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Is $^{70}\text{Zn}(d,x)^{67}\text{Cu}$ the best way to produce ^{67}Cu for medical applications?

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The theranostic approach combines diagnostic and therapy towards personalised treatment for patients. Among the different possibilities, associating two radionuclides of the same element is appealing, one for imaging purpose and the other for therapy. Copper offers such a pair of radionuclides with ^{64}Cu ($T_{1/2}=12.7$ h) allowing PET imaging and ^{67}Cu ($T_{1/2}=61.8$ h) for targeted beta therapy. If for ^{64}Cu the production route is well defined (a biomedical cyclotron delivering protons on a ^{64}Ni target), this is not the case for ^{67}Cu . Many production routes have been explored using neutrons, charged particles or photons. For charged particles, the main challenge relies on the limitation of ^{64}Cu co-production, even if its real impact on the patient and staff radioprotection needs to be studied and clarified. This work aims at identifying and studying an optimized production route for ^{67}Cu while limiting the impact of ^{64}Cu .

Within this frame, a preliminary research identified the production route $^{70}\text{Zn}(d,x)$. We have measured its production cross sections for ^{67}Cu up to 30 MeV. Measurements were done using the well-known stacked foils technique on 97.5 % enriched ^{70}Zn homemade electroplated targets. Beam intensity has been obtained using an instrumented Faraday cup. Cross sections were also measured for the monitor reactions $^{nat}\text{Ti}(d,x)^{48}\text{V}$ and $^{nat}\text{Ni}(d,x)^{61}\text{Cu}$. They complement at higher incident energies the only set of data available in nuclear databases. The maximum of the cross section is reached for an incident energy of 23 MeV. Its value, 30 mb, is twice higher than the one obtained with a proton irradiation. With deuterons below 26 MeV, ^{64}Cu production is limited and directly connected to the enrichment of the target. Using this data, the production yield was calculated and production optimization parameters were proposed (energy incident of the deuteron, thickness crossed by the particles, irradiation time, waiting time).

This production route is of great interest as it limits strongly the production of ^{64}Cu that is directly linked to the level of ^{68}Zn impurity in the target. Using a 26 MeV deuteron beam and an enriched ^{70}Zn target, it is then possible to produce high purity ^{67}Cu . Activity of 16.4 GBq can be obtained for 26 MeV and 80 μA beam crossing 576 μm of ^{70}Zn thickness during 40 hours. By waiting 70 minutes after irradiation for decays, the activity of ^{67}Cu reaches 99.99 % of the total copper activity and, at this time, the specific activity is 1.87 GBq/nmol or 27.9 TBq/mg. This specific activity value is very close to the theoretical maximum (28 TBq/mg). This production route can be of interest for future linear accelerators under development where mA deuteron beams can be available if adequate targetry is developed.

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The $N = 126$ Factory: A new multi-nucleon transfer reaction facility at Argonne National Laboratory

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