Pilot-Test Experiment with Os of a SISAK Setup for Hs-Chemistry Studies

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A liquid-liquid extraction system for investigating chemical properties of element 108, hassium, was developed [1] using γ-emitting ^{181}Os produced at the Oslo Cyclotron Laboratory (OCL). The system is targeted for the fast solvent extraction system SISAK [2] and based on OsO_4 reacting with NaOH. Such an experiment would be the first attempt to study Hs in the liquid phase. Successful Rf and Db experiments [3-5] performed at LBNL in Berkeley indicate that SISAK with its liquid scintillation detectors is sensitive enough to detect Hs, even though the Hs cross section is ~3 orders of magnitude lower.

The first investigation of the reaction between HsO_4 and NaOH was performed in a gas phase experiment [6]. The interaction of HsO_4 appeared somewhat weaker with NaOH than that of OsO_4, in fair agreement with theoretical predictions [7]. The liquid-liquid extraction Hs-experiment proposed in the work presented here is based on results from this gas-phase experiment. In aqueous solution, it is assumed [1] that the reactions occurring are:

$$OsO_4(aq) + NaOH(aq) \leftrightarrow Na[OsO_4(OH)](aq) \quad (1)$$

$$Na[OsO_4(OH)] + NaOH \leftrightarrow Na_2[OsO_4(OH)_2] \quad (2)$$

$$OsO_4(aq) \rightarrow OsO_4(org) \quad (3)$$

The distribution ratio between NaOH solution and toluene, which was selected as organic phase because it is also suitable as solvent for the liquid scintillation detection used by SISAK, is given by:

$$D = \frac{[OsO_4]_{org}}{[OsO_4]_{aq} + [OsO_4(OH)]^{-} + [OsO_4(OH)_2]^{2-}} \quad (4)$$

which can be rewritten as:

$$D = \frac{K_D}{1 + K_1[OH^-] + K_1K_2[OH^-]^2} \quad (5)$$

where K_1, K_2 and K_D are equilibrium constants for reactions (1), (2), and (3), respectively. Experiments were performed in Oslo, utilizing manual extractions and SISAK on-line measurements to carefully study the behavior of Os in this chemical system, see Samadani et al. [1] for details. The results are summarized in Fig. 1.

Based on the results from Oslo a "proof-of-principle" experiment with α-decaying Os isotopes was performed at GSI: the full SISAK setup [8], as it would be used for a Hs experiment with double α-detector arrays to simultaneously measure both phases (for the aqueous phase done indirectly, after a second extraction step) was set up and tested. $^{40}Ar^{11+}$ ions from the UNILAC irradiated a ^{nat}Ce target in the gas-filled separator TASCA (TransActinide Separator and Chemistry Apparatus) producing $^{172-175}$Os.

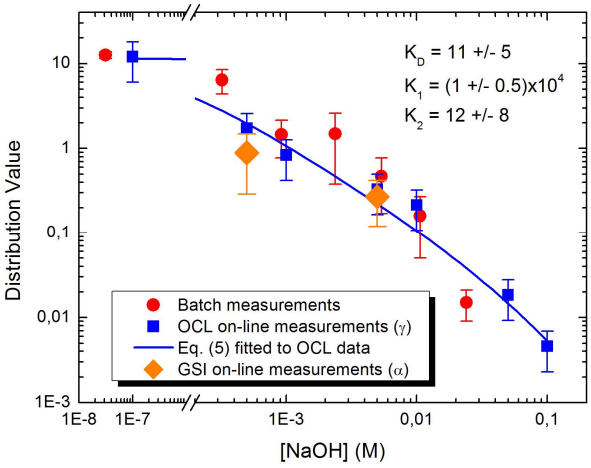

Figure 1: Comparison of data from OCL and GSI, together with fit of eq. (5) to OCL data.

In the separator focal plane a Recoil Transfer Chamber (RTC) was mounted. It was flushed with a He/O_2 gas mixture, which passed an oven (run at 600°C) mounted at the exit of the RTC to ensure fast and complete oxidation of Os. The volatile osmium tetroxide was transported to SISAK by the He/O_2 gas and dissolved in NaOH solution. After extraction into toluene the α-activity was measured in on-line flow cells by liquid scintillation detection. This was the first SISAK experiment behind TASCA. Results from this run using α-decaying ^{172}Os agree well with those of γ-measurements obtained in Oslo, as shown in Fig. 1. This successful experiment proved that the system is suitable for studying Hs.

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