Medical Research and Innovations

Research Article ISSN: 2514-3700

An application and importance of production of medical radioisotopes used in cancer therapy and diagnosis

Ozan Artun*

Department of Physics, Zonguldak Bülent Ecevit University, Turkey

Abstract

This work points out importance of medical radioisotopes in nuclear medicine based on treatment and diagnosis of cancer. Moreover, possible production methods of medical radioisotopes are evaluated, and an application for the production of two medical radioisotopes through neutron and deuteron induced reaction processes is discussed by comparing with experimental data in the literature.

Introduction

Nuclear medicine plays an important role in diagnosis and treatment of cancerous cells using different devices some of which are Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), which are used in diagnostic aims [1-4]. Addition to diagnosis, cancer treatment is also available in nuclear medicine; however, the therapy can be separated two section as internal and external therapy. For instance, Intensity-modulated radiation therapy (IMRT) [5] that is a type of 3-D conformal radiation therapy [6] is an external therapy device. On the other hand, brachytherapy that is fairly important method can be called as internal therapy. In the literature, a lot of devices and methods to use medical radioisotopes in nuclear medicine are available in the literature. Common point of ones is definitely radioisotopes used in diagnosis and treatment of cancer, and these radioisotopes are produced by either nuclear reactors or particle accelerators via neutron reactions like (n,γ) or charged particle induced reaction processes e.g. proton, deuteron and alpha particles. Some of the famous radioisotopes produced in nuclear reactors may give Mo-99, P-32, Cu-64, Y-90 radioisotopes. Furthermore, medical radioisotopes produced by the charged particle induced reactions are commonly used in PET and SPECT. Such a production is carried out particle accelerators with energy ranges 1-50 MeV such as O-15, F-18, Ga-68 etc. But, for production of Ac-225 that is therapeutic purpose particle accelerators with higher energy are necessary [7]. Therefore, the production method of radioisotopes used in nuclear medicine can change kind of nuclei based on their half-lives and type of emission.

For an application of the production of medical radioisotopes, we investigated the production of Kr-42 and Mn-51 radioisotopes via deuteron and neutron induced reaction processes.

Materials and method

The productions of K-42 and Mn-51 radioisotopes used for medical aims were carried out by neutron and deuteron induced reaction in energy region between 1 MeV and 30 MeV incident energy. Therefore, we used $^{45}Sc(n,\alpha)^{42}K$ and $^{50}Cr(d,n)^{51}Mn$ reactions where the purities of the target materials are above 99% and each target is uniform [5,7,8]. The cross-section calculations were performed two component exciton models via TALYS 1.9 code [9] and the level density model was chosen Fermi gas model with constant temperature [1]. The calculated results for each reaction were compared with experimental data obtained from Exfor database [10].

Results and discussion

The calculated cross-sections of $^{45}Sc(n,\alpha)^{42}K$ and $^{50}Cr(d,n)^{51}Mn$ reactions are presented in figures 1 and 2 as dependent on incident energy. In $^{45}Sc(n,\alpha)^{42}K$ reaction, there are a lot of experimental data measured by Subasi et al. (1998), Molla et al. (1998), Doczi et al. (1998), Bostan and Qaim (1994), Grallert et al. (1993), Belgaid et al. (1992), Ikeda et al. (1988), Levkovskii et al. (1969), Bayhurst and Prestwood (1961) [11-19], and it is clear that the calculated cross-section generally consistent with the experimental data, especially in the maximum cross-section values about 14 MeV neutron incident energy where the experimental cross-section values reach up to 70 MeV. Furthermore, for $^{50}Cr(d,n)^{51}Mn$ reaction, the experimental data reported by Klein et al. (2000) [20] agree with the calculated cross-section curves from threshold to 5 MeV; however, beyond 5 MeV, the experimental data are higher than the theoretical cross-section curves. On the other hand, both experimental and theoretical values are the same up to 5 MeV (Figure 2).

Conclusion

In this work, we calculated the production of ^{51}Mn and ^{42}K radioisotopes for neutron and deuteron induced reactions and the obtained results were compared with experimental data in the literature data. The calculated data were in good agreement with experimental data in maximum cross-section values which define the appropriate incident energy. Additionally, to produce ^{51}Mn radioisotope, the deuteron induced reaction do not has enough experimental and theoretical results in the literature. Therefore, we can propose new works for the production of ^{51}Mn as both experimental and theoretical.

