Extraction Experiments with ^{257}Rf and ^{258}Db using SISAK in Combination with the Berkeley Gas-filled Separator (BGS) and improvements of the Set-up

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SISAK is a fast, continuous, chemical separation system. It was developed to investigate short-lived nuclei recoiling out of an irradiated target and transported in a gas jet. The system is based on small (0.3 mL volume) centrifuges with a continuous feed and output. See [1] and references therein for details.

The first successful SISAK experiment with transactinides was performed at the LBNL 88-inch cyclotron in December 2000. The experiment proved that the SISAK system is fast enough to separate ^{257}Rf (4 s half-life) and that our Liquid Scintillation (LS) detection system is sensitive enough to detect this nuclide [2]:

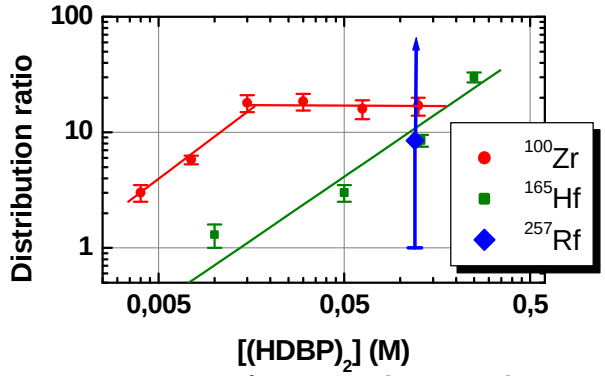

Figure 1 Extraction of groupe-IV elements with HDBP.

The December 2000 experiment gave results on the extraction of Rf into toluene [3] as a nitrate-dibutyl-phosphate complex. However, the rather long transport time of 18-20 s resulted in a low overall yield due to decay loses. Thus, only five ^{257}Rf atoms reached the LS detectors and were detected in a 16 h run. In order to perform detailed studies of the chemistry of Rf the loses must be reduced significantly.

A follow-up experiment performed in March 2001 aimed at improving the yield by:

- Reducing the volume of the recoil transfer chamber (used to transfer the recoils exiting the BGS vacuum window to the gas-jet transport system) by using N_2 gas instead of He. The stopping range is shorter in N_2 than in He.
- Increasing the gas-flow in the gas-jet transport system.
- Increasing the liquid flow through the SISAK system and the LS detectors.
- Using a separation system without a washing step for the organic phase, e.g. extraction from dilute oxalic-acid instead of 6 M HNO_3.

The above measures reduced the transport time by more than 5 seconds. However, the overall yield did not improve. This is attributed to non-laminar flow in the gas-jet. Therefore, in future experiments the gas-jet flow cannot be increased as much as in the experiment reported here. However, the experiments clearly indicate that significant gains can be achieved by using optimum gas and liquid flow rates. Furthermore, it is possible to gain several seconds in reduced transport time if the chemistry apparatus can be positioned closer to the BGS. With these improvements, detailed SISAK studies of the aqueous chemistry of Rf should be possible and are being planned for the summer of 2002.

In addition to the work performed to reduce the transport time, two additional experiments were done:

1. Extraction of Rf from 0.5 M oxalic acid with 0.1 M trioctyl-amine (TOA), dissolved in toluene. This experiment was based on the work reported in [4]. The result indicates that Rf is extracted as its lighter homologues Zr and Hf, although with a slightly lower yield. The latter might result from the uncertainty due to the low number of Rf detected during this experiment. The experiment served as a pilot experiment for future studies of the Rf complexation behaviour.
2. A first attempt to detect ^{258}Db failed. Due to its complex decay scheme ^{258}Db could not be identified unambigously with the LS detection system.

Further experiments are planned for summer 2002 with an improved LS-detection based on digital pulse-shape measurements.

References

[?] U. of Mainz, U. of Gothenburg and U. Of Oslo collaboration: J. Alstad, H. Breivik, K. Eberhardt, M. Johansson, J.V. Kratz, M. Mendel, A. Nähler, L.A. Omtvedt, G. Skarnemark, L. Stavsetra, N. Wiehl, J.P. Omtvedt, N. Trautmann,

[?] C.M. Folden III, T. Ginter, K.E. Gregorich, U.W. Kirbach, D.M. Lee, V. Ninov, J.B. Patin, R. Sudowe, P.A. Wilk, P.M. Zielinski, H. Nitsche, D.C. Hoffman.

1 J.P. Omtvedt et al., J. Alloys and Compounds, **271**, 303, (1998).

2 J.P. Omtvedt et al.: *"Detection of ^{257}Rf with the SISAK On-Line LS Detectors"*, LBNL NSD Annual Report 2000.

3 J.P. Omtvedt et al.: *"SISAK Liquid-Liquid Extraction Experiments with Preseparated ^{257}Rf"*, submitted to the Proceedings of the ASR2001 symposium, which will be published as a special issue of the Journal of Nuclear and Radiochemical Sciences.

4 L.A. Omtvedt et al: *"Extraction of Zr and Hf into Trioctylamine in Toluene from Oxalic Acid Solutions"*, LBNL NSD Annual Report 2000.