

# Fluoride Complexation of Rutherfordium (Rf, Element 104)

E. Strub, J.V. Kratz, A. Kronenberg, A. Nähler, P. Thörle (Universität Mainz), W. Brüchle, E. Jäger, Z. Li, M. Schädel, B. Schausten, E. Schimpf (GSI Darmstadt), D. Jost, A. Türlér (PSI), H.W. Gäggeler (Univ. Bern & PSI), J.P. Glatz (ITU Karlsruhe)

The distribution coefficient ( $K_d$ ) of  $^{261}\text{Rf}$  on ion exchange resins at various  $\text{HNO}_3/\text{HF}$  concentrations had been studied [1]. Rf was eluted at higher HF concentrations from CIX than Zr and Hf and rather resembled Th. Up to 1 M HF, Rf was not retained on the AIX also resembling its pseudo-homolog Th.

Th is known to form no anionic fluoride complexes, while Zr and Hf are forming complexes of the type  $[\text{MF}_6]^{2-}$  in HF solutions and therefore can be resorbed on AIX resins.

We have continued these studies. Now of Rf and on-line produced Hf by systematically varying both the  $\text{HNO}_3$  and the HF concentration. If Rf is resembling Th, there should exist no concentration range in which Rf is adsorbed on the AIX.

$^{261}\text{Rf}$  was produced in the  $^{248}\text{Cm}(^{18}\text{O}, 5n)$  reaction at the PSI Philips Cyclotron. A  $730 \mu\text{g}/\text{cm}^2$   $^{248}\text{Cm}$  target was bombarded with a  $0.5 \mu\text{A}_{\text{part}} ^{18}\text{O}^{5+}$  beam. The target contained 10% Gd thus producing simultaneously short-lived Hf isotopes. Rf and Hf were transported by a  $\text{He}(\text{KCl})$  gas jet and collected for 90 s by impaction on a slider in the Automatic Rapid Chemistry Apparatus ARCA II. The residue was dissolved in  $200 \mu\text{l}$  0.1 M  $\text{HNO}_3/x$  M HF ( $x$  variable) and fed onto the AIX. The effluent was evaporated to dryness as sample 1. In order to elute remaining Rf from the column, a second fraction ( $200 \mu\text{l}$ ) was collected which is known to elute group 4 elements from the column (2 M  $\text{HCl}/0.01$  M HF). This fraction was prepared as sample 2. 78-s  $^{261}\text{Rf}$  was detected by  $\alpha$ -spectroscopy. The counting time was 12 min. Every 8th pair of samples was monitored by additional  $\gamma$ -spectroscopy to determine the distribution of Hf. From the ratio of the counting rates, the  $K_d$  values were calculated.

The results are shown in the table and are also plotted in the 3D graphs below (some values in the plot are interpolated).

It is obvious that the behavior of Rf and Hf in the examined system are remarkably different. While the  $K_d$  values of Rf are varying strongly with both HF and  $\text{HNO}_3$  concentration, the dependence of the Hf  $K_d$  values on the acid concentrations is rather weak.

[ $\text{HNO}_3$ ]	[HF]	$\log K_d$ (Hf)	$\log K_d$ (Rf)
0.1	0.01	2.1	0.8
0.1	0.03	2.1	0.9
0.1	0.05	2.0	0.8
0.1	0.5	2.1	0.9
0.1	1	2.2	0.7
0.03	0.5	2.2	1.7
0.01	0.01	2.1	1.0
0.01	0.05	2.3	1.6
0.01	0.5	2.5	1.6
0.003	0.5	2.7	1.7
0	0.01	2.5	2.7
0	0.1	2.7	2.4
0	0.5	2.8	1.8

Table:  $\log K_d$  values of Hf and Rf in different media

Strong adsorption of both elements onto AIX can only be observed in pure HF solutions with concentrations  $[\text{HF}] > 0.01$  M. This indicates the presence of anionic complexes under this condition which is in agreement with [3].

On the other hand, the sorption of the complexes on AIX seems to be influenced by the presence of other anions acting as counter ions on the exchanger resin ( $\text{NO}_3^-$  and/or  $\text{HF}_2^-$ , see [2]).

Thus, Rf shows the typical behavior of group 4 (formation of anionic fluoride complexes), but the interaction of these complexes with different counter ions is enhanced with respect to Zr and Hf.

## References

- [1] E. Strub et al., *Radiochimica Acta* 88, 265 (2000)
- [2] E. Strub, *Dissertation Universität Mainz* (2000)
- [3] Szegłowski et al., *Radiochim. Acta* 51, 71 (1990)

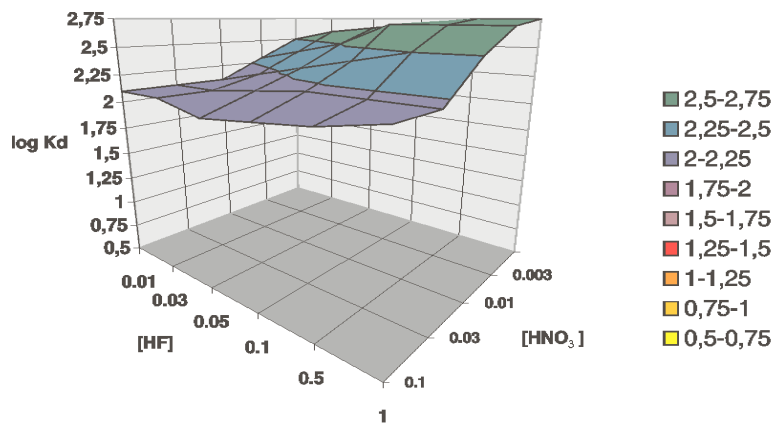


Fig.1: Sorption of Hf in  $\text{HNO}_3/\text{HF}$  solutions on a AIX resin (Aminex A27 or Riedel de Haën).

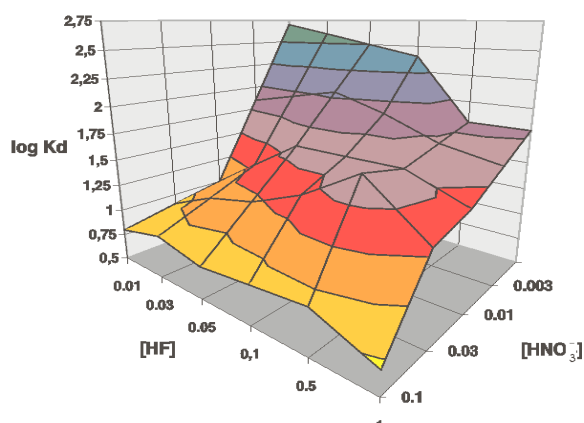


Fig.2: Sorption of Rf in  $\text{HNO}_3/\text{HF}$  solutions on a AIX resin (Aminex A27 or Riedel de Haën).