Extraction behaviors of Nb and Ta with triisooctyl amine from hydrochloric acid solution

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Of the studies of the 105th element, Db, only three reports have been published on the chloride complexes of Db in the aqueous phase.[1–3] In two of the reported experiments, chloride complex formation and its extraction behavior with triisooctyl amine (TiOA) were investigated.[1,2] The observed sequence of the extraction was Ta > Nb > Db > Pa. However the influence of fluoride ions on the extraction sequence was suggested because a mixed HCl/HF solution was used in the extraction.[4] Only one experiment using a pure HCl solution has been reported so far, where a reversed-phase column chromatographic experiment using 6 M HCl and Aliquat 336 on an inert support was performed.[3] The sequence of extraction was Pa > Nb ≧ Db > Ta. This is a reversal of the earlier observed sequence. To clarify the complex formation mechanism of Db with chloride ions, it is important to study the behavior of Db in pure HCl solutions.

We have already started investigating the extraction behaviors of Nb and Ta as lighter homologues of Db from pure HCl solutions with TiOA on a tracer scale. As a result of the liquid-liquid extraction using radiotracers ^{95g}Nb ($T_{1/2}$ = 34.991 d) and ^{179}Ta ($T_{1/2}$ = 1.82 y) preserved in concentrated HCl after purification by ion exchange separation with HF solution, the behavior of Ta, influenced by the remaining fluoride ions, was observed.[5] In this paper, we report on the extraction behaviors of Nb and Ta using radiotracers transported by a He/KCl gas-jet method, which makes it possible to observe the extraction behaviors of these two elements without the effects of HF.

Radiotracers of ^{90g}Nb ($T_{1/2}$ = 14.60 h) and ^{178}Ta ($T_{1/2}$ = 2.36 h) were produced in the ^{nat}Zr(d,xn) and ^{nat}Hf(d,xn) reactions, respectively, using a 24-MeV deuteron beam supplied by the RIKEN AVF cyclotron. Nuclear reaction products recoiling out of the targets were transported by a He/KCl gas-jet method at a He gas flow rate of 2.5 L/min. The transported products were collected on a Naflon® sheet for 1.5 min. The collected products were then dissolved in 1 mL of 2–10 M HCl. From this solution, 300 μL aliquots were pipetted to a polypropylene tube in which 300 μL of 2–10 M HCl and 600 μL of 0.12 M TiOA in xylene had been added. After shaking with a Voltex mixer for 10 min, the mixture was centrifuged for 1 min. From each phase, 420 μL aliquots were separated into sample tubes. The radioactivity of each phase was measured with a Ge detector. We calculated the distribution ratios (D) of ^{90g}Nb and ^{178}Ta using the following equation:

$$D = (A_{org} / V_{org}) / (A_{aq} / V_{aq}),$$

where A_{org} and A_{aq} are the radioactivities in the organic and aqueous phases, respectively, and V_{org} and V_{aq} are the volumes of the organic and aqueous phases, respectively.

The dependence of the D values of ^{90g}Nb and ^{178}Ta extracted into 0.12 M TiOA in xylene is shown in Fig. 1 as a function of the HCl concentration ([HCl]). The D values of both elements increase with increasing [HCl]. The D values of ^{178}Ta are greater than the values in the literature[6] for relatively high [HCl], although those of ^{90g}Nb are in agreement with those in the literature.[6] It is presumed that the formed Ta complexes differ in the present experiment and reported experiment,[6] which was performed on a macro scale. To obtain further information on the extracted complexes of Nb and Ta and the differences between the D values of Ta in the present experiment and the literature,[6] we need to conduct a detailed investigation. We will then investigate the behavior of Db and discuss the complex Db formation mechanism.

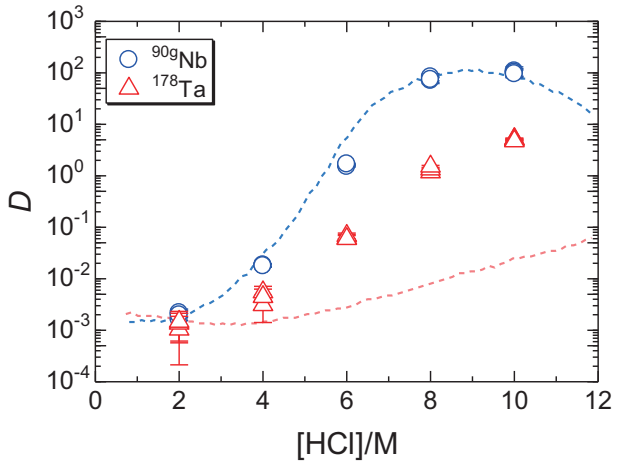

Fig. 1. Distribution ratios of ^{90g}Nb and ^{178}Ta extracted into 0.12 M TiOA in xylene as a function of the HCl concentration ([HCl]). Dashed lines indicate the values of Nb (blue) and Ta (red) reported in the literature.[6]

References

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