

Solvent extraction of Zr and Hf using the online flow-type extraction apparatus for superheavy elements

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Thus far, ion-exchange and solid-liquid extraction experiments have often been performed in solution chemistry on superheavy elements.¹⁾ Solvent extraction experiments were also conducted using rapid solvent extraction apparatuses. However, sufficient distribution data for discussion on complex formation were hardly obtained in the extraction of short-lived superheavy elements because it is difficult to achieve rapid equilibration and phase separation. Stable repetitive extractions and α -particle detections are also difficult in online extraction experiments. We developed an online flow-type solvent extraction apparatus to accomplish rapid solvent extraction and phase separation with the short-lived ^{261}Rf (68 s).²⁾ In this experiment, by using the developed apparatus, we performed the online solvent extraction of Zr and Hf (homologues of Rf) produced with the AVF cyclotron at RIKEN to check the performance of the apparatus and to search for suitable conditions of Rf experiments.

The developed extraction apparatus involves a reactor tube (extraction unit, EU) filled with PTFE chips to mix aqueous and organic solutions well (shortening of the diffusion length between these solutions is expected). Rapid phase separation between aqueous and organic solutions was achieved with a flow-type phase separator (PS) using a PTFE membrane filter. We found that separation with the purity of each phase greater than 95% was accomplished with a 1-step separator. The entire setup of the online extraction experiment at RIKEN is shown in Fig. 1. $^{89\text{g.m}}\text{Zr}$ and ^{173}Hf were produced in the $^{nat}\text{Sr}(\alpha, xn)$ and $^{nat}\text{Yb}(\alpha, xn)$ reactions, respectively. The nuclear reaction products were rapidly transported to the dissolution apparatus in the chemistry room by the He/KCl gas-jet system. The solvent extraction of Zr and Hf was performed in a 7.8, 9.2, and 10.4 M HCl/0.01 M Aliquat 336 carbon tetrachloride solution system. 30-cm EU was used and the flow rate was 500 $\mu\text{L}/\text{min}$ for both phases. The length of EU required to reach equilibrium was tested beforehand through an offline extraction experiment using the apparatus. The eluted aqueous and organic solutions were separately collected and subjected to γ -ray measurement, and the distribution ratios, D (the ratio of metal concentration in organic solution to that in aqueous solution), were determined.

The obtained D values are shown in Fig. 2. In this figure, the equilibrium D values obtained beforehand in the offline batch extraction experiment are also shown for comparison.

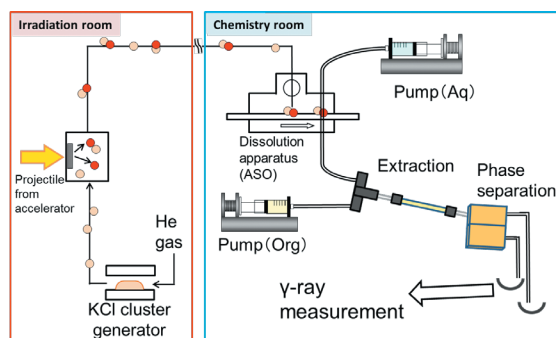


Fig. 1. The entire setup of the online extraction experiment at RIKEN

The D values obtained in the present online experiment basically match the tendency of the D values in equilibrium. This result indicates that extraction equilibrium of the chemical reactions involved in the present solvent extraction was achieved in the online experiment using the apparatus. At 9.2 M HCl, the D values of both Zr and Hf were slightly lower than the equilibrium data. Repetitive extraction was not performed in the present experiment. Thus, these low D values might be due to uncertainty of the data; if not, the length of the EU was insufficient (not equilibrated). We need to investigate the reproducibility of the data in the online experiment. The time taken to accomplish one extraction procedure was approximately 1 min, which is suitable for Rf experiments. In conclusion, we were able to check the movement of the developed apparatus and obtained the D values of Zr and Hf in an online experiment.

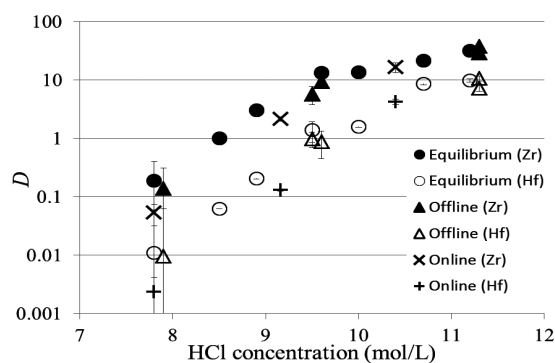


Fig. 2. The D values of Zr and Hf

References

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