Excitation functions of $^{nat}Zn(p,x)$ nuclear reactions with proton beam energy below 18 MeV

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Introduction

We measured the excitation functions of ^{nat}Zn (p,x) reactions up to 17.6 MeV using the stacked-foils activation technique. High-purity natural zinc (and copper) foils were irradiated with proton beams from an 18MeV medical cyclotron, the predominant purpose of which is to provide a routine regional service for clinical PET radiopharmaceuticals. Thick-target integral yields were also deduced from the measured excitation functions of the produced radioisotopes. These results were compared with the literature and were found to be in good agreement with most but not all published reports.

Material and Methods

The excitation functions of the $^{nat}Zn(p,x)$ reactions were measured by the well-known stacked foil technique (1). High purity zinc foils (99.99%; Goodfellow Metals Ltd., UK) each thickness 0.025 ± 0.003 mm with isotopic composition ^{64}Zn (48.6 %), ^{66}Zn (27.9 %), ^{67}Zn (4.1 %), ^{68}Zn (18.8 %) and ^{70}Zn (0.6 %) were loaded into a solid targetry system on a 300-mm external beam line utilising helium-gas and chilled water to cool the target body (2). A typical foils stack consisted of repeated units of four Zn foils interleaved with a high purity copper foil (0.025 ± 0.004 mm); the latter for monitoring beam flux using the well documented $^{63,65}Cu(p,n)^{63,65}Zn$ reactions. Foil stacks were irradiated with a primary beam of energy 17.6 MeV, accounting for beam degradation by an obligatory 0.0250 ± 0.0005 mm-thick Havar® foil beam-line vacuum window. Irradiation was for 3 min at a beam current of 5 µA. Activated foils were measured using cryo high-purity Ge γ-spectroscopy to quantify the product radionuclides ^{61}Cu, ^{66}Ga, ^{67}Ga and ^{65}Zn. Radioactivity of each isotope was corrected to end of bombardment (EOB).

Results and Conclusion

New cross-sectional data for $^{nat}Zn(p,x)$ reactions up to 17.6 MeV yielding ^{61}Cu, ^{66}Ga, ^{67}Ga and ^{65}Zn isotopes were measured in independent replicated (N = 3) experiments. Results were generally in good agreement with published data.

These isotopes can potentially be used in clinical or preclinical studies, following appropriate chemical separations of the zinc, gallium and copper (3). The FIG. 1 shows thick-target integral yields calculated from excitation functions measured in this study.

It can be calculated (for example) that useful activities of ^{61}Cu can be produced using a 100 µm thick ^{nat}Zn target in a beam provided by a standard medium-energy medical cyclotron. For example, an irradiation at 40 µA for 2 hr at 17.6 MeV would produce approximately 1.7 GBq of ^{61}Cu at EOB. Such currents are readily achievable using solid targetry in our laboratory (2).

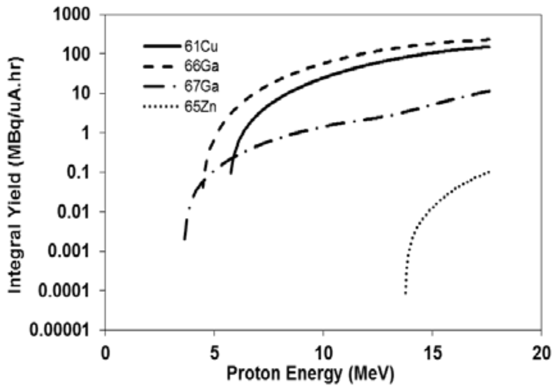

FIGURE 1. Thick target integral yields for the isotopes produced from $^{nat}Zn(p,x)$ reactions, calculated from the measured excitation functions of this study.

References

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