Production of ^{67}Cu using the ^{70}Zn(d,an)^{67}Cu reaction

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Since 2007, we have distributed purified radioisotopes such as ^{65}Zn and ^{109}Cd prepared at the RIKEN AVF cyclotron for the purpose of contribution to society throughout industrial application of accelerator based- science.[1] Copper-67 (half-life $T_{1/2}$ = 61.83 h and β^--decay branch I_β- = 100%) is one of the promising radioisotopes for radiotherapy and radiodiagnosis.[2] Although several routes have been proposed for the production of ^{67}Cu, the high-energy proton-induced reaction of ^{68}Zn(p,$2p$)^{67}Cu has been used most often.[3] In this route, however, a large-scale cyclotron is required to accelerate protons up to ~ 100 MeV, and a large contamination of the radionuclidic impurity of ^{64}Cu is unavoidable in the ^{67}Cu product.[3] Further, the long-lived byproduct of ^{65}Zn ($T_{1/2}$ = 244.06 d) is also undesired in the recycle process of the enriched target material of ^{68}Zn. Thus, we plan to produce ^{67}Cu in the ^{70}Zn(d,αn)^{67}Cu reaction, where small amounts of ^{64}Cu and ^{65}Zn are produced.[4] In this work, for the future distribution of ^{67}Cu, we investigated a procedure to prepare purified ^{67}Cu in the ^{70}Zn(d,αn)^{67}Cu reaction at the AVF cyclotron.

In the ^{70}Zn(d,αn)^{67}Cu route, ^{67}Ga can be produced from Zn isotopes such as ^{66}Zn and ^{67}Zn, which are contained in small amounts in the enriched ^{70}Zn target. The γ-ray energies of ^{67}Ga are identical to those of ^{67}Cu, because ^{67}Ga and ^{67}Cu decay to the same excited levels of ^{67}Zn by EC- and β^--decay, respectively. In addition, the half-life of ^{67}Ga ($T_{1/2}$ = 3.26 d) is almost the same as that of ^{67}Cu. Thus, it is difficult to distinguish between ^{67}Cu and ^{67}Ga by γ-ray spectrometry. Also the expensive enriched isotope of ^{70}Zn should be recovered for reuse. To develop a chemical procedure to remove ^{67}Ga from ^{67}Cu and to recover the rare ^{70}Zn material, we first produced radiotracers of ^{61}Cu, ^{66}Ga, and ^{69m}Zn in the ^{nat}Zn(d,X) reactions by irradiating 24-MeV deuterons on a metallic ^{nat}Zn foil (nat: natural isotopic abundance; chemical purity: >99.99%; thickness: 71.4 mg cm^{-2}). The average beam intensity was 150 nA, and the irradiation time was 26 min. An enriched ^{70}ZnO target (^{70}Zn isotopic abundance: 96.87%; thickness: 327 mg cm^{-2}) was also irradiated with the 24-MeV deuterons in order to evaluate the production yield of ^{67}Cu from ^{70}Zn and the quality of the purified ^{67}Cu product. The average beam intensity was 18 nA, and the irradiation time was 56 min. After the irradiation, as shown in Fig. 1, Cu isotopes were separated from the ^{nat}Zn and ^{70}ZnO targets through a two-step chromatographic separation using the Eichrom Cu resin and the Dowex 1X8 anion-exchange resin.[5] We carried out the chemical procedure using the radiotracers of ^{61}Cu, ^{66}Ga, and ^{69m}Zn produced in the ^{nat}Zn(d,X) reaction. A high chemical yield of 97% was obtained for ^{61}Cu. Decontamination factors of ^{66}Ga and ^{69m}Zn from ^{61}Cu were evaluated to be~10^3 and >10^3,respectively. The recovery of >99% for ^{69m}Zn, was high enough for recycling of the ^{70}Zn target material. Figure 2 shows the γ-ray spectrum of the purified ^{67}Cu from the enriched ^{70}Zn target. Under the present experimental condition, the production yield of ^{67}Cu was 4.0 MBq μA^{-1}h^{-1}. The radioactivity ratio of A(^{67}Cu)/A(^{67}Ga) was about 2×10^4 after the chemical separation. Based on the present results, we estimate that about 1 GBq of ^{67}Cu could be distributed after 3-days irradiation of a metallic ^{70}Zn target of 357-mg cm^{-2} thickness with a 24-MeV and 10-μA deuteron beam, followed by 3 days for chemical separation and shipment.

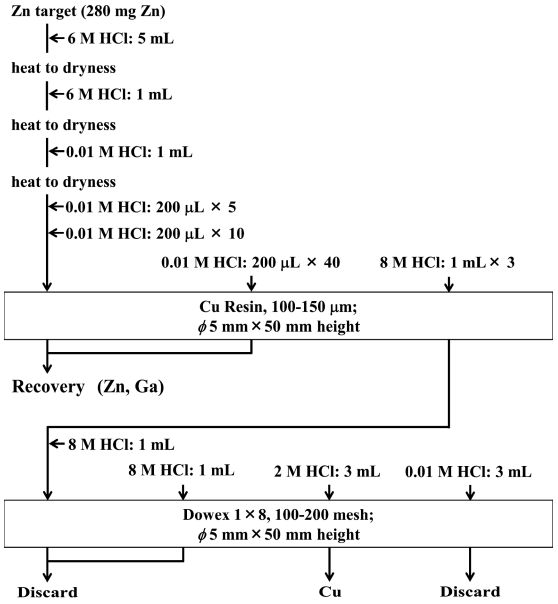

Fig. 1. Chemical separation procedure for ^{67}Cu produced in the ^{70}Zn(d,αn)^{67}Cu reaction.

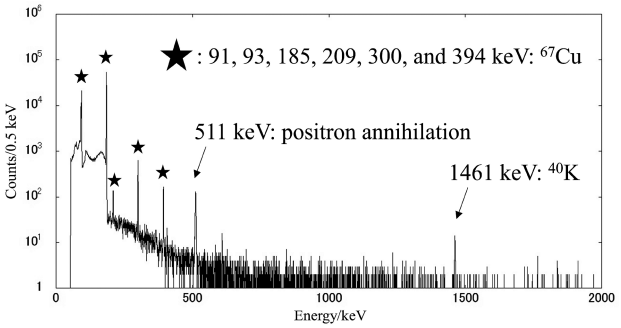

Fig. 2. γ-ray spectrum of the purified ^{67}Cu from the enriched ^{70}Zn target irradiated with the 24-MeV deuteron.

References

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