***Correspondence to:** Ozan Artun, Department of Physics, Zonguldak Bülent Ecevit University, Turkey, E-mail: ozanartun@beun.edu.tr / ozanartun@yahoo.com

Received: March 12, 2019; **Accepted:** March 25, 2019; **Published:** March 28, 2019

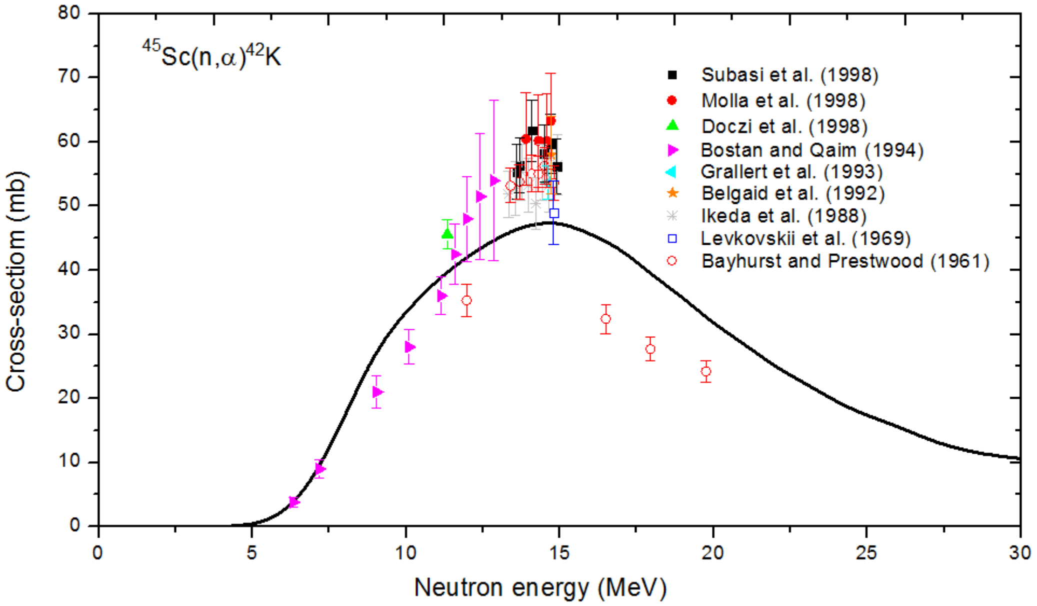

Figure 1. Calculation of cross-section of ^{45}Sc(n,α)^{42}K reaction.

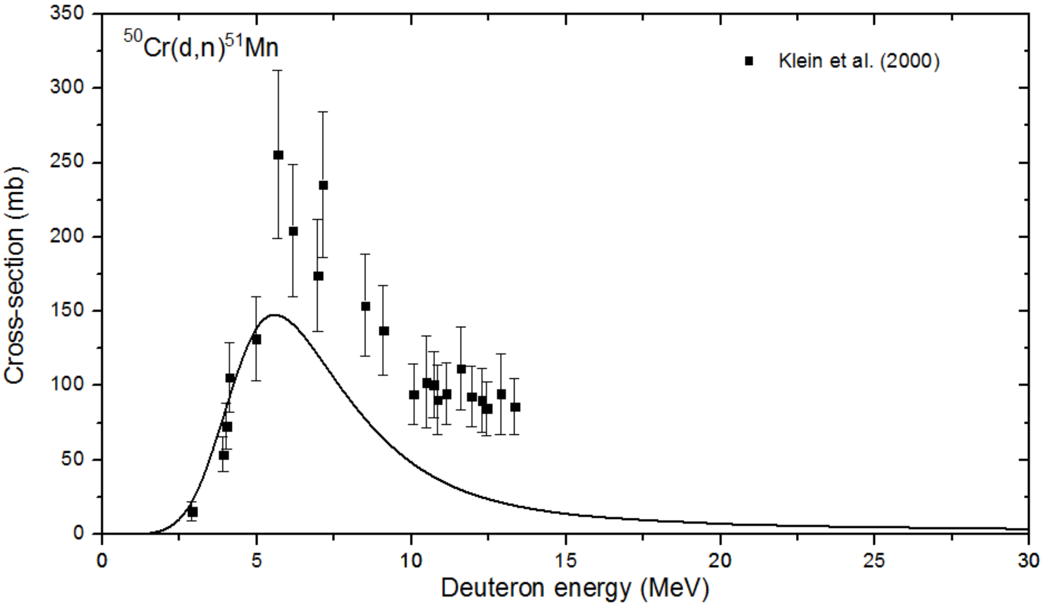

Figure 2. Calculation of cross-section of ^{50}Cr(d,n)^{51}Mn reaction.

