Chemical investigation of hassium (Hs, Z=108)

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The heaviest element, whose chemical behavior has been studied so far is bohrium (Bh) with Z=107 [1] behaving like a typical member of group 7 of the periodic table. The longest-lived α-decaying isotope of the next heavier element hassium (Hs, Z=108) is ^{269}Hs ($T_{½}$=11.3 s) which has been identified in the decay chain of ^{277}112 [2,3]. Hs is supposed to be a member of group 8 of the periodic table and should thus form a very volatile tetroxide. Relativistic density functional calculations predicted the electronic structure of HsO_4 to be similar to the one of OsO_4 [4]. Application of different semiempirical models of the interaction of a MeO_4 molecule with quartz surface predicted the adsorption behavior of OsO_4 and HsO_4 to be very similar [4]. Extrapolations of trends within group 8 of the periodic table also predicted HsO_4 and OsO_4 to behave similar in a gas adsorption chromatography experiment [5].

Hs isotopes were produced directly in the reaction ^{248}Cm(^{26}Mg;5,4n)^{269,270}Hs at the UNILAC at GSI Darmstadt [6]. Hs isotopes recoiling from the target were thermalized and oxidized in a He/O_2 mixture in the recoil chamber of the In-situ Volatilization and On-line detection apparatus IVO [7]. Volatile HsO_4 was transported with the carrier gas to the Cryo-On-Line-Detector (COLD), a thermochromatography device. Along a narrow channel formed of PIN-diodes registering α-decaying and spontaneously fissioning (SF) nuclides, a temperature gradient form -20 to -170 °C was established. The deposition temperature of volatile species could therefore be determined, allowing for the determination of their adsorption enthalpy. COLD is an improved version of the Cryo-Thermochromatography Separator CTS developed at Berkeley [8].

Five decay chains were detected in the course of the experiment which were attributed to ^{269}Hs or the so far unknown isotope ^{270}Hs [6]. In addition, two α-SF correlations were observed in detectors 3 and 4 that still have a rather low random probability, but could not be assigned with certainty to either ^{269}Hs or ^{270}Hs [6]. The deposition temperature of the Hs containing molecules was determined to (-44±5) °C giving strong evidence of the formation of HsO_4. In an irradiation of a ^{152}Gd target, ^{172}Os ($T_{½}$=19.2 s) was produced in the reaction ^{152}Gd(^{26}Mg;6n) and a deposition temperature of (-82±5) °C was measured for $^{172}OsO_4$. The deposition distribution in the COLD array along the detector pairs is shown in Fig. 1. From these deposition peaks the adsorption enthalpies were deduced applying a Monte-Carlo simulation based on a microscopic description of the transport process in the chromatography column [9], i.e. in the COLD system. Since the half-life of the nuclide is a crucial parameter in this simulation and this value has not yet been measured for ^{270}Hs, only the three events

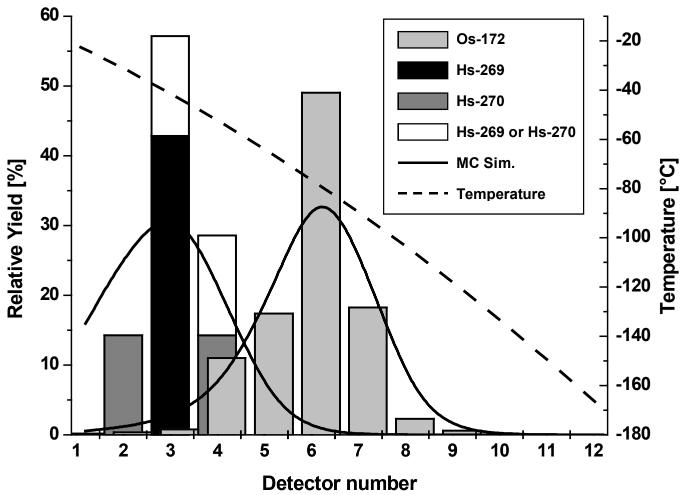

Fig. 1 Merged thermochromatograms of OsO_4 and HsO_4. The solid lines represent results of a Monte-Carlo Simulation with ΔH_{ads} values of -39.5 kJ·mol^{-1} (OsO_4) and -47 kJ·mol^{-1} (HsO_4), respectively. The dashed line indicates the temperature gradient.

assigned to ^{269}Hs were used for the simulation. $\Delta H_{ads}(HsO_4)$=(-47±2) kJ·mol^{-1} (68 % c.i.) was evaluated, compared to $\Delta H_{ads}(OsO_4)$=(-39.5±1.0) kJ·mol^{-1}. The latter value is in good agreement with $\Delta H_{ads}(OsO_4)$= (-38.0±1.5) kJ·mol^{-1} evaluated in earlier experiments.

With the formation of a very volatile oxide, presumably HsO_4, Hs behaves similar to Os, its next lighter homologue in group 8 of the periodic table.

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