

Source preparation technique for ^{211}At for alpha spectroscopy

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^{211}At has attracted a considerable amount of interest because of its potential advantages in targeted alpha therapy. High-resolution alpha spectroscopy is one of the most important techniques in radiochemical analyses and precise radioactivity measurements. Electroplating is widely used as a conventional technique to prepare α sources. However, there are several difficulties in applying this method to the measurement of ^{211}At such as its short half-life and high volatility. To overcome such difficulties, we studied another practical approach using a Ag plate without electroplating.

In this study, carrier-free ^{211}At was produced by the $^{209}\text{Bi}(\alpha, 2n)^{211}\text{At}$ reaction using the RIKEN AVF cyclotron.¹⁾ Three different chemical forms of 100 kBq/mL of ^{211}At solutions were prepared as listed in Table 1. To reduce the radioactivity loss due to the volatility of At, ascorbic acid (AA) was added to solution (II) considering the result of a previous study on At retention using AA by Toyoshima *et al.*²⁾ At is also expected to have stable alkalinity; thus, NaOH was added to solution (III). Ag plates with a thickness of 0.1 mm were used to fix ^{211}At . Approximately 30 μL of each ^{211}At solution in Table 1 was directly dropped onto a Ag plate. Sources were dried in a desiccator with silica gel. After drying process, sources were measured using a ZnS (Ag) scintillation detector with a 2π geometry to evaluate the deposition yield of ^{211}At on silver. A Si detector was also used to obtain an α spectrum from each source with the defined source-detector geometry in vacuum. In addition, imaging plate (IP) was used to confirm the distribution of radioactivity in an active area on the Ag plate with ^{211}At solution (I).

Table 1. ^{211}At solutions used in the present study.

^{211}At solutions		Chemical form
(I)	^{211}At	^{211}At in H_2O
(II)	$^{211}\text{At}+\text{AA}$	^{211}At in 1 $\mu\text{g}/\text{mL}$ AA aqueous solution
(III)	$^{211}\text{At}+\text{NaOH}$	^{211}At in 50 $\mu\text{g}/\text{mL}$ NaOH aqueous solution

Figure 1 shows the measured α spectra obtained by three different types of sources. Two major peaks of ^{211}At ($E_\alpha = 5.87$ MeV) and ^{211}Po ($E_\alpha = 7.45$ MeV)

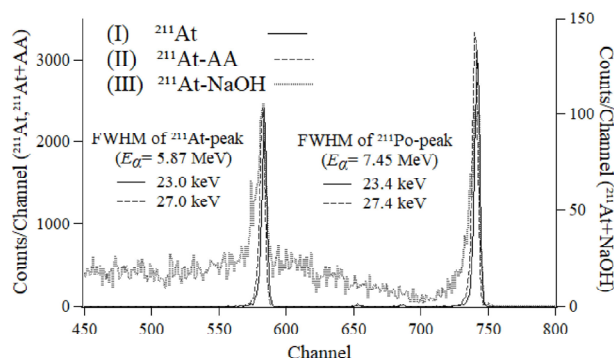


Fig. 1. Measured α spectra obtained by ^{211}At sources.

were observed in each spectrum. As shown in Fig. 1, the ^{211}Po peaks obtained by source (II) shifted to the lower energy side by approximately 20 keV compared to those for source (I). This could be due to self-absorption caused by AA. However, the full width at half maximum (FWHM) of the ^{211}At peak of source (II) increased by only 4 keV compared with that for source (I); thus, it could not cause a large uncertainty in the activity measurement. In contrast, a significant degradation in the spectrum was observed for source (III) compared with the two other sources. The deposition yield of each ^{211}At source was determined as a ratio of the $2\pi\alpha$ count rate to the activity of ^{211}At . The resulting deposition yields were $88.3\% \pm 1.2\%$, $98.4\% \pm 1.3\%$, and $40.3\% \pm 6.8\%$ for sources (I), (II), and (III), respectively, indicating that AA contributes to the retention of ^{211}At during drying. However, the results obtained for source (III) may be affected by self-absorption, resulting in underestimation of the deposition yield.

Figure 2 shows the distribution of ^{211}At on a Ag plate for ^{211}At solution (I) with an IP. Although the

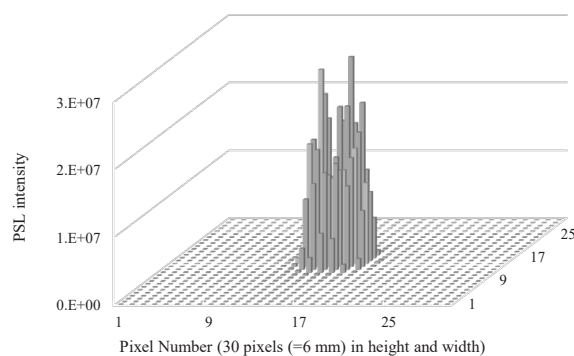


Fig. 2. Distribution of ^{211}At on a Ag plate.

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diameter of the ^{211}At solution drop before drying was around 6 mm, 99% of the radioactivity of the source was concentrated within a diameter of 2 mm. In the measurements with a defined solid angle, an extension of the active area might increase the uncertainty in the evaluation of the geometric efficiency. Therefore, a source with a small active area, such as that prepared in the present study, could have the advantage that the activity could be determined with a smaller uncertainty.

References

- 1) Y. Wang *et al.*, RIKEN Accel. Prog. Rep. **53**, 192 (2019).
- 2) A. Toyoshima *et al.*, Radiat. Saf. Manage. **18**, 13 (2019).