

Reversed-phase extraction behavior of the 105th element, Db, with tributyl phosphate

M. Murakami,^{*1,*2} S. Tsuto,^{*1} K. Ooe,^{*1} S. Goto,^{*1} D. Sato,^{*1} N. Goto,^{*1} T. Koyama,^{*1} T. Nagaoka,^{*1}
R. Motoyama,^{*1} H. Haba,^{*2} Y. Komori,^{*2} A. Toyoshima,^{*3} A. Mitsukai,^{*3,*4} Y. Kitayama,^{*5} Y. Fukuda,^{*5}
and H. Kudo^{*1}

Our group has investigated the extraction behavior of Nb and Ta, homologs of the 105th element Db, from HF solutions with tributyl phosphate (TBP) by the batchwise and on-line column chromatographic methods.^{1,2)} In the on-line column experiment with a 62 wt% TBP resin,²⁾ the obtained distribution coefficients (K_d) of Ta were in agreement with those obtained by the batch experiment, indicating that the studied system can be applicable to the column chromatographic experiment with the short-lived ²⁶²Db ($T_{1/2} = 33.8$ s). In this work, the extraction behavior of Db was studied to discuss the chemical form of Db in HF media by comparing the behavior of Nb and Ta.

The isotopes ²⁶²Db and ¹⁷⁰Ta ($T_{1/2} = 6.76$ min) were simultaneously produced in the bombardment of a ¹⁹F beam on the mixed ²⁴⁸Cm/^{nat}Gd target. The ¹⁹F beam was delivered from the AVF cyclotron, and its energy was 105.3 MeV at the center of the target. The typical beam intensity was 700 particle-nA. The reaction products were transported with a He/KCl gas-jet system to a chemistry laboratory and were deposited on a collection site in Automated Rapid Chemistry Apparatus (ARCA³⁾) for 80 s. Then, the products were dissolved in 140 μ L of 1.0 M HF and were loaded onto a column (1.6 mm i.d. \times 7.0 mm height) filled with the 62 wt% TBP resin. The flow rate of the eluent was 1.0 mL/min. The effluent was collected in a Ta dish as Fraction 1. The remaining products in the column were stripped with 140 μ L of 10 M HF at a flow rate of 1.0 mL/min, and the effluent was collected in another Ta dish as Fraction 2. Both effluent fractions in the Ta dishes were evaporated to dryness and subjected to α spectrometry using an automated rapid α /SF detection system.⁴⁾ The α -particle measurement was started at 43 s and 57 s after the collection of the products for Fractions 1 and 2, respectively. The counting duration was 259 s and 248 s for Fractions 1 and 2, respectively. After the α -particle measurement, every third or fifth pair of Ta dishes was subjected to γ -ray spectrometry to monitor the behavior of ¹⁷⁰Ta and its chemical yield.

In total, 820 cycles of chromatographic separation were conducted. In the α energy region ($E_\alpha = 8.42$ –

8.74 MeV) for ²⁶²Db and its α -decay daughter ²⁵⁸Lr ($T_{1/2} = 3.9$ s), 16 and 2 events were observed in Fractions 1 and 2, respectively, including one time-correlated α pair in Fraction 1. The chemical yield of ¹⁷⁰Ta, including deposition and dissolution efficiencies of the aerosols, was $44 \pm 13\%$.

Percent extraction (%Ext) values were evaluated using the equation

$$\%Ext = \frac{100A_2}{A_1 + A_2}, \quad (1)$$

where A_1 and A_2 are the radioactivities in Fractions 1 and 2, respectively. The correction for the radioactive decay was considered for A_1 and A_2 . In Fig. 1, the obtained %Ext values of ²⁶²Db and ¹⁷⁰Ta are shown as closed symbols, together with those of ⁹⁰⁹Nb and ^{178a}Ta (open symbols) obtained in the separate experiment,²⁾ as a function of the initial HF concentration, $[HF]_{ini}$. Because of the small number of the ²⁶²Db events in Fraction 2, an upper-limit %Ext value of $\leq 25\%$ was evaluated for ²⁶²Db. The evaluated %Ext value for ¹⁷⁰Ta was $93 \pm 5\%$, which was in agreement with the previous result for ^{178a}Ta (%Ext = $94 \pm 4\%$ ²⁾). This suggests that Db would not form a Ta-like fluoride complex $[DbF_6]^-$ in 1.0 M HF, where Ta forms an extractable species, $[HTaF_6(TBP)_3]$.⁵⁾

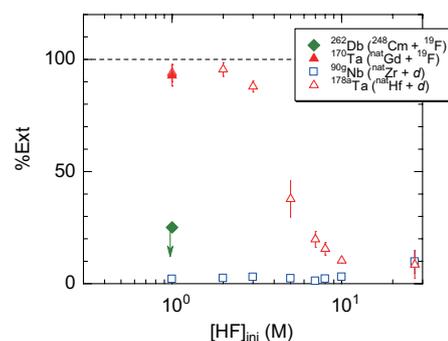


Fig. 1. Dependence of %Ext values of Nb, Ta, and Db on $[HF]_{ini}$.

References

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*1 Department of Chemistry, Niigata University

*2 RIKEN Nishina Center

*3 Advanced Science Research Center, Japan Atomic Energy Agency

*4 Faculty of Science, Ibaraki University

*5 Graduate School of Natural Science and Technology, Kanazawa University