Transactions of the Korean Nuclear Society AutumnMeeting
Gyeongju,Korea,October24-25, 2013

Feasibility Study on Simultaneous Multi-Radioisotope Production using Double Stacked Target in MC-50 Cyclotron

Gyehong Kim[a*], Kwonsoo Chun[a], Byeongil Kim[a]
[a]*Radiopharmaceuticals Production Center, Korea Institute of Radiological & Medical Sciences, 75 Nowon-ro, Nowon-gu, Seoul, Korea, 139-706*
[*]*Corresponding author:white5950@kirams.re.kr*

1. Introduction

The radionuclides are often used in medicine for diagnosis, treatment and research. Alpha and beta(or electron) emitting radionuclides have become a promising method for the treatment of some tumors. ^{117m} Sn emits short-range electrons with a high linear energy transfer, and thus a high *S* value resulting in high quality therapeutic radiation [1]. ^{211}At has gained considerable interest for cancer treatment because its half-life of 7.2 hours matches better with the biological half-life of most carrier molecules. Moreover its decay scheme exhibits practically 100% yield for the emission of α-particles, with very low intensity gamma emissions [2, 3]. This work was mainly focused on the feasibility of double target system for simultaneous two-radioisotope production.

2. Methods and Results

MCNPX(Monte Carlo N-Particle) is a general-purpose Monte Carlo radiation transport code for modeling the interaction of radiation with matter. In particular, this code can be used to simulate the irradiation of target materials with hadrons to optimize target design and study the activation of the materials.

We use it to simulate alpha particle irradiations, to model particle fluence, energy distribution. Targets consist of target materials (^{209}Biand enriched ^{116}Cd) and base plate as shown in Fig. 1.

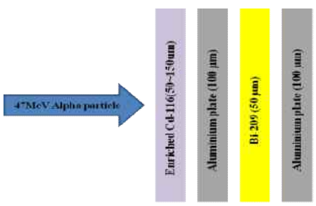

Fig. 1. Configuration of double target system simulated.

α-particle fluences and particle energy distributions were computed using MCNPX version 2.5. The MCNPX input file included detailed information on the geometry of the beam, the targets and base plates. Repeated simulations were run with a statistic of 10^8 primary particles. The results of the simulations were reporded by MCNPX in terms of α-particle flux(α-particle fluence per cm^2 per source particle simulated) in the meshed target. To estimate radionuclide activity at the EOB(end of bombardment), the particle distribution function *P(E)* was reported from the F4 and F2 tally output (fluence) data that were normalized over the entire particle energy range.

The energy distribution function for α-particles was further utilized to calculate radionuclide yield estimates for the formation of ^{117m}Sn via ^{116}Cd(α, 3n) and ^{209}Bi(α, 2n)^{211}At. The energy distribution function and the cross section $\sigma(E)$ can be used to calculate the product function $P(E)\,\sigma(E)$. Energy-dependent cross section $\sigma(E)$ data fitted polynomially and exponentially was used from literature experimental cross sections shown in Fig. 2 [4, 5]. Integrating and solving the following differential equation for an instable product nuclide result can determine the identities of the generated radionuclides:

$$A(t) = \int_0^{E_{max}} P(E)\sigma(E)dE\,\frac{dN_\alpha}{dt}N\left(1 - e^{-\lambda t}\right)$$

where *A(t)* is the radionuclide radioactivity, dN_α/dt is the intensity of the irradiating α-particles(number of α-particles/cm^2s), λ is the radionuclide decay constant and t is the duration of irradiation.

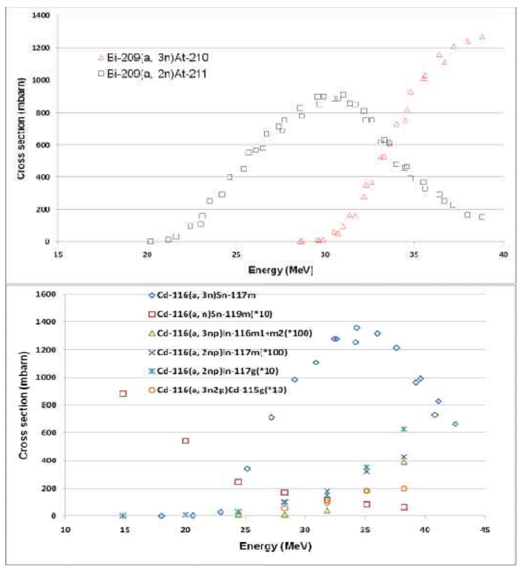

Fig. 2. Experimental excitation functions of the reactions of alpha particle with ^{209}Bi and ^{116}Cd.

Fig. 3 shows the normalized energy distribution function for alpha particles on the ^{209}Bi target entrance of double-layer target system.

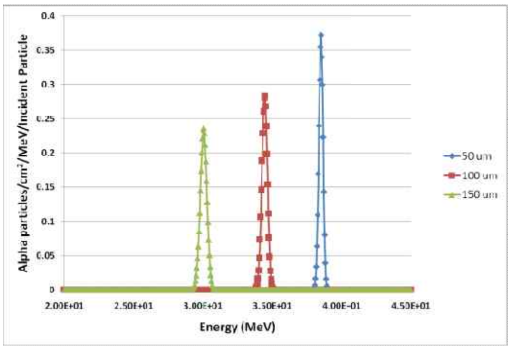

Fig. 3. Energy distribution of the 47 MeV alpha beam after different depht of 50-150 μm ^{116}Cd taget on the ^{209}Bi target entrance.

3. Conclusions

A simple double target was simulated for simultaneous production of ^{117m}Sn and ^{211}At. To determine the optimum thickness of target layer, We demonstrated that the combination of double target system with a cyclotron capable of generating 47 MeV alpha particle provides simultaneous production of ^{117m}Sn and ^{211}At.

REFERENCES

[1] Suresh C. Srivastava, The Role of Electron-Emitting Radiopharmaceuticals in the Palliative Treatment of Metastatic Bone Pain and for Radiosynovectomy: Applications of Conversion Electron Emitter Tin-117, An International Journal of Brazilian Archives of Biology and Technology, Vol. 50, p. 49, 2007.

[2] K. H. Lieser, Nuclear and Radiochemistry: Fundamentals and Applications, John Wiley Sons, 1997.

[3] R. B. Firestone and C. M. Baglin, S. Y. F. Chu, Table of Isotopes 8th Ed. update on CD-ROM, John Wiley & Sons, 1998.

[4] E.L.Kelly, E.Segre, Some Excitation Functions of Bismuth, Physical Review, Vol. 75, p. 999, 1949.

[5] R.A.Rebeles, A.Hermanne, P.VanDenWinkel, F.Tarkanyi, S.Takacs, L.Daraban, Alpha induced reactions on ^{114}Cd and ^{116}Cd: An experimental study of excitation functions, Nucl. Instrum. Methods in Physics Res., Sect.B Vol. 266, p. 4731, 2008.