic nuclear medicine [1]. Along with PET tracers' developments, brachytherapy with radioisotope has been challenged to other conventional cancer treatments. Prostate brachytherapy with the interstitial implantation of carrier-free ^{103}Pd seed in the prostate gland has been recognized as an effective tumor therapy method for its decay characteristics ($T_{1/2}$ = 16.9 day, E_γ = 39 keV (99.97 %), E_γ = 357 keV (0.02 %)). The energetic gamma-rays emitted through radioactive decay by mode of electron capture and emission of photon irradiate to the internal tissues of prostates diminishing the volume of tumor and killing the cancer cells. In this work, we report the production result of ^{103}Pd radioisotope using (p,n) nuclear reaction.

2. Methods and Results

2.1. Target Fabrication

Using a 4π solid target as shown in Figure 1, ^{103}Pd radionuclide is produced by utilizing MC50 cyclotron [2] at KIRAMS. To maximize the yield of desired products and minimize the level of radionuclidic impurities, incident energy of proton beam is optimized by placing Al degrader in front of the target according to the high cross-section ranges in order to take a full benefit of the (p,n) reaction excitation curve. Employing the target inclined 45 degree with respect to the beam direction, the Rh thickness should be optimized within the desired energy ranges of beams passing through the target layer [3].

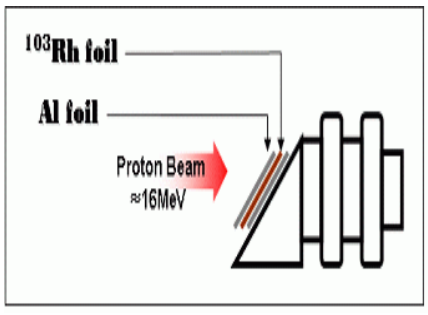

Figure 1. Schematic diagram of a 4π target (not scaled) for the production of ^{103}Pd radionuclide. The target inclined 45 degree with respect to the direction of the incident beam. Cooling water flows both a front and a back faces of the target.

2.2. ^{103}Pd Production

Figure 2 shows the process of developing ^{103}Pd radionuclide. Experiments have been done using a 20 mm x 30 mm Rh-foil (Goodfellow) target sandwiched between a Al foil and Cu foil, that has been irradiated in the external beam of MC50 cyclotron with protons of 30 MeV. The excitation function for the ^{103}Rh(p,n)^{103}Pd reaction is shown in Figure 3, where the optimum energy range (E_p = 18 → 7 MeV) for the production is marked while 16 MeV was selected in this experiment.

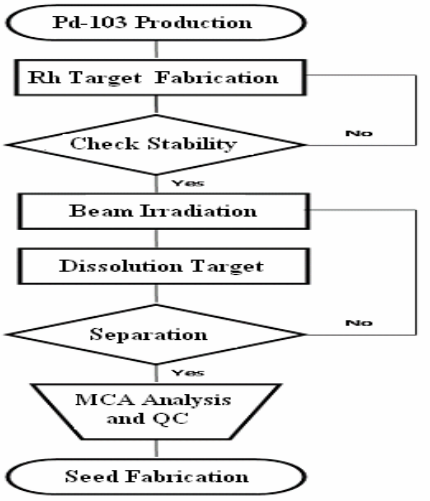

Figure 2. Production process for developing ^{103}Pd radionuclide

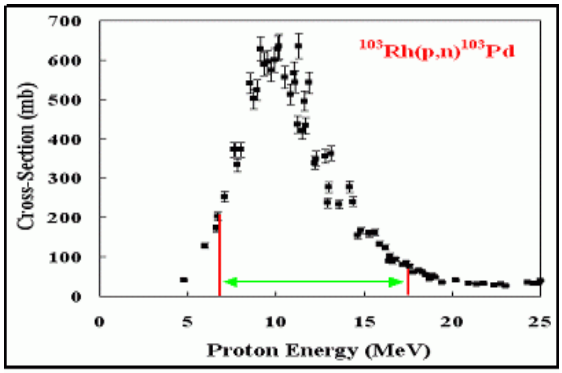

Figure 3. Excitation function of ^{103}Rh(p,n)^{103}Pd reaction (taken from ref.[1])

