

CALLISTO - an improved setup for the chemical investigation of hassium tetroxide

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It has been predicted [1] and confirmed [2], that hassium forms a volatile tetroxide. The first attempt to study a chemical reaction of this compound, and to learn more about the chemical behaviour of Hs, is described in a companion contribution [3].

For this purpose, CALLISTO [4] has been developed in recent years. This system, which is in principle gas chemistry using reactive surfaces, was completely redesigned to integrate all the results of the many preliminary experiments.

The volatile tetroxide is formed in-situ in the target chamber, where the recoils are stopped in the jet gas (a mixture of 1 l/min He and 0.1 l/min O₂) [5]. At the exit of the target chamber, the gas flow passes a quartz glass tube containing a quartz wool plug, both heated to 500 °C in order to complete the oxidation of osmium and hassium to the tetroxide. The gas is transported via a 13 m long PTFE capillary to the detection system.

Because water seems to influence the deposition of OsO₄ on the NaOH surface [6], it was necessary to introduce it into the chemical system. As H₂O cannot be added before the He passes the target chamber (it prohibits an accurate beam current measurement), it was added after the target chamber and before the detection system.

For that reason, a special moisturizing unit was designed for CALLISTO. It consists of a large, thermostated moisturizer [7], which continuously adds at a defined temperature (30 °C) water to a second helium jet (0.1 l/min with the option to use 0.05 - 2 l/min). This humidified helium passes through a de-clusterizer at 200 °C to evaporate all remaining water aerosols. Thereafter, the humidity of the gas was monitored with a dew-point transmitter (~20 g H₂O per kg gas). This moisturized helium is added to the jet gas from the target chamber, containing only a few ppm of water and resulting in a humidity of about 2 g H₂O per kg gas in the final gas jet. This jet is then distributed through a system of 4 computer-controlled valves to 4 detection arrays (Fig. 1).

During an experiment, the He gas is flowing through 3 detection arrays, whereas 1 detection array is cut off from the gas flow; it is in a "service mode" to change the deposition material. We used a thin layer of NaOH as a deposition material, which was prepared by coating plates of stainless steel with 1M ethanolic NaOH and by drying these plates. Every 60 minutes, the valves were automatically switched and the deposition plate of the detection array, being in the "service mode", was manually changed, cleaned and recoated. Thus, a continuously working detection and deposition system was realized.

The surface of the deposition material loses reactivity with time [6]. One possible explanation is, that NaOH is partially neutralized by CO₂, which is an impurity of the used gases and

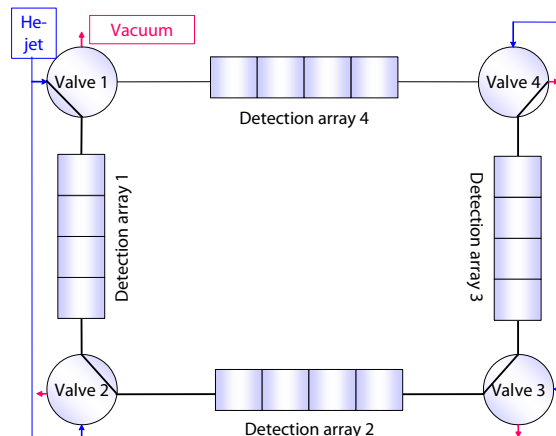


Fig. 1: Schematic of CALLISTO's valve- and detection system

probably formed by a reaction of the carbon beam dump with the oxygen of the jet gas, too. The Na₂CO₃ has a decreased reactivity and shows only a yield of about 50%, compared to NaOH.

After the volatile oxides (OsO₄, HsO₄) are deposited, their α -decay and spontaneous fission can be detected with the detection arrays, each consisting of four (10x10) mm² large PIN-diodes facing the deposition material (Fig. 2).

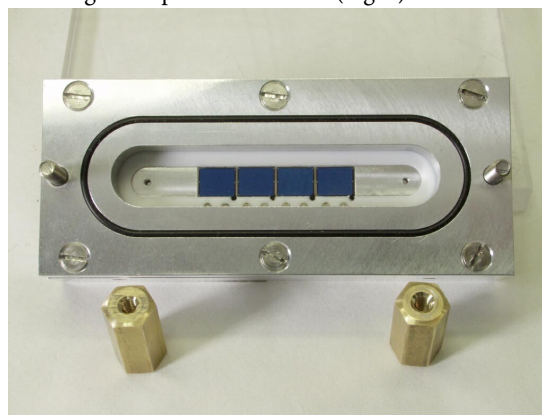


Fig. 2: Detection array (Photo: A. Zschau / G.Otto, GSI)

The CALLISTO set-up has been successfully used to produce and deposit OsO₄ and HsO₄ during the beamtime October/November 2002 [3]. The analysis of the data is still in progress and more information will be available soon.

References

- [1] V. Pershina *et al.*, J. Chem. Phys. **115** (2001), p. 792
- [2] C. Düllmann *et al.*, Nature, **418**, (2002) 859
- [3] A. von Zweidorf *et al.*, this GSI Scientific Report
- [4] A. von Zweidorf *et al.*, GSI Scientific Report 2001, p. 181
- [5] A. von Zweidorf *et al.*, GSI Scientific Report 1999, p. 236
- [6] A. von Zweidorf *et al.*, this GSI Scientific Report
- [7] Pictures are available at <http://www.callisto.ws>