Cyclotron production of ^{89}Zr: A potent radionuclide for positron emission tomography

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Introduction

The zirconium-89 radionuclide has a real medical interest because ^{89}Zr decays by positron emission ($T_{1/2}$ = 3.27 day, I_{β^+} = 23%, E_{β^+} = 0.897 MeV) and by electron capture (77%) to stable ^{89}Y. It is well known that a radioisotope must be in carrier-free-from when it is used for the field of positron emission tomography (PET) radioisotope production and application. Cross section for the production of the therapeutic radionuclide ^{89}Zr was measured by several authors [1, 2]. The motivation of the present work was to production of ^{89}Zr via ^{89}Y (p, n) ^{89}Zr reaction. The excitation functions of the proton-induced reaction on yttrium-89 were calculated by ALICE/ASH (Hybrid Model) and TALYS- 1.0 codes and compared to existing data is presented in Figure 1 [3, 4].

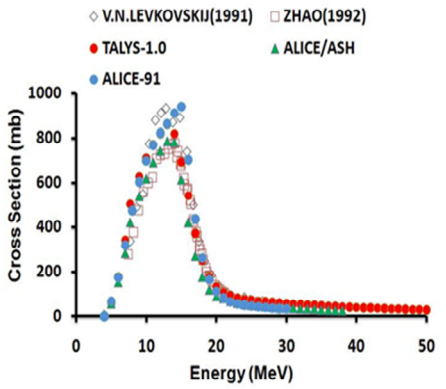

Fig. 1 Excitation function of ^{89}Y (p,n)^{89}Zr Reaction.

The evaluation of the acquired data showed that the best range of the energy is 15 to 5 MeV.

Target preparation

To obtain the optimum physical dimensions of the target some estimation from the SRIM 2006 code were performed. Enhance of the projectile energy, the beam current and the time of bombardment increase the production yield. The calculated required target thickness is 743.39 µm for 90° geometry .The ^{89}Zr production yields were 58.36 and 86.47 MBq/µAh for cross section data of ALICE ASH and TALYS-1.0 codes, respectively. To minimize the thickness of the yttrium oxide layer and to increase heat transfer, 6° geometry is preferred, in which case a 74.33 µm Y_2O_3 layer is recommended. An Y_2O_3 thick layer was deposited on the copper substrate (11.69 cm^2 surface area) by means of sedimentation method. The details of sedimentation method have been discussed in our previous work [5]. The scanning electron microscope (SEM) of yttrium oxide which is deposited on the Cu backing is given in Figure 2.

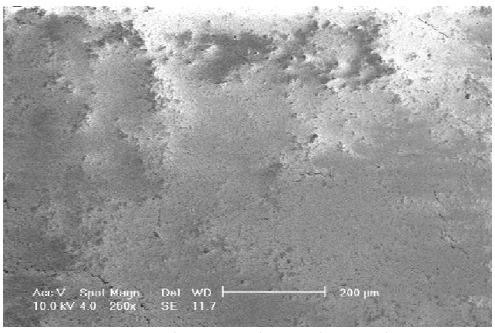

Fig. 2 SEM of Y_2O_3 deposit on the Cu

Quantity of EC is an important factor for adhering and coating among physical properties of the samples, so the quantity of EC should be optimum.

Irradiation

The coated natural Y_2O_3 was introduced into a target holder and bombarded with 15 MeV protons at current of 20 μA for 20 min. The AMIRS (Agricultural, Medical and Industrial Research School) employs a Cyclone-30 (IBA, Belgium). To protect the target material from reaching excessively high temperatures, during the irradiation a jet of cooling water flows across the back of copper substrate in direct contact with it. No direct cooling is used over the front of the deposited target.

Determination of experimental yield

The target material Y_2O_3 was irradiated in the energy range of 15-5 MeV. The single isotope of ^{89}Zr (Eγ=908.964, Iγ=100%) was observed through gamma ray spectrum of the present work and therefore the radionuclide purity was determined via γ-ray spectroscopy. Identification and assay of gamma-ray emitting radionuclides were carried out using γ-ray spectroscopy with a high-purity germanium (HPGe) detector (Canberra™ model GC1020-7500SL). Zirconium-89 was mainly identified by two gamma peaks: 908.96 keV, 511keV. The γ-ray spectrum of a highly purified ^{89}Zr sample as measured at an HPGe detector is presented in Figure 3.

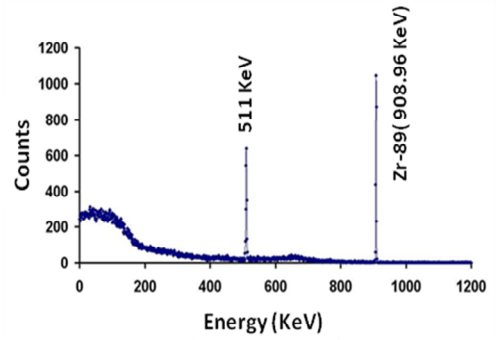

Fig. 3 HPGe spectrum of Irradiated target.

The chemical impurity in the separated radio zirconium was measured against yttrium. The radiochemical separation of radio zirconium was attempted via ion-exchange chromatography technique.

Result and discussion

As the present work shows, the experimental production yield of ^{89}Zr as 69.77 MBq/ μAh, which is higher than Kandil et al. (2007), because they have used pressing method in their target preparation, so, they could not able to produce ^{89}Zr with high beam current as compare to present work. Uddin et al. (2005), has reported the ^{89}Zr production yield as 85 MBq/ μAh by using the stacked foil yttrium target which is much more expensive than present work target. As well as the previous section separation was done using the ion-exchange chromatography. About 95±5% of ^{89}Zr was extracted. The concentration of yttrium in the solution after separation was determined by inductively coupled plasma-atomic emission spectrometry (ICP-AES, JY-124) being 40.9 ppm.

References

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