

# **K<sub>d</sub>-Value Determination for <sup>261</sup>Rf (Element 104) with the Multi-Column Technique**

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After online experiments with <sup>165</sup>Hf (*t*<sub>1/2</sub> = 76 s, decaying into <sup>165</sup>Lu) produced in the reaction <sup>158</sup>Dy(<sup>12</sup>C, 5n) at UNILAC at GSI [1], we attempted the first transactinide experiment using the multi-column-technique [2] in the system HF/0.1 M HNO<sub>3</sub>. In this technique, the KCl aerosol particles transporting the activities from the target chamber in a gas-jet are continuously dissolved in a degasser unit in an aqueous solution which is continuously pumped through three consecutive columns. The achieved degasser yield is about 80%.

The solution from the degasser unit is pumped with a chemically inert HPLC-pump through the three columns with resin in HPLC quality. The transport time between the degasser unit and the first column through capillary of 0.3 mm inner diameter and a distance of 64 cm is about 6 sec. The hold-up time in the degasser is about 2 sec.

The first column (F), filled with a cation exchange resin (Dowex 50WX8, -400 mesh), acts as a filter for all decay products of rutherfordium-261 (see decay scheme in Fig. 1), while the latter passes through. The second column (C), filled with an anion exchange resin (Dowex 1X8, -400 mesh), is the true chromatographic column where Rf experiences a retention time, *t*<sub>R</sub>, being of the order of its nuclear half life, *t*<sub>1/2</sub>. The *t*<sub>R</sub> can be manipulated by changing the mass of the resin. The daughter nuclides that are formed during the retention time of Rf on column C are strongly retained on column D (daughter activity, A<sub>D</sub>), filled with a cation exchange resin (Dowex 50WX8, -400 mesh). The part of Rf that passes C is also passing the third column D without notable retention. The final eluate (E) is sampled in order to collect the residual atoms as well as its decay products (daughter activity A<sub>E</sub>).

After the experiment, the activities of the decay products on column D and in the final eluate E are measured and the retention time is obtained according to (1). The distribution coefficient, K<sub>d</sub>, of rutherfordium in column C may then be obtained from (2)

$$t_R = \frac{t_{1/2}}{\ln 2} \ln \left( \frac{A_D + A_E}{A_E} \right) \quad (1); \quad K_d = (t_R - t_0) \frac{V}{m} \quad (2)$$

where

*t*<sub>0</sub> = column hold-up time due to its dead volume [s]

*V* = flow rate of the mobile phase [ml\*s<sup>-1</sup>]

*m* = mass of the stationary phase [g].

The preparation of the samples is done by the evaporation of the eluate E and the activity A<sub>0</sub> stripped from the Columns D with 0.5 M α-HIB (at pH 3.8). For the determination of the chemical yield, <sup>241</sup>Am (E<sub>α</sub>=5.5 MeV) is used. The samples are prepared by molecular plating on thin Ti-foils (420μg/cm<sup>2</sup>) with about 80% chemical yield (700V, 2-3 mA/cm<sup>2</sup>, pH 2-3, isopropanol). The α-decay of <sup>253</sup>Es (E<sub>α</sub>=6.6 MeV) can be measured by 4π alpha-spectrometry. The background count rate

in the range of 6.4 to 6.8 MeV is 1.5 events per week with our detectors.

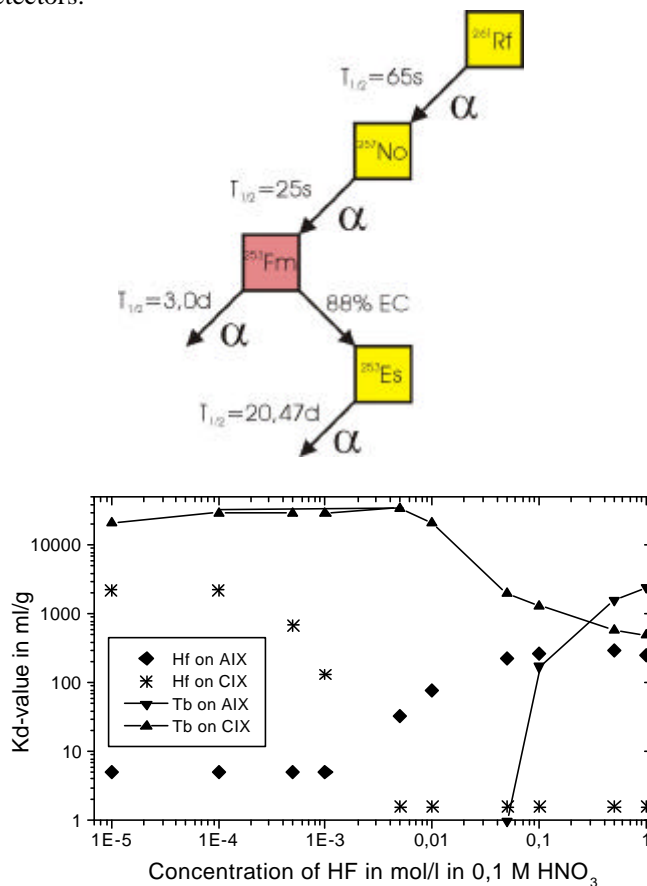


Fig. 1 Decay scheme for <sup>261</sup>Rf

Fig. 2 K<sub>d</sub>-values of Hf and Tb in variable HF/0.1 mol/l HNO<sub>3</sub> on DOWEX 1X8 (AIX) und DOWEX 50WX8 (CIX)

As shown in Fig.2, the K<sub>d</sub>-values of trivalent metal ions (Tb<sup>3+</sup>) are in excess of 10000 in 0.1 M HNO<sub>3</sub> for HF concentrations up to 10<sup>-2</sup> M and decrease for higher HF concentrations due to the formation of fluoride complexes (3500 in 0.05 M HF and 700 in 0.5 M HF). The K<sub>d</sub>-value in 0.5 M HF/0.1 M HNO<sub>3</sub> was also verified for <sup>250</sup>Fm produced on-line in the <sup>238</sup>U(<sup>18</sup>O, 6n) reaction at PSI. This decrease of the K<sub>d</sub>-values was ignored in [3]. For <sup>261</sup>Rf, K<sub>d</sub>-values on an AIX were determined with ARCA to be 7 +/- 5 ml/g in 0.5 M HF/0.1 M HNO<sub>3</sub> and 112<sup>+197</sup><sub>-84</sub> ml/g in 0.05 M HF/0.01 M HNO<sub>3</sub> [4]. This difference is tentatively attributed to the competition of the counter ion NO<sub>3</sub><sup>-</sup> for the binding sites on the AIX. The Rf experiments with the multi-column technique will test this interpretation.

## References

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