Determination of ^{211}At activity using liquid scintillation counting

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^{211}At has gained attention as a promising radionuclide in Targeted Alpha Therapy (TAT) for cancer treatment, which requires reliable radioactivity measurement. While the $\alpha(\beta)$-γ coincidence technique is one of the most reliable methods for activity measurement, its application to ^{211}At is impossible due to a lack of γ emission following the decay of ^{211}At. Therefore, we evaluated the applicability of the extrapolation method for determining the activity of ^{211}At using the liquid scintillation counting technique.

In the present study, ^{211}At was produced via the ^{209}Bi$(\alpha, 2n)^{211}$At reaction at the RIKEN AVF cyclotron. The dried ^{211}At sample was dissolved in 0.5 mL of ion-exchanged water, and 0.25 mL of this solution was mixed with 0.75 mL of ascorbic acid with 0.01 mg/mL to avoid activity loss due to its volatility. Approximately 30 mg of the prepared solution was then dispensed into 20 mL plastic vials. Each vial was filled with 15 mL of ULTIMA GOLD™ scintillation cocktail (Perkin Elmer) and 1 mL of ion-exchanged water. The sample was placed into the sample chamber, to which a single R331 photomultiplier tube (Hamamatsu Photonics) was vertically attached to the side. The output signals were fed to the MCA (APG7400A, TechnoAP) via the fast amplifier (Model 2024, Canberra). Three samples were prepared and measured sequentially.

Figure 1 shows the measured spectra for the three samples. Two distinct α peaks corresponding to ^{211}At (E_α = 5.98 MeV) and its progeny ^{211}Po (E_α = 7.59 MeV) were observed. Counting efficiency for α particles in liquid scintillation counting is expected to approach 100% provided the sample is not significantly chemically or optically quenched. In contrast, a continuous low energy distribution (<60 channels) was observed, which is attributed to the EC decay mode. The EC decay exhibits a relatively low counting efficiency, making it challenging to determine its counting efficiency accurately.

To overcome this difficulty, the contribution of the EC mode was eliminated by applying pulse height discrimination, so that the activity of ^{211}At was determined solely based on selective above-threshold α-counts.

Figure 2 represents the variation in the integral pulse height distribution obtained from net counts in the channel range of 10 to 250. The net counts at the thresholds ranging from i = 100 to 150 channels were nearly constant, confirming that interference from EC decay was effectively removed. To determine the activity of ^{211}At, compensating for possible losses of α-counts below the threshold i = 100 channels, the integral bias method with an extrapolation technique was applied.[1)]

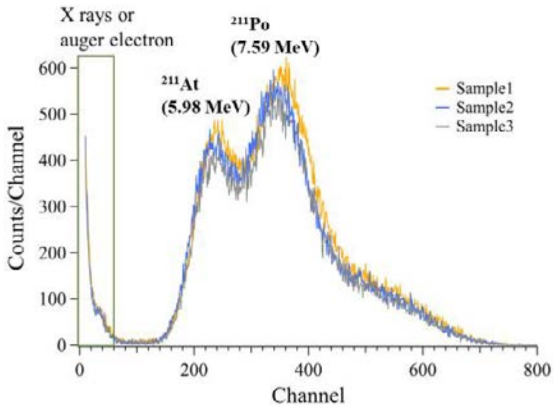

Fig. 1. Measured spectra of ^{211}At for three samples.

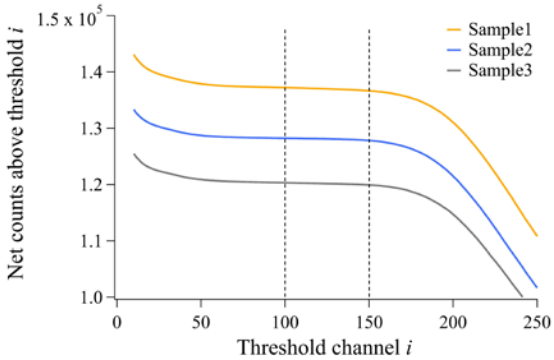

Fig. 2. Variation of net counts as a function of threshold.

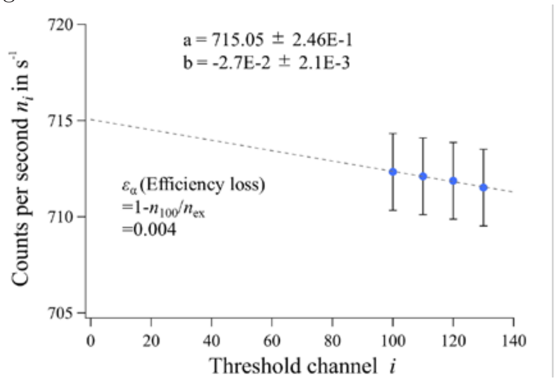

Fig. 3. Linear extrapolation function derived from the measurement of sample 2. The error bars indicate the statistical standard uncertainty.

As shown in Fig. 3, the linear extrapolation function was obtained from the net count rate n_{i} between 100 and 130 channels. Consequently, the value of the disintegration rate n_0, derived as an extrapolated value, was determined to be 715.05 ± 0.25 Bq.

Reference

1) H. Ishikawa *et al.*, Radioisotopes **24**, 748 (1975).

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