^{67}Cu Radioisotope Production with using ^{70}Zn(p,α)^{67}Cu Nuclear Reaction on Cyclone-30 High Current Cyclotron

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1. Introduction

Copper radionuclides, ^{62}Cu, ^{64}Cu, ^{67}Cu are considered to have potential for application in nuclear medicine[1]. Among them, ^{67}Cu is an important therapeutic isotope due to emitting strong beta particles and suitable particle range in tissue with a mean energy of 141keV for treatment and long half-life of 61.9hr for labeling with ligands and biomolecules, γ-rays of 91.3keV(7.0%), 93.3keV(16.1%), and 184.6keV (48.7%) for distribution measurement of ^{67}Cu in the tissue with SPECT scanner[2], [3].

Several nuclear reactions with charged particle irradiation in the accelerator, i.e., ^{68}Zn(p,2p)^{67}Cu, ^{67}Zn(d,2p)^{67}Cu, ^{64}Ni(α,p)^{67}Cu and ^{70}Zn(p,α)^{67}Cu have been investigated for ^{67}Cu production. Based on consideration of the production yield and radioisotopes impurities level in ^{67}Cu solution, the characteristics of cyclotron beam in our institute, the latter nuclear reaction is best for ^{67}Cu production even though the target material, the enriched ^{70}Zn is very expensive.

2. Methods and Results

2.1 Materials

All reagents used for production were of analytical grade. Enriched ^{70}Zn (isotopic purity 99.5%) was purchased from Isoflex, Russia. The reagents for Au plating for protect Cu plating from dissolving Zn target, $KAu(CN)_2$ was purchased from Merck and KH_2PO_4, EDTA was bought from Aldrich. Boric acid and NaCl for ^{70}Zn electrolyte were obtained from Merck. All ion exchange resin, anion (AG1-x8) and cation (AG50w-x8) were supplied from Bio-Rad. Dithizone and CCl_4 for solvent extraction were bought from Merck and Aldrich.

2.2 Preparation of Electrolyte for Au Plating and Enriched ^{64}Ni Material on Cu Cooling Plate

The electrolyte for Au plating on Cu cooling plate was made of 300mg of $KAu(CN)_2$, 2g of KH_2PO_4 and 3g of EDTA in 500ml water. The electrolyte for ^{70}Zn plating on the Au-coated Cu cooling plate was prepared with 1.2g of ^{70}Zn, 0.5g of boric acid and 1g of NaCl in 80ml water.

2.3 Electroplating of Au and enriched ^{70}Zn on Cu Cooling Plate

Cu cooling plates were cleaned with abrasive wool, rinsed with water, acetone and air-dried. Two Cu plates were mounted in the plating vessel home-made. Under vigorous stirring (900rpm / 10:10 seconds) with PE rod and applying the constant current (60mA) with dc power supply on Cu plates (cathode) in the plating vessel for 12hrs, Au was coated on the plates with 9.5mg/cm^2 of thickness. Careful observation of the Au surface has been done to confirm no crack on the surface. Au coated Cu cooling plate was mounted on the Zn electroplating device, the ^{70}Zn electrolyte was poured on it and the constant current (200mA) was applied on Cu cooling plate for 6hrs. The cathode current efficiency of the Ni plating was about 50%.

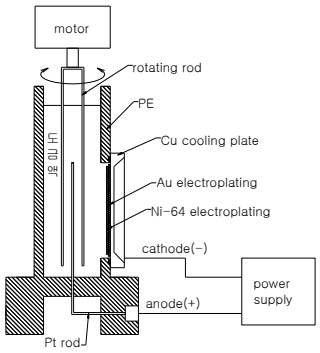

Fig.1. Schematic drawing of ^{70}Zn electroplating device.

2.4 Proton Irradiation on the ^{70}Zn Target

The proton beam irradiation on the Zn target was done with Cyclone-30 accelerator. The beam energy was controlled to 23MeV and the beam current was increased up to 200μA step by step.

2.5 Irradiated ^{70}Zn target dissolving and Chemical Separation of ^{67}Cu from ^{70}Zn with solvent extraction and ion exchange resin

After the irradiation, Zn target was dissolved with 30ml of 5N HCl on the dissolving device (Fig.2.) without heating. 450ml of water was added to ^{64}Ni solution to dilute the normality of its hydrochloric acid to 0.5M.

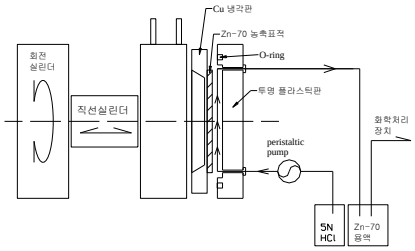

Fig. 2. Schematic drawing of the target dissolving device.

The chemical separation of ^{70}Cu from ^{70}Zn target was performed with 250ml of 0.01% dithizone in CCl_4[4]. In order to remove remained impurity RI completely in the organic phase, the organic phase was washed with 0.5N HCl and finally ^{70}Zn was recovered with the back extraction with 20ml of 7N HCl. For further purification of the final ^{67}Cu solution, the anion exchange resin (AG1- x8) was applied. The gamma-ray of RI in the dissolved ^{70}Zn solution and the final ^{67}Cu solution were measured with HPGe detector coupled with MCA. ^{67}Cu, ^{67}Ga, ^{62}Zn, ^{69m}Zn, ^{195m}Hg and ^{195}Hg were found on the dissolved solution (Fig. 3) and only ^{67}Cu was on the final ^{67}Cu solution (Fig. 4).

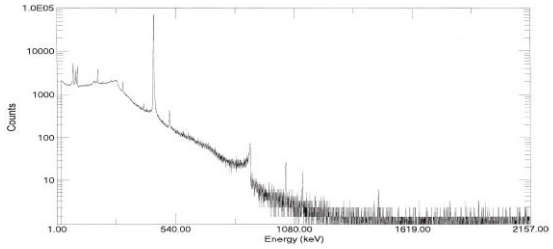

Fig. 3. Gamma-ray spectrum of the dissolved ^{70}Zn solution.

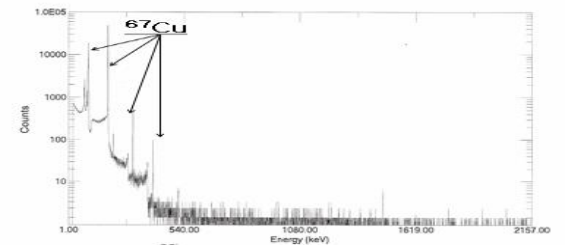

Fig. 4. The gamma-ray spectrum of the ^{67}Cu solution.

2.5 Chemical process of ^{70}Zn recovery for recycling.

^{70}Zn in the aqueous phase after solvent extraction and in the electrolyte after electroplating was recovered with anion (AG1-x8) and cation (AG50w-x8) resin quantitatively.

3. Conclusions

^{67}Cu was produced with ^{70}Zn(p,α)^{67}Cu nuclear reaction in high current cyclotron cyclone-30. For high beam current irradiation on ^{70}Zn target, the electroplating method was successful and physical status of the ^{70}Zn was good, but unfortunately melting on the surface was found during 200μA proton irradiation on the target. The efficient chemical separation method for ^{67}Cu separation from irradiated ^{70}Zn target using solvent extraction (0.01% dithizone in CCl_4-HCl) followed by ion exchange method and the recycling process for the enriched ^{70}Zn material were developed

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