A Practical High Current 11 MeV Production of High Specific Activity ^{89}Zr

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Introduction

Zr-89 is a useful radionuclide for radiolabeling proteins and other molecules.[1,2] There are many reports of cyclotron production of ^{89}Zr by the ^{89}Y (p,n) reaction. Most irradiations use thin metal backed deposits of Y and irradiation currents up to 100 µA or thicker amounts of Y or Y_2O_3 with ~ 20 µA irradiations.[3,4] We are working to develop high specific activity ^{89}Zr using a low energy 11 MeV cyclotron. We have found that target Y metal contains carrier Zr and higher specific activities are achieved with less Y. The goal of this work was to optimize yield while minimizing the amount of Y that was irradiated.

Material and Methods

All irradiations were done using a Siemens Eclipse 11 MeV proton cyclotron. Y foils were used for the experiments described here. Y_2O_3 was tried and abandoned due to lower yield and poor heat transfer. Yttrium metal foils from Alfa Aesar, ESPI Metals and Sigma Aldrich, 0.1 to 1 mm in thickness, were tested. Each foil was irradiated for 10 to 15 minutes.

The targets to hold the Y foils were made of aluminum and were designed to fit within the "paper burn" unit of the Siemen's Eclipse target station, allowing the Y target body to be easily inserted and removed from the system. Several Al targets of 2 cm diam. and 7.6 cm long were tested with the face of the targets from 11, 26 or 90° relative to the beam to vary watts cm^{-2} on the foil. The front of the foils was cooled by He convection and the foil backs by conduction to the Al target body. The target body was cooled by conduction to the water cooled Al sleeve of the target holder.

Results and Conclusion

The best target was two stacked, 0.25 mm thick, foils to stop beam. 92% of the ^{89}Zr activity was in the front 0.25 mm Y foil. With the greatest slant we could irradiate up to 30 µA of beam on target. However, the 13×30 mm dimensions of the foil was more mass (0.41 g) and lower specific activity than was desired. Redesign of the target gave a target 90° to the beam with 12×12 mm foils (0.15 g/foil) that were undamaged with up to 30 µA irradiation when two foils were used. This design has a reduction in beam at the edges of ~10%. With this design, a single Y foil, 0.25 mm thick sustained over 31 µA of beam and a peak power on target of 270 watts cm^{-2}. The product was radionuclidically pure ^{89}Zr after all ^{89m}Zr and small amounts of ^{13}N produced from oxygen at the surface had decayed (TABLE 1).

	Yield MBq / µA hr	
	Two Y foils	Single Y foil
Average	21.2	21.6
Std Deviation	1.2	2.4
No. of runs	10	5

TABLE 1. Average ^{89}Zr yields at EOB for single and 2 stacked 0.25 Y foils from 10 to 31 µA irradiations using an 11 MeV cyclotron onto aluminum target body 90° to beam.

Our conclusion is that the optimum target is a single 0.25 mm thick Y foil to obtain the greatest specific activity at this proton energy. This produces 167 MBq of ^{89}Zr at EOB with a 15 minute and 31 µA irradiation. We are continuing to redesign the clamp design to reduce losses at the edge of the beam.

References

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