Production and purification of ^{88}Zr and ^{121m}Te

T. Kubota,[*1,*2] S. Yanou,[*2] S. Shibata,[*2] H. Haba,[*2] and S. Takahashi[*1]

Zirconium and tellurium are produced as a result of nuclear fission. Experimental investigations of their migration in the environment are rarer than those of cesium, strontium, and plutonium and require, if possible, carrier-free radionuclides, which mean they are undiluted with naturally occurring isotopes. Such radionuclides can be produced by bombardment with protons, deuterons, or alpha particles. In this report, we present investigations of purification methods for zirconium and tellurium from yttrium and antimony, respectively, as target material.

Radionuclides, ^{88}Zr and ^{121m}Te, were produced at the RIKEN AVF cyclotron and transferred to the Kyoto University Research Reactor Institute and then separated from target materials, yttrium and antimony. The purification was estimated by using the decontamination factor, DF, which is defined as the ratio of the radioactivity of X in the initial sample to that in the purified sample, where X is the target material, yttrium or antimony. The radioactivity was determined by γ-spectrometry.

Zirconium-88 was produced by the bombardment of yttrium foil (purity: 99%, size: 18 mm x 18 mm x 0.15 mm) with 24-MeV[1)] deuterons at 4.1 particle-μA for 2 h. ^{88}Zr was purified from an yttrium matrix by solvent extraction after the by-product ^{89}Zr decayed out to ^{89}Y. The yttrium foil was dissolved in c.HCl, and a black residue was removed by centrifugation. The supernatant was diluted to 0.1 M HCl, which was used as the initial solution. ^{88}Zr in the initial solution was extracted into 0.5 M 2-thenoyltrifluoroacetone (TTA) in xylene.[2)] The xylene solution was washed with 0.1 M HCl and diluted with xylene to 0.05 M TTA. ^{88}Zr was extracted into c.HCl and the aqueous solution was washed with cyclohexane to remove TTA. The c.HCl solution was vapored and then the solution of ^{88}Zr in 0.1 M HCl was prepared.

Tellurium-121m was produced by a bombardment of an Sb_2O_3 pellet[3)] (diameter 15 mm), which was prepared by pressing Sb_2O_3 powder (purity 99.999%) at 3 t for 5 min, with deuterons. ^{121m}Te was purified from an antimony matrix by anion exchange chromatography.[4)] The Sb_2O_3 pellet was dissolved in c.HCl, following which NaClO was added to regulate the atomic valence to Sb(V) and Te(VI). This oxidized solution was loaded onto anion exchange resin (50-100 mesh Cl^-form). The pentavalent of antimony in c.HCl forms $SbCl_6^-$ and strongly adsorbs onto anion exchange resin, while H_2TeO_4, which has Te(VI), is not adsorbed. However, some fraction of tellurium was adsorbed onto anion exchange resin, which could have been caused by incomplete oxidation. In order to recover tellurium, the anion exchange resin was washed with a mixture of c.HCl and 5% NaClO solution several times.

The radioactivity of ^{88}Zr in the initial solution was 2.4 MBq excluding the radioactivity in the undissolved material, which is the black residue. ^{88}Zr completely remained in the organic solution in the extraction with 0.5 M TTA and washing with 0.1 M HCl, while yttrium completely remained in the aqueous solution. This showed that a high purity of ^{88}Zr solution can be obtained. In the back extraction from 0.05 M TTA, 75% of ^{88}Zr was extracted into c.HCl in one process. This recovery rate is sufficiently high; however, if necessary, the repeat of back extraction would yield a higher value. The DF evaluated from the distribution of ^{88}Y, which is produced in the Y(d, 2np) reaction, was greater than 10^4.

The radioactivity of ^{121m}Te produced was 2.8 MBq. The DF was 10^3 at most, and the recovery of tellurium was 50%. Moreover, the low DF value of approximately 10 was often obtained. This low recovery ratio and selectivity could be ascribed to the redox reaction of antimony and tellurium, and further investigation is required. As another purification method, solvent extraction methods are planned to be applied.

In this investigation, ^{88}Zr and ^{121m}Te without the dilution of naturally occurring isotopes were produced, and these nuclides were purified. ^{88}Zr was purified by solvent extraction with TTA, while ^{121m}Te was incompletely purified by anion exchange chromatography.

References

1) M. S. Uddin et al., Radiochim. Acta. **95**, 187 (2007).
2) H. Onish et al., Talanta. **19,** 473 (1972).
3) S. Takács et al., Nucl. Instr. and Meth. Phys. Res. B. **278** 93 (2012).
4) D. Downs et al., J. Radio. Nucl. Chem. **262,** 241 (2004).

[*1] Kyoto University Research Reactor Institute
[*2] RIKEN Nishina Center