

## EXTRACTION AND THIN-LAYER CHROMATOGRAPHY BEHAVIOR OF <sup>211</sup>At OBTAINED BY DRY DISTILLATION

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Recently, alpha-particle emitters are studied to apply to the internal treatment of cancerous cells, called as targeted alpha therapy (TAT), because these have high ability to kill tumors. Astatine-211 (<sup>211</sup>At), element 85, attracts a lot of attention as an alpha-emitting radionuclide suitable for TAT. It has some advantages such as a moderate half-life (7.2 h) for TAT and weak gamma-ray emission including its daughter nuclides. In the purification of <sup>211</sup>At after the nuclear synthesis, separation from a solid Bi target is often performed by dry distillation [1]. This distillation procedure is quite simple and allows a variety of sample solutions such as water, saline, or methanol. However, little is known about chemical species of <sup>211</sup>At in aqueous solution after the dry distillation. Thus, the present study aims to obtain information on chemical species of <sup>211</sup>At in distilled water. In our previous study, solvent extraction behavior of <sup>211</sup>At, prepared by the dry distillation method, was preliminarily investigated where organic and aqueous phases were hexane + 0.1 M HDEHP and 1 M HClO<sub>4</sub>, respectively. As a result, the extraction behavior of <sup>211</sup>At seemed to be dependent on the elapsed time after the separation. Thus, in the present study, we studied extraction and thin-layer chromatography (TLC) behavior of <sup>211</sup>At with and without oxidizing and reducing agents with varying the elapsed time after its preparation.

<sup>211</sup>At was produced in the <sup>209</sup>Bi( $\alpha$ , 2n)<sup>211</sup>At reaction at the AVF cyclotron of Research Center of Nuclear Physics, Osaka University. The irradiation time was for 30 min to a few hours. The purification of <sup>211</sup>At was carried out by the dry distillation. In a typical procedure, an irradiated Bi target was put in a quart column, the inside pressure was reduced, and then He and O<sub>2</sub> mixed gas (3 : 1 volume ratio) was flowed at a rate of 20 mL/min. A quartz column was heated up to 840°C with a tubular furnace for 30 min. <sup>211</sup>At was volatilized and was then trapped in a cooled Teflon tube, which was connected to the quart column, soaked in liquid nitrogen. After heating, trapped <sup>211</sup>At was eluted with 1000  $\mu$ L of distilled water. The elapsed time started when the distilled water was flowed into the Teflon tube. <sup>211</sup>At was determined by the measurement of the 79 keV characteristic X-ray of its EC-decay daughter <sup>211</sup>Po using a Ge detector. At the elapsed time between 2 min and 30 h, the extraction experiments were carried out. The organic phase used was hexane and hexane + 0.1 M HDEHP, while the aqueous phase was 1 M HClO<sub>4</sub>, 1 M HClO<sub>4</sub> + 0.01 M KCrO<sub>4</sub>, and 1 M HClO<sub>4</sub> + 0.1 M Na<sub>2</sub>SO<sub>3</sub>. After shaking for 2 min – 2 h, 500  $\mu$ L of both the phases were precisely taken and were then separately subjected to the X-ray measurement with a Ge detector. The distribution ratio  $D$  was calculated as  $D = A_{\text{org}}V_{\text{aq}} / A_{\text{aq}}V_{\text{org}}$  where  $A_{\text{org}}$  and  $A_{\text{aq}}$  are the radioactivities of the organic and aqueous phases, respectively, and  $V_{\text{org}}$  and  $V_{\text{aq}}$  are the volume of the organic and aqueous phases, respectively. The TLC analysis was also performed for the <sup>211</sup>At samples in distilled water which elapsed time was 14 min and 200 min to assess whether chemical species of <sup>211</sup>At with different polarities are formed in the solution. The stationary phase of the TLC used was silica gel. The deposited <sup>211</sup>At sample was developed with methanol for 10 min. Then, the thin layer of the TLC was cut by 0.5 cm, and each layer was subjected to  $\gamma$ -ray spectrometry to examine peak positions of developed <sup>211</sup>At species.

The  $D$  values of <sup>211</sup>At into both hexane and HDEHP increased with increasing shaking time under the conditions without oxidizing and reducing agents. These variations of the  $D$  values entirely became low as the time elapsed after the dissolution, being consistent with the results of our preliminary experiments. These imply that the different chemical species of <sup>211</sup>At exist in distilled water and amounts of these species are relating to the elapsed time from the dissolution. On the other hand, <sup>211</sup>At was not extracted into hexane under the oxidative and reductive conditions where ionic species of AtO<sup>+</sup> and At<sup>-</sup>, respectively, were proposed to be formed [2]. Accordingly, another species of <sup>211</sup>At are considered to be formed in the distilled water solution just after preparation. Because <sup>211</sup>At was extracted into both hexane and HDEHP without using oxidative and reductive agents, neutral species and cationic one with low polarity are suggested to be formed in distilled water. In the TLC experiments, the <sup>211</sup>At sample 14 min after the dissolution showed different 2 peaks with around 0.4 and 0.9 of  $R_f$  values. On the other hand, the <sup>211</sup>At solution with the 200-min elapsed-time revealed only 1 peak at around  $R_f = 0.4$ . This suggests that ionic and neutral species of <sup>211</sup>At are contained in the former solution, while only ionic species of At exists in the latter. This result is consistent with those of the extraction experiments. In the symposium, experimental results of the chemical

characterization of <sup>211</sup>At will be presented in more detail.

#### REFERENCES

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