Specification of ^{67}Cu produced in the ^{70}Zn($d,\alpha n$)^{67}Cu reaction

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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.[1)] In our preliminary study,[2)] about 70 kBq of ^{67}Cu was produced in the ^{70}Zn($d,\alpha n$)^{67}Cu reaction at the AVF cyclotron. The production yield of ^{67}Cu was 4.0 MBq/μA h at 24-MeV deuteron beam energy. We also investigated a chemical purification procedure for ^{67}Cu. The chemical yield of ^{67}Cu was 97%, and the decontamination factors for Ga and Zn were evaluated to be ~10^3 and >10^3, respectively. In this work, we developed a new irradiation chamber to produce a larger amount of ^{67}Cu (> 100 MBq) with a more intense deuteron beam. About 100 MBq of the purified ^{67}Cu was obtained and its radionuclidic purity, specific radioactivity, and chemical purity were evaluated.

A schematic of the ^{67}Cu production chamber is shown in Fig. 1. The 24-MeV deuteron beam with an intensity of 4 μA was extracted from the AVF cyclotron. The ^{70}Zn-enriched oxide (^{70}ZnO) powder was prepared as a disk with 10-mm diameter and 340-mg cm^{-2} thickness at a pressure of 2×10^3 kg cm^{-2} for 3 min. The isotopic composition of the ^{70}Zn target was 96.87% ^{70}Zn, 1.55% ^{68}Zn, 0.09% ^{67}Zn, 0.55% ^{66}Zn, and 0.94% ^{64}Zn. As shown in Fig. 1, the ^{70}ZnO disk placed on a Ta beam stopper was covered by a high-purity Al foil 10 μm in thickness. During the irradiation, the ^{70}ZnO target was cooled with circulating helium gas (30 L min^{-1}) and water (1.5 L min^{-1}). The beam axis was continuously rotated in 3-mm diameter at 2 Hz to avoid local heating of the target using electromagnets on the beam line of the AVF cyclotron. After the 10-h irradiation, ^{67}Cu was separated from the target material and by-products such as ^{67}Ga, ^{69m}Zn, and ^{71}Zn through the chemical procedure reported in Ref.[2)] The purified ^{67}Cu was obtained as 300 μL of 0.1 M CH_3COOH for synthesis of the ^{67}Cu-labeled antibody.[3)] The radioactivity and radionuclidic purity was determined by γ-ray spectrometry using a Ge detector. The specific radioactivity and chemical purity were also evaluated by chemical analysis using an inductively coupled plasma mass spectrometer (Agilent Technologies 7700x).

A γ-ray spectrum of the purified ^{67}Cu is shown in Fig. 2. 135 MBq of ^{67}Cu was produced at the end of bombardment (EOB). The major radionuclidic impurity in the purified ^{67}Cu was ^{64}Cu ($T_{1/2}$ = 12.70 h). The radioactivity ratio $A(^{64}\mathrm{Cu})/A(^{67}\mathrm{Cu})$ was 1.2×10^{-2} at EOB, which decreased to 8.9×10^{-4} at 60 h after EOB (a typical time for its application studies). The present $A(^{64}\mathrm{Cu})/A(^{67}\mathrm{Cu})$ ratio is smaller than the typical value of 6.7 in the ^{68}Zn(p,2p)^{67}Cu reaction.[4)] The radionuclidic purity of the ^{67}Cu solution was then evaluated to be >99.9% 60 h after EOB. In the ICP-MS analysis, only Cu (2.1 ppm) and Br (1.0 ppm) were detected with concentrations >1 ppm among the elements having atomic number $Z \geq 20$. The specific radioactivity of ^{67}Cu was then determined to be 220 MBq μg^{-1} at EOB. Hundreds of MBq of the purified ^{67}Cu are ready for application studies. The results of synthesis of the ^{67}Cu-labeled antibody will be reported elsewhere.[3)]

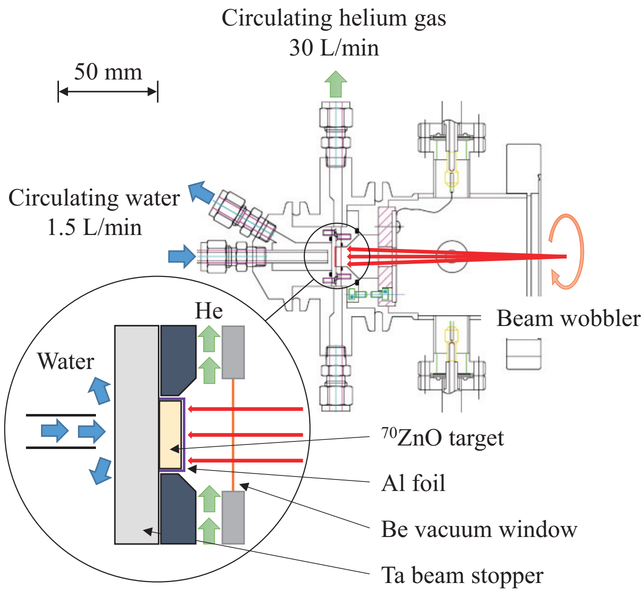

Fig. 1. Schematic of the new ^{67}Cu production chamber.

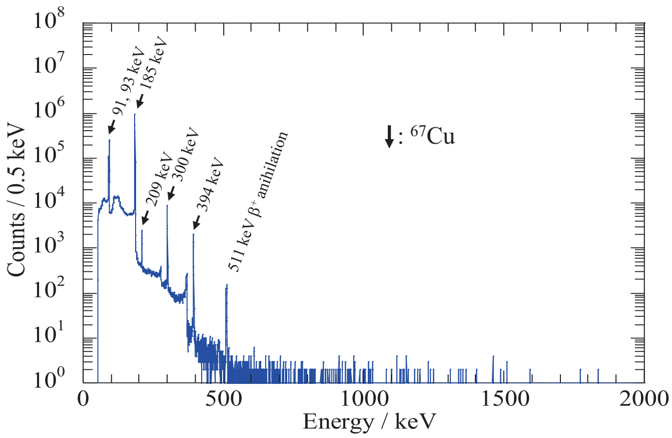

Fig. 2. Typical γ-ray spectrum of the purified ^{67}Cu.

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References
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