



## Preliminary investigations towards the separation of hexavalent and tetravalent seaborgium - extraction of homologs

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Element 106, seaborgium (Sg) is a group-6 element with the lighter homologs tungsten (W) and molybdenum (Mo). The homologs have several stable oxidation states in aqueous solutions. Therefore, one can empirically expect that Sg should exhibit similar properties. In addition, theoretical estimates of redox potentials of group-6 elements show that Sg can be reduced from the most stable hexavalent state to a lower oxidation state [1]. The aim of the present study is to find a suitable chemical extraction and separation system to be applied in future reduction studies of Sg [2] to distinguish and isolate reduced species from Sg(VI) by its different extraction behavior in a subsequent liquid-liquid extraction stage. Our strategy to achieve this is to identify a chemical system where the reduced and non-reduced species in solution have opposite charge. It should then be possible to distinguish between them by simply using a cation or anion extraction agent. Details of the strategy and overall system for performing liquid-phase redox studies on seaborgium will be presented in a separate contribution to this RadChem conference [3].

The extraction behavior of Mo(VI) and W(VI) from HCl with Hinokitol in toluene has been investigated in our previous work [4]. In the present work, we have focused our investigation towards systems where reduced species are anionic and hexavalent ions are cationic. Radiotracers of  $^{89}\text{Zr}$  and  $^{93}\text{mMo}$  was used to represent reduced species of Sg(IV) and non-oxidized Sg(VI), respectively. 0.1 M solutions of  $\text{H}_2\text{SO}_4$ , HCl, and  $\text{HClO}_4$  with and without 0.01 M HF were investigated. Di-(2-ethylhexyl)phosphoric acid (HDEHP) and Tri-n-octylamine (TOA) dissolved in toluene were used as extraction agents.

The Oslo Cyclotron Laboratory's (OCL) MC35 Scanditronix Cyclotron was used for producing the  $^{89}\text{Zr}$  and  $^{93}\text{mMo}$  radiotracer. While all these experiments were performed as discontinuous "batch" extractions, in the future, on-line studies will have to be performed using the full on-line and automated system (SISAK with a redox cell, see [3] for details) to test realistic conditions for a Sg experiment. 30 MeV  $^4\text{He}^{2+}$  ions, delivered with an intensity of ~350 nA (electrical), were used for the nuclear reactions  $\text{natZr}(\alpha,x)^{93}\text{mMo}$  and  $\text{natSr}(\alpha,x)^{89}\text{Zr}$ . The activity was then transported in a KCl gas-jet and was deposited on a filter paper. This was gently washed off using the desired aqueous solution. The solution was mixed with an organic extractant dissolved in toluene and was violently shaken for 5 min using a Vortex shaker. Using  $\text{H}_2\text{SO}_4 + 0.01 \text{ M HF}$  with either 0.1 M HDEHP or 0.1 M TOA gave the best separation between Mo and Zr. The obtained results indicate that a solution of 0.1 M  $\text{H}_2\text{SO}_4 + 0.01 \text{ M HF}$  with 0.1M HDEHP provided the best separation: 88% Mo(VI) and 12% Zr(IV) were extracted. This is a promising start to develop suitable conditions for a future element 106 (Sg) experiment. These experiments will be presented in more detail. Preliminary data of the reduction of Mo(VI) to Mo(IV) using a Flow Electrolytic Column (FEC) [5] in combination with a promising extraction system will be presented by Toyoshima et al. in a parallel contribution to this conference [2].

### References

- [1] V. Pershina, E. Johnson, and B. Fricke. "Theoretical Estimates of Redox Potentials for Group 6 Elements, Including Element 106, Seaborgium, in Acid Solutions". In: *The Journal of Physical Chemistry A* 103 (1999), pp. 8463–8470.
- [2] A. Toyoshima et al., contribution to this conference
- [3] J.P. Omtvedt et al., contribution to this conference
- [4] S. Miyashita et al. "Solvent extraction of hexavalent Mo and W using 4-isopropyltropolone (Hinokitol) for seaborgium (Sg) reduction experiment" APSORC 13, Kanazawa – Japan.
- [5] A. Toyoshima et al. "Development of an Electrochemistry Apparatus for the Heaviest Elements". In:

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