Radioactivity calibrations of ^{225}Ac and ^{211}At

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^{225}Ac and ^{211}At are short half-life α-emitters that have attracted attention as radiopharmaceuticals. The minimum requirements for radiopharmaceuticals, the radioactivity of most preparations is specified as 90–110%. To confirm of fulfill the specification, the calibration of measuring instruments, and thus standard sources with small uncertainties to the best extent possible is essential. However, certain issues plague the radioactivity calibration. First, ^{213}Po, which is one of the progenies of ^{225}Ac, interferes with the measurement. The short half-life of 3.70 μs[1)] of ^{213}Po causes counting loss owing to the β-rays emitted from its parent ^{213}Bi when measured using a commercial liquid scintillation counter (LSC) with dead time of a few μs. Thus, a correction for counting efficiency is necessary. Second, ^{211}At is highly volatile; however, there is minimal knowledge on suitable samples for the LSC measurement. In addition, ^{207}Bi, which is one of the progenies of ^{211}At, is not in radiative equilibrium; thus, the contribution of ^{207}Bi and its uncertainty on the calibration must be evaluated. In this study, our radioactivity calibration methods for ^{225}Ac and ^{211}At were examined to solve the above problems through comparisons with the results obtained from the National Institute of Advanced Industrial Science and Technology (AIST).

The commercial LSC, Tricarb 4810TR (Perkinelmer Inc.) and the custom-build LSC with variable dead time, LSC0001 were used in the radioactivity measurements of ^{225}Ac and ^{211}At. To correct for the counting loss of ^{213}Po in an ^{225}Ac solution, the dead time of LSC0001 was set to 100 μs, and a correction factor was calculated from the ratio of the count rate measured by LSC0001 to that measured by 4810TR. The radioactivity was calculated by the CIEMAT-NIST method[2)] for both Japan Radioisotope Association (JRIA) and AIST.

^{211}At was produced in the ^{209}Bi$(\alpha, 2n)^{211}$At reaction at the RIKEN AVF cyclotoron.[3)] ^{211}At was dissolved with 1.2% ascorbic acid in 5/15 M phosphate buffer or 1 M sodium hydroxide aqueous solution;[4,5)] the sodium hydroxide solution was selected to suppress loss of volatile ^{211}At. The contribution of ^{207}Bi to the measurement at 24 h after distillation was estimated to be approximately 0.1%. Therefore, measurements were performed using Tricarb 4810TR within 2 half-lives after dry distillation to minimize the contribution of ^{207}Bi as low as possible. After ^{211}At had decayed sufficiently (above 10 days), the contribution of ^{207}Bi was evaluated through re-measurements. The radioactivity of ^{211}At was also calculated by the CIEMAT-NIST method.[2)]

The radioactivities of ^{225}Ac and ^{211}At were measured to be 318.9 ± 4.6 kBq/g ($k = 2$) and 3.155 ± 0.064 kBq/g ($k = 2$), respectively, and they are shown in Fig. 1. Most of the uncertainty components were uncertainties in the calculations by the CIEMAT-NIST method. In addition, the radioactivities of ^{225}Ac and ^{211}At by AIST were 317.1 ± 4.8 kBq/g ($k = 2$) and 3.143 ± 0.025 kBq/g ($k = 2$), respectively, and both were consistent with our data within the uncertainty range.

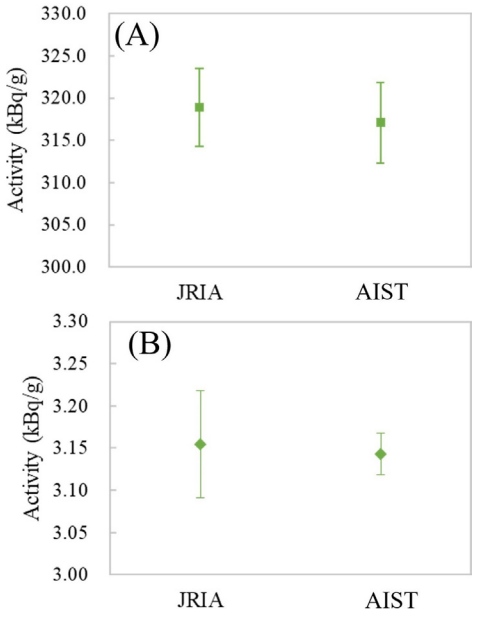

Fig. 1. Intercomparison result of (A) ^{225}Ac and (B) ^{211}At radioactivity.

In summary, the radioactivities of ^{225}Ac and ^{211}At were measured and compared with those by AIST. Consistent results were obtained for both nuclides. JRIA is an accredited calibration laboratory related radiation and radioactivity in Japan Calibration Service System (JCSS). Accredited calibration laboratories, which satisfy the requirements of the measurement act can issue calibration certificate with the "JCSS" logo. Furthermore, we are ready to calibrate ^{225}Ac radioactivity for JCSS calibration. In the future, where ^{211}At is scheduled to applied for JCSS calibration nuclide and is already available for a general calibration.

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