

Development of $^{211}\text{Rn}/^{211}\text{At}$ generator through liquid phase recovery of radon and ionic liquid extraction of astatine

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The short path length and high linear energy transfer of α particles are expected to facilitate targeted alpha therapy for the treatment of tumor. A promising nuclide among various α emitters is ^{211}At with a half-life of 7.21 h, which has gained popularity owing to its appropriate life and potential to synthesize labeled compounds as a halogen element. This has led to several preclinical studies on At chemistry.¹⁾ To improve the availability of ^{211}At , a $^{211}\text{Rn}/^{211}\text{At}$ generator was developed via the extraction using organic solvent of DIPE or MIBK for expanding nuclide production away from accelerator facilities because ^{211}Rn , which has a half-life of 14.6 h, is the parent nuclide of ^{211}At .²⁾ In this study, we proved the wet chemistry processes through liquid phase recovery of radon and ionic liquid extraction of astatine for the generator.

In recent years, ionic liquids have attracted attention as an alternative to organic solvents from the perspective of green chemistry. Ionic liquids exist in the liquid phase at room temperature, have low volatility, and are flame-retardant; therefore, the environmental load or risk of accidents is minimal. Further, the amount of radioactive waste can be reduced compared to that using organic solvents owing to their repeated usability. In addition, ionic liquids are considered promising solvents for extracting ^{211}At as per the reports on radiation resistance.³⁾

The nuclide of ^{211}At was produced via the $^{209}\text{Bi}(\alpha, 2n)$ reaction at the RIKEN AVF cyclotron or the decay of ^{211}Rn from the $^{209}\text{Bi}(^7\text{Li}, 5n)$ reaction at the JAEA tandem Van de Graaff accelerator. The irradiated Bi target was dissolved in 6 M HNO_3 and finally the ^{211}At nuclide was collected in dodecane solvent although the At species may differ depending on the procedures of preparation. The ^{211}At was further extracted to 3 M HCl solution. Subsequently, ^{211}At was extracted into an ionic liquid (IL) of $[\text{C}_8\text{mim}]^+[\text{Tf}_2\text{N}]^-$, where $[\text{C}_8\text{mim}]^+$ and $[\text{Tf}_2\text{N}]^-$ are alkylimidazolium ion and bis (trifluoromethanesulfonyl) imide ions, respectively. Finally, it was back-extracted into 0.1 M NaOH solutions. The α radioactivity of ^{211}At was measured using a liquid scintillation counter to determine extraction rates of the nuclide for the relevant

extraction procedures.

Figure 1 shows the extraction rates of ^{211}At from dodecane into HCl solution, from HCl solution into IL, and from IL into NaOH solution. Species in dodecane were found to be dependent on the preparation of At as observed upon the comparison of the results. Following the extraction in HCl solution, At species appeared to behave in a similar manner.

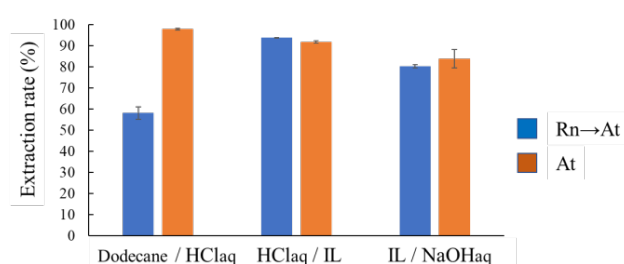


Fig. 1. Extraction rates for At from the decay of Rn (Rn → At) and directly produced At (At).

Figure 2 shows the same extraction rates of ^{211}At from the decay of ^{211}Rn , as in Fig. 1, but for with and without H_2O_2 as a reductant. Reduction of At species enhanced extraction into HCl and worked the other way in back-extraction with NaOH. This suggests that solvent extraction in practical applications necessitates the adjustment of chemical species to have a good recovery of At.

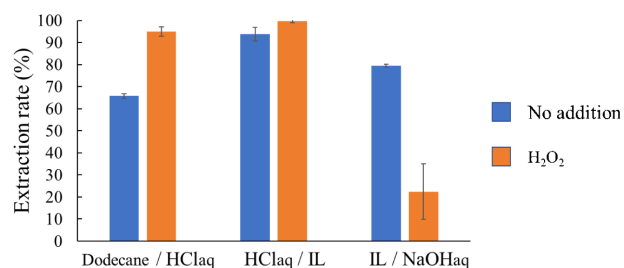


Fig. 2. Extraction rates for At from the decay of Rn with and without H_2O_2 .

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