Dispersion rates of astatine-211 from aqueous solutions and chloroform†

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Airborne concentrations of radioactive materials are crucial for the evaluation of human exposure and radiation protection protocols. An important factor influencing airborne radioactivity concentration is the dispersal rate from a radioactive solid or liquid sample, which depends on the chemical forms of the radioactive materials. Therefore, to evaluate the airborne concentration, it is indispensable to experimentally determine the dispersal rates under various conditions. Recently, targeted alpha therapy using a short-lived radioisotope emitting α particles was developed.[1] ^{211}At with a half-life of 7.2 h is a promising α-emitter for the therapy.[2] However, because of the lack of long-lived At isotopes, its dispersion has been rarely studied.[3] For realistic and effective clinical use of ^{211}At, the evaluation of its airborne concentration is necessary. Herein, we investigated the dispersal rates of ^{211}At in aqueous acidic, neutral, and alkaline solutions and in chloroform.

^{211}At was produced in the ^{209}Bi$(\alpha, 2n)^{211}$At reaction using the AVF cyclotron at the Research Center of Nuclear Physics, Osaka University. ^{211}At was also supplied from RIKEN through the Supply Platform of Short-lived Radioisotopes. ^{211}At was then separated from the irradiated Bi target by dry distillation. The experimental setup to measure the dispersal rate of ^{211}At is shown in Fig. 1. Details of the setup can be found in the full article. A plastic cylinder was connected to a filter holder in which a glass-fiber filter paper, charcoal-impregnated filter paper, and two charcoal cartridges were placed. The inside of the cylinder was covered with a thin polyethylene terephthalate sheet to catch dispersed ^{211}At on its surface. An air pump for ventilation was connected to the top of the holder. To a 100 mL beaker, 0.010 mL of the ^{211}At stock solution was added to 20 mL of the aqueous solutions and chloroform. To a 1.5 mL microtube, 0.002 mL of the ^{211}At solution was pipetted into 0.50 mL of the aqueous solutions. The radioactivity of ^{211}At used in a single run was 0.4–2 MBq at the start of the experiment. The interior of the system was ventilated at an air flow rate of 30 L/min. The solution was stirred with a magnetic stirrer during ventilation for 60 min. Subsequently, the characteristic 79 keV X-ray of Po attributed to the electron capture (EC) decay of ^{211}At in/on the sample solution, vessel, filter papers, cartridges, etc. was measured using a Ge detector.

Under all the studied conditions, the recovered yields

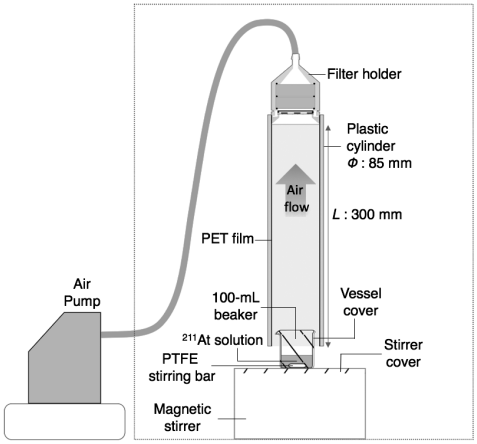

Fig. 1. Experimental setup for the measurement of dispersal rates of ^{211}At.

of ^{211}At were 100% within the error. This indicates that dispersed ^{211}At was completely collected using the setup. For the 100 mL beaker data, the dispersal rate of ^{211}At depended on the solution acidity, where 13% and 16% of ^{211}At dispersed moderately in the acidic and basic solutions, respectively, and 30% dispersed in the neutral buffer. In contrast, for the microtube, the dispersal rates of ^{211}At were much smaller (2–4%) than those from the beaker and were largely unchanged among the studied conditions. These results clearly show that ^{211}At dispersion was suppressed in the microtube because of the much smaller liquid surface area and was not strongly influenced by solution conditions. Upon the addition of ascorbic acid (AA) to the neutral buffer, the dispersal rate of ^{211}At was remarkably suppressed because of the reduction of the originally present At species to the monovalent ionic At^-.[4] In our previous clinical study with Na^{211}At,[5] AA was required to be admixed at 1.2 weight/volume% to ^{211}At-stocked distilled water as a stabilizer in vivo. Thus, for the actual use of Na^{211}At, the dispersal rate of ^{211}At can be extremely low. In chloroform as well, a very low dispersal rate of ^{211}At was observed.

In conclusion, the dispersal rates of ^{211}At were found to vary depending on the solution conditions, with the maximum dispersion observed at pH 7. In the neutral solution containing AA, the dispersion rate of ^{211}At was quite low, suggesting that the dispersion of ^{211}At should be negligible in future clinical studies with Na^{211}At.

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