First results of the CALLISTO-experiment: Evidence for the formation of a hassate(VIII)

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In October/November 2002, after an intensive optimization of many experimental parameters, the CALLISTO-project finally led to a hassium chemistry experiment [1] at the UNILAC. Since it has been predicted, that hassium forms a volatile tetroxide [2], which was recently confirmed by C. Düllmann et al. [3], we decided to investigate this compound of hassium.

For the very volatile OsO_4, it is known that it dissolves in strongly basic alkali hydroxide solutions thereby forming red, diamagnetic osmates(VIII) of stoichiometry $[OsO_4(OH)_2]^{2-}$. In previous beamtimes, in which OsO_4 was produced in-situ directly behind the target [4], we demonstrated, that the volatile OsO_4 deposits effectively on NaOH surfaces from humid He gas.

This behaviour was used to design a continuously working system for the formation, transport, deposition and detection of OsO_4 and HsO_4 [1]. This system, which uses 4 computer-controlled valves and 4 detection arrays, each with 4 alpha-detectors [5], combines the advantages of a continuously operating system and adds the possibility to change the deposition material, a thin layer of NaOH on a plate of stainless steel, on a regular basis without interrupting the experiment. Changing the deposition material is necessary, as the deposition efficiency decreases with time [1].

Fig. 1: Rotating target wheel (Photo: W. Brüchle)

A rotating target wheel (Fig. 1), containing two ^{248}Cm-targets of 0.6 mg/cm^2 each and one ^{152}Gd-enriched-Gd-target, was irradiated with $1.18 \cdot 10^{18}$ ^{26}Mg beam particles at 144-149 MeV. In the second part of the beamtime, the ^{152}Gd-target segment was replaced with a ^{248}Cm/^{152}Gd-hybrid target to enhance the hassium production. This target wheel was irradiated with a total amount of $1.64 \cdot 10^{18}$ particles at 142-150 MeV.

Os and Hs recoils, synthesized simultaneously, are stopped in a mixture of He and O_2 inside a recoil chamber especially designed for this purpose. This results in an in-situ formation of volatile oxides, which are carried out with the He-gas jet.

In our experiment, about 290 deposition plates were coated with NaOH and successfully used. The main part of the OsO_4 deposits in the first detection array. The distribution of the activity of OsO_4 in the detection system is shown in Fig. 2.

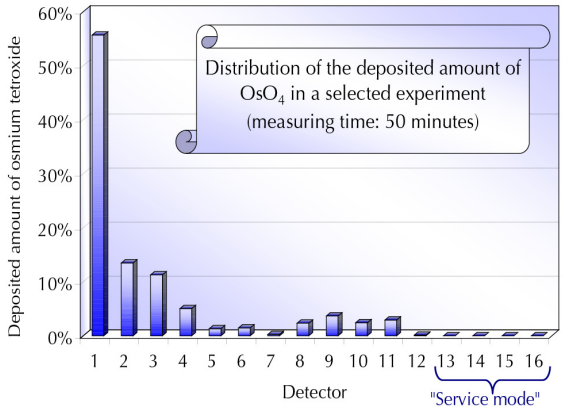

Fig. 2: Distribution of Os in the detection system

The data evaluation is in progress. A first and preliminary analysis shows α-α-decay chains and α-SF correlations which we tentatively attribute to the decay of Hs isotopes. For the first time, a chemical reaction has been performed with hassium tetroxide. Since the observed deposition of HsO_4 under the conditions of this CALLISTO set-up is only possible, if this volatile substance reacts with NaOH, we conclude, that HsO_4 reacted with NaOH. Since very similar properties for OsO_4 and HsO_4 can be expected [2], we suppose, that sodium dihydroxo-tetraoxohassate(VIII) was formed:

$$2NaOH + HsO_4 \rightarrow Na_2[HsO_4(OH)_2]$$

So, if the off-line analysis substantiates the above findings, for the first time in the history of element 108, a classical acid-base-reaction was successfully carried out one-atom-at-a-time using its tetroxide.

Besides it should be noted, that ^{34m}Cl has been produced as a byproduct in the target chamber. It was deposited on the alkaline surface too and was identified via γ-spectroscopy. Generally, the CALLISTO set-up may be able to investigate the chemistry of other volatile substances, which are able to react with reactive surfaces, too.

References

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[2] V. Pershina *et al.*, J. Chem. Phys. **115** (2001), p. 792
[3] C. Düllmann *et al.*, Nature, 418, (2002) 859
[4] A. von Zweidorf *et al.*, GSI Scientific Report 2001, p. 181
[5] Pictures are available at *http://www.callisto.ws*