

Source preparation technique of astatine-211 without electroplating for alpha spectroscopy

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^{211}At has attracted much interest because of its potential advantages in targeted alpha therapy. The high-resolution alpha spectrometry is one of the most important techniques in radiochemical analyses and precise radioactivity measurements. The electroplating method is widely used as a conventional technique to prepare α sources. However, some difficulties are encountered in applying this method to ^{211}At owing to its short half-life and high volatility. These difficulties were overcome by employing another practical approach using a silver plate, which is one of the major procedures of preparing solid radio-iodine sources,¹⁾ to prepare ^{211}At α sources. In addition, a coprecipitation technique using AgNO_3 was studied.

In this study, carrier-free ^{211}At produced via the $^{209}\text{Bi}(\alpha, 2n)^{211}\text{At}$ reaction at the RIKEN AVF cyclotron was used.²⁾ Approximately 1 MBq of dried elemental ^{211}At was dissolved in 10 mL of ion-exchanged water. Silver plates with a thickness of 0.1 mm were used to fix ^{211}At . In this study, approximately 10 μL of the ^{211}At solution was directly dropped onto silver plates. As another approach, an ^{211}At source was also prepared with ascorbic acid (AA) to avoid ^{211}At loss due to volatilization.³⁾ In this case, a 180 μL of ^{211}At solution was mixed with 20 μL of AA solution with a concentration of 0.01 mg/mL, and the mixed solution was dropped onto silver plates. All sources were dried in the atmosphere at room temperature. To investigate the time dependence of the deposition yield of ^{211}At , ^{211}At deposited on the plate was washed off with ion-exchanged water in 15, 30, 45, 60, or 75 min for the sources prepared without AA.

A 0.1 mg/g AgNO_3 solution was used to prepare the source using the coprecipitation technique. Here, 30 μL of the ^{211}At solution was directly dropped on the plastic plate and 10 μL of the AgNO_3 solution was added. These sources were dried in a desiccator with silica gel. All the sources prepared were measured using a $\text{ZnS}(\text{Ag})$ scintillation detector with 2π geometry and/or an ion-implanted Si detector (MIRRIION PD 300-16-100 AM) with the defined source-detector geometry in a vacuum.

Figure 1 shows the time dependence of the deposition yield of ^{211}At on the silver plates. The deposition yield was determined as a ratio of the ^{211}At α count rate measured for each silver plate to that estimated from the radioactivity concentration of the ^{211}At solu-



Fig. 1. Time dependence of the deposition yield.

tion and a weight of its drop on each plate. As shown in this figure, the deposition yield was saturated at approximately 75% in 30 min. For the sample dried with AA, the deposition yield reached 98% in this study. However, the deposition yield of the sample coprecipitated with silver nitrate was 70%. The method with silver nitrate is one of reliable methods for the standardization of the radio-iodine activity. These results suggest that the methods applicable to the radio-iodine cannot always be applied to the same halogen elemental astatine source without volatilization.

Alpha spectra were measured using the Si detector for the sources prepared above. Two alpha-peaks of ^{211}At ($E_\alpha = 5.87$ MeV) and ^{211}Po ($E_\alpha = 7.45$ MeV) were observed in each spectrum. As shown in Fig. 2,

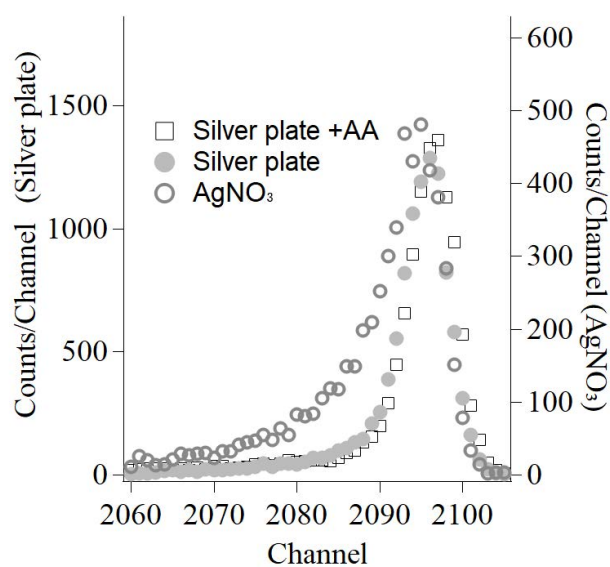


Fig. 2. Measured α -spectra of ^{211}At ($E_\alpha = 5.87$ MeV).

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the FWHMs of the 5.87 MeV peak in the measured spectra for the source prepared on a silver plate with and without AA were approximately 20 keV or less. For the source prepared using the coprecipitation technique, significant broadenings were observed, resulting in a FWHM of 23.9 keV at 5.87 MeV.

Among three types of sources, the sources prepared on a silver plate with and without AA exhibited better FWHM, and the source prepared on a silver plate with AA had the best deposition yield, while an additional study using more samples is required. Therefore, the method to prepare the source on a silver plate with AA can have potential advantage to be employed as a source preparation technique for radioactivity measurement using the solid angle α counting technique with a small correction for loss of radioactivity during the drying process owing to its volatility.

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References

- 1) I. Cieszykowska *et al.*, *Nukleonika* **50**, 17 (2005).
- 2) Y. Wang *et al.*, *RIKEN Accel. Prog. Rep.* **53**, 192 (2019).
- 3) A. Toyoshima *et al.*, *Radiat. Safe. Manage.* **18**, 13 (2019).