First chemical synthesis and investigation of $Sg(CO)_6$†

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Gas phase chemical studies of the superheavy elements have been limited to simple inorganic compounds so far.[1)] Due to challenging experimental conditions, access to other compound classes was limited. With the combination of physical preseparation with gas-phase chemistry techniques, parts of the experimental limitations could be overcome.[2-3)]

We succeeded in the synthesis of the first carbonyl complex of a superheavy element, namely seaborgium hexacarbonyl ($Sg(CO)_6$), at the GAs-filled Recoil Ion Separator GARIS[4)]. $Sg(CO)_6$ has been predicted to be stable[5)] and its adsorption behavior on SiO_2 surface is expected to be very similar to that of $W(CO)_6$[6)]. We therefore investigated $Sg(CO)_6$ along with $W(CO)_6$. Short-lived ^{164}W, and ~10-s ^{265}Sg were synthesized in the reactions $^{144}Sm(^{24}Mg,4n)^{164}W$ and $^{248}Cm(^{22}Ne,5n)^{265}Sg$. The evaporation residues (EVRs) were separated from the primary beam and lighter transfer products within GARIS. At the focal plane of GARIS, a recoil transfer chamber (RTC) was installed. The EVRs passed the entrance window of the RTC and were thermalized in a He / CO atmosphere (~600 mbar) in the RTC. The free single ions of W and Sg reacted with CO, forming volatile complexes[7)]. The RTC was flushed continuously, transporting volatile compounds through a 10-m long capillary to the Cryo Online Multidetector for Physics and Chemistry of the Transactinides COMPACT[8)], a thermochromatography detector array. The chromatography channel is formed by 32 pairs of silicon PIN diodes covered with a SiO_2 surface, kept at temperatures between 22 °C and -140°C. Volatile compounds adsorb at a certain temperature on the detector surface. The deposition pattern compared with Monte Carlo Simulations MCS, which allowed determining the adsorption enthalpy $-\Delta H_{ads}$. W as well as Sg were transported to COMPACT, hence, formed volatile compounds with the CO. In total 15 decay chains assigned to the decay of ^{265}Sg plus three uncorrelated fission event assigned to originate from members of the ^{265}Sg decay chain were observed under almost background free conditions at a total beam integral of $1.52 \cdot 10^{19}$. Both, the W as well as the Sg complexes deposited mainly in the last third of the detector (see Fig. 1). The W chromatograms are in agreement with former experiments reported in [3)], where the transported species was assigned to $W(CO)_6$. The Sg species shows the same adsorption behavior on SiO_2 as $W(CO)_6$, which strongly supports the assignment to $Sg(CO)_6$ [7)]. The experimental distribution and MCS are shown in Figure 1.

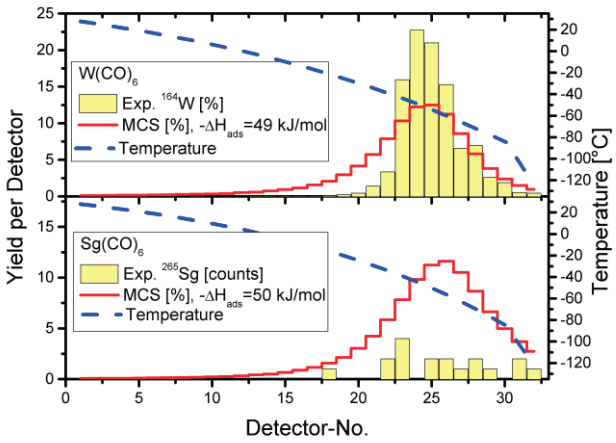

Fig. 1. Distribution of ^{164}W (upper graph) and ^{265}Sg (bottom graphic). ^{164}W was measured at 1L/min; the lower panel shows a combined chromatogram of all observed Sg events (flow rates between 1 L/min and 2.2 L/min). The black curve shows the result of the MCS (after [7]).

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