References

1. Artun O (2019) Calculation of productions of medical 201Pb, 198Au, 186Re, 111Ag, 103Pd, 90Y, 89Sr, 77Kr, 77As, 67Cu, 64Cu, 47Sc and 32P nuclei used in cancer therapy via phenomenological and microscopic level density models. *Appl Radiat Isot* 144: 64-79. [Crossref]

2. Artun O (2018) Calculation of productions of PET radioisotopes via phenomenological level density models. *Radiat Phys Chem* 149: 73-83.

3. Artun O (2018) Investigation of the productions of medical 82Sr and 68Ge for 82Sr/82Rb and 68Ge/68Ga generators via proton accelerator. *Nucl Sci Tech* 29: 137.

4. Artun O (2018) A study of some nuclear structure properties of 11C, 13N, 15O, 18F, 52Mn, 52Fe, 60Cu, 62Zn, 63Zn, 66Ga, 68Ga, 76Br, 81Rb, 82Rb, 82Sr, 83Sr, 86Y, 89Zr and 92Rb nuclei used for PET in the axial deformation. *Indian J Phys* 92: 1449-1460.

5. Artun O (2017) Investigation of the production of cobalt-60 via particle accelerator. *Nucl Tech Radiat Protec* 32: 327-333.

6. Cancer treatment (2019). [https://www.cancer.gov/about-cancer/treatment/types/radiation-therapy/external-beam]

7. Artun O (2017) Estimation of the production of medical Ac-225 on thorium material via proton accelerator. *Appl Radiat Isot* 127: 166-172. [Crossref]

8. Artun O (2017) Investigation of the production of promethium-147 via particle accelerator. *Indian J Phys* 91: 909-914.

9. Koning A, Hilaire S, Goriely S (2017) Talys manual 1.9. .

10. Exfor (2019) Experimental Nuclear Reaction Data. .

11. Subasi M, Erduran MN, Bostan M, Reyhancan IA, Gueltekin E, et al. (1998) (n,alpha) reaction cross sections of 44Ca, 45Sc and 51V nuclei from 13.6 to 14.9 MeV. *Nucl Sci Eng* 130: 254.

12. Molla NI, Basunia S, Miah RU, Hossain SM, Rahman M, et al. (1998) Radiochemical study of the Sc-45(n,p)Ac-45 and Y-89(n,p)Sr-89 reactions in the neutron energy range of 13.9 to 14.7 MeV. *Radiochim Acta* 80: 189. [Crossref]

13. Doczi R, Semkova V, Fenyvesi A, Yamamuro N, Buczko CM, et al. (1998) Excitation functions of some (n,p) and (n,alpha) reactions from threshold to 16 MeV. *Nucl Sci Eng* 129: 164.

14. Bostan M, Qaim SM (1994) Excitation functions of threshold reactions on 45Sc and 55Mn induced by 6 to 13 MeV neutrons. *Phys Rev C Nucl Phys* 49: 266-271. [Crossref]

15. Grallert A Csikai J, Buczko CM, Shaddad I (1993) Investigations on the systematics in (n,a) cross sections at 14.6 MeV. IAEA Nucl Data Sect. *Report* 286: 131.

16. Belgaid M, Siad M, Allab M (1992) Measurement of 14.7 MeV Neutron Cross Sections for Several Isotopes. *J Radioanalytical Nucl Chem Letters* 166: 493.

17. Ikeda Y, Konno C, Oishi K, Nakamura T, Miyade H, et al. (1988) Activation cross section measurements for fusion reactor structural materials at neutron energy from 13.3 to 15.0 MeV using FNS facility. JAERI Reports No 1312. [Crossref]

18. Levkovskii VN, Kovel`skaya GE, Vinitskaya GP, Stepanov VM, Sokol`ski VV (1969) Cross sections of the (n,p) and (n,alpha) reactions at 14.8 MeV . *Sov J Nucl Phys* 8: 4.

19. Bayhurst BP, Prestwood RJ (1961) (n,p) and (n,alpha) Excitation functions of several nuclei from 7.0 to 19.8 MeV. *J Inorg Nucl Chem* 23:173.

20. Klein ATJ, Roesch F, Qaim SM (2000) Investigation of Cr-50(d,n)Mn-51 and Nat-Cr(p,x)Mn-51 processes with respect to the production of the positron emitter Mn-51. *Radiochimica Acta* 88: 253.