The irradiated Rh-foil by 16 MeV proton beam with 1uA for 20 mins is transported into the electro-chemical dissolution system filling with 6 M HCl (10 ml) as shown in Figure 4. Appling AC power between the Rh foil and a graphite flowing 1~2 mA current for 60 mins, the Rh and Pd are dissolved into the solution. Separation of Pd and Rh is achieved by using a cation exchange column with Dowex-1x8(Cl-) resin as indicated in figure 5.

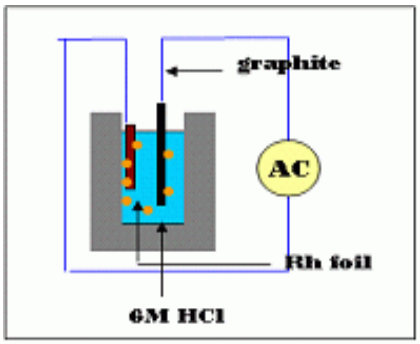

Figure 4. Rh/Pd electro-chemical dissolution system.

The solution is loaded onto the column and then washed 6M HCl (200 ml). This hydrochloric solution contains a majority of Rh target materials. And then, the ^{103}Pd is extracted with a mixture of 0.5M NH_3 and NH_4Cl solution. The purified Pd is taken into the gamma spectrometry (HPGe detector) as shown in figure 6.

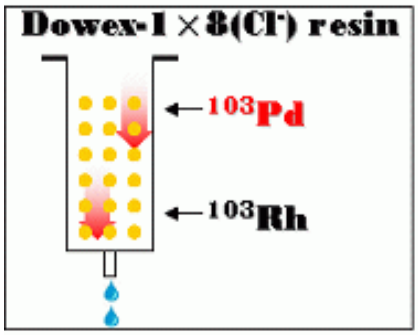

Figure 5. Schematic of separation process of Rh and Pd.

Figure 6 shows the gamma spectrum obtained the final purified product, which indicates the existence of ^{101m}Rh and ^{103}Pd radionuclides. The 356 keV (0.02 %)characteristic peak is appeared and the production rate could be estimated by summing the count rate under the peak.

3. Conclusion

Nuclear data is useful to medical application of a radioisotope, such as diagnostic and therapeutic applications. In this work, we present the optimization of production route of ^{103}Pd radioisotope for brachytherapy purpose using (p,n) nuclear reaction. Prostate brachytherapy with the interstitial implantation of carrier-free ^{103}Pd seed in the prostate gland has been recognized as an effective tumor therapy method for its decay characteristics ($T_{1/2}$ = 16.9 day, E_γ = 39 keV (99.97 %), E_γ = 357 keV (0.02 %)). The energetic gamma-rays emitted through radioactive decay by mode of electron capture and emission of photon irradiate to the internal tissues of prostates diminishing the volume of tumor and killing the cancer cells. In addition, an understanding of the underlying reaction mechanisms is required as well as theoretical models with a good prediction

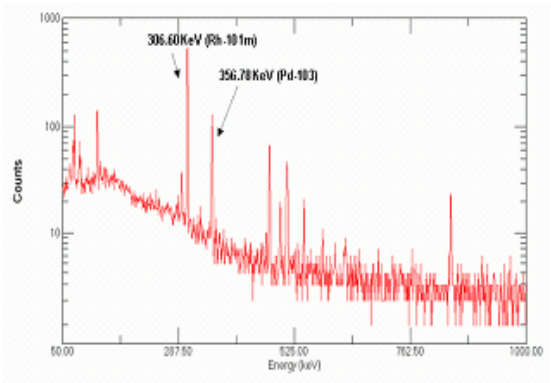

Figure 6. The gamma spectrum obtained after separation. The spectrum indicates the existence of ^{101m}Rh and ^{103}Pd radionuclides.

Acknowledgement

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