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Astatine and iodine chemical species in solutions prepared by dry distillation

Objectives: ^{211}At, an astatine radionuclide, with half-life of 7.2 h is one of the prospective candidates for targeted alpha radiotherapy of cancers. Astatine shows some different chemical behaviors in comparison with its homologue iodine. The understanding of basic properties of astatine has been required to develop targeted alpha therapy agents for cancers [1]. In this work, astatine and iodine chemical species in solutions prepared by a method of dry distillation have been determined by control experiments of thin layer chromatography (TLC) [2].

Methods: The astatine radionuclides ^{208,209,210,211}At and iodine ones ^{120,121,123}I were simultaneously produced through the ^{nat}Pb(^{7}Li,xn)^{208,209,210,211}At and ^{nat}Sn(^{7}Li,xn)^{120,121,123}I reactions, respectively, by ^{7}Li beam irradiation of a stack of lead and tin targets at the JAEA tandem accelerator facility [2]. After measuring activities produced in the targets, the astatine and iodine radionuclides were each separated from the targets and purified in a test tube by dry distillation [2]. No-carrier-added astatine or iodine was recovered by rinsing the test tube with 1.8 mL of ethanol or distilled water. In order to study oxidation-reduction degrees of astatine ions, astatine in the aqueous solution was reacted with an oxidizing of KIO_4, a reducing agent Na_2SO_3 or hydrazine hydrate. Separation of the astatine and the iodine ions in the solutions was conducted by TLC on a silica gel plate with an ethanol/water solution (v/v, 1:1). The astatine and iodine radioactivity separated on the silica gel plates was measured by using imaging plates. The distribution of radioactivity on the plates was visualized by Bioimaging Analyzer System to determine Rf values and amounts of the ions separated by TLC. In addition, the Rf values of the non-radioactive standard iodine ions, iodide I^-, iodate IO_3^-, and periodate IO_4^-, were determined under the same condition of the TLC for radioactive astatine and iodine.

Results and Conclusion: The R_f values of the non-radioactive standard iodine anions were determined to be R_f = 0.87 for I^-, 0.78 for IO_3^- and 0.00 for IO_4^-. TLC for radioactive iodine shows one spot with R_f = 0.84-0.86 while that for astatine shows three (or two) spots with R_f = 0.74-0.82, 0.66-0.69 and 0.00. Iodine was identified as a single chemical form of I^- in the solutions prepared by dry distillation, while astatine was three anions of At^-, AtO_3^- and AtO_4^-, compared with the standard iodine anions. The relative amounts of the astatine anions were dependent on the presence of oxidizing and reducing agents. This reveals that astatine species are certainly identified as At^-, AtO_3^- and AtO_4^-.

References

1. D. S. Wilber, Nat. Chem., 5, 246 (2013).
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