

## Solvent extraction behavior of $^{95g}\text{Nb}$ and $^{179}\text{Ta}$ in HF medium with tributyl phosphate

S. Tsuto,<sup>\*1</sup> M. Murakami,<sup>\*1,\*2</sup> K. Ooe,<sup>\*1</sup> H. Haba,<sup>\*2</sup> J. Kanaya,<sup>\*2</sup> M. Huang,<sup>\*2</sup> S. Goto,<sup>\*1</sup> and H. Kudo<sup>\*3</sup>

In a previous study,<sup>1)</sup> a long-lived isotope with a half-life of 27 h,  $^{268}\text{Db}$ , was assigned as the descendant nucleus of  $^{288}115$  because of its similar chemical behavior to group-5 elements. It was also reported that the chemical behavior of Db was similar to that of Ta rather than of Nb.<sup>1)</sup> Recently, a chemical experiment on  $^{262}\text{Db}$  ( $T_{1/2} = 34$  s) has been carried out in a mixed HF/HNO<sub>3</sub> solution.<sup>2)</sup> In contrast, this experiment showed a contrary result that the chemical behavior of Db is similar to that of Nb. Therefore, more detailed studies on the chemical properties of Db are required for the clear identification of element 115. In this study, extraction behaviors of the lighter homologs of Db, Nb and Ta, and the extraction kinetics is investigated toward the chemical identification of Db. To carry out chemical experiments of Db on a atom-at-a-time scale, the chemical studies of Nb and Ta should be conducted on a tracer scale. Moreover, in the experiment on Db, rapid kinetics for the extraction equilibrium is required because only short-lived radioisotopes of Db can be produced directly by heavy-ion induced nuclear reactions. We tried solvent extraction with  $^{95g}\text{Nb}$  ( $T_{1/2} = 34.991$  d) and  $^{179}\text{Ta}$  ( $T_{1/2} = 1.82$  y) with tributyl phosphate (TBP), which is widely used in the industrial separation of Ta from Nb.<sup>3,4)</sup>

The radiotracers of  $^{95g}\text{Nb}$  and  $^{179}\text{Ta}$  were produced via  $^{nat}\text{Zr}(p,xn)$  and  $^{nat}\text{Hf}(p,xn)$  reactions, respectively, using a 14-MeV proton beam supplied by the RIKEN AVF cyclotron.<sup>5)</sup> These tracers were chemically separated from the target materials by means of anion exchange chromatography and stored in a 1 M HF solution. After evaporation of this solution, HF solution with a desired concentration was added to the tracers. One milliliter of the aqueous solution with the desired HF concentration containing  $^{95g}\text{Nb}$  and  $^{179}\text{Ta}$  tracers was mixed with the same volume of 1.8 M TBP in 1, 2-dichloroethane. The mixture was shaken mechanically for 180 min at 25°C. After centrifugation, 700  $\mu\text{L}$  aliquots of each phase were taken separately. Gamma- and X-rays emitted from the  $^{95g}\text{Nb}$  and  $^{179}\text{Ta}$  tracers were measured using a Ge detector. From these results, we calculated the distribution ratio ( $D$ ):

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

where  $A$  is the radioactivity of the metals, and  $V$  is the volume of each phase. The subscripts aq and org denote the aqueous and organic phases, respectively.

We also studied the extraction kinetics of this system by changing the shaking time  $t$  ( $t = 0.2, 0.5, 1, 5, 10, 90,$  and  $180$  min). In the experiment for investigating extraction kinetics with 1.8 M TBP in 1, 2-dichloroethane and 5.4 M HF solutions, the  $D$  values of  $^{95g}\text{Nb}$  and  $^{179}\text{Ta}$  were almost constant in the studied range of shaking time studied, suggesting that the extraction equilibrium is very fast.

Figure 1 shows HF concentration dependences of the distribution ratios of  $^{95g}\text{Nb}$  and  $^{179}\text{Ta}$  in 1.8 M TBP in 1, 2-dichloroethane. When  $[\text{HF}]_{\text{ini}} = 0.27$  M, the  $D$  value of  $^{179}\text{Ta}$  has a maximum of  $346 \pm 58$ , while the value of  $^{95g}\text{Nb}$  is approximately  $10^{-2}$ . This indicates that Ta can be clearly separated from Nb in the 0.27 M HF solution and the predominant complex of Ta in HF solution varies near this concentration. Therefore, this experimental condition would be suitable to investigate whether Db behaves like Nb or Ta.

For chemical experiments on short-lived Db, an on-line rapid extraction apparatus is required. The development of an apparatus utilizing a flow injection analysis system is in progress.<sup>6)</sup> The on-line extraction of Nb and Ta from HF solution into TBP will be performed using the apparatus.

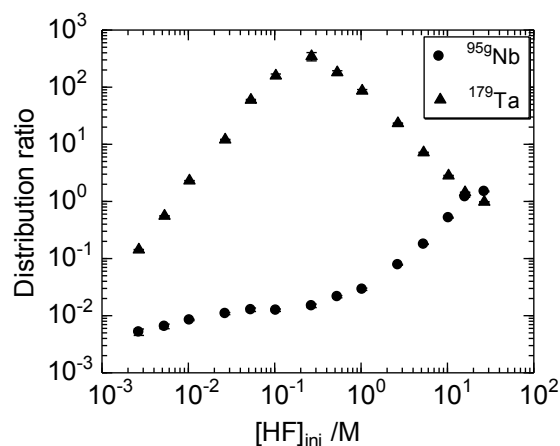


Fig. 1. HF concentration dependences of distribution ratios of  $^{95g}\text{Nb}$  and  $^{179}\text{Ta}$  into 1.8 M TBP in 1, 2-dichloroethane.

### References

- 1) N. J. Stoyer et al.: Nucl. Phys. **A787**, 388c (2007)
- 2) Y. Kasamatsu et al.: Chem. Lett. **38**, 1084 (2009).
- 3) Z. Zhu and C. Y. Cheng: Hydrometallurgy **107**, 1 (2011).
- 4) S. Nishimura et al.: Trans. JIM **5**, 79 (1964).
- 5) M. Murakami et al.: Appl. Radiat. Isot. in press.
- 6) T. Koyama et al.: In this report.

<sup>\*1</sup> Graduate School of Science and Technology, Niigata University

<sup>\*2</sup> RIKEN Nishina Center

<sup>\*3</sup> Faculty of Science, Niigata University