Indication for a gaseous element 112

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The expected relativistic stabilization of the closed-shell electronic ground state lead to the prediction of noble gas like properties for element 112 [1]. Other prediction methods yielded a volatile noble metallic character [2,3]. First chemical investigations yielded evidence that element 112 does not behave like Hg at room temperature. An upper limit of the adsorption enthalpy (ΔH_{ads}) of element 112 on gold was deduced as $-\Delta H_{ads}^{Au}(E112) < 60$ kJ/mol. [4] Our experiment was designed to measure the adsorption enthalpy of element 112 on Au, which is decisive on whether it forms a metallic bond or a noble-gas like van der Waals interaction. So far, the only directly produced isotope of element 112 with a long enough half-life to be chemically characterised is ^{283}112. Recent results [5] show that this isotope can be produced in the nuclear fusion reaction ^{238}U(^{48}Ca,3n) with a cross-section of ~2 pb. It decays via spontaneous fission with $t_{½}$ ~5 min. At the UNILAC accelerator at GSI Darmstadt a ^{238}U target was irradiated with about $2.8 \cdot 10^{18}$ particles of ^{48}Ca. Volatile products of the nuclear reaction were thermalized in pure He and swept through a PFA capillary to a getter oven containing Ta and Ti metal and operated at 1000°C in order to remove traces of water and oxygen from the carrier gas. Subsequently, the still volatile products were swept to the thermochromatographic device COLD. The adsorption behaviour of element 112 in the COLD detector was compared simultaneously with that of ^{185}Hg produced in the nuclear reactions of ^{nat}Nd (admixture to the target) with ^{48}Ca and of ^{220}Rn, a transfer-product of the reaction of ^{238}U and ^{48}Ca. A detailed description of the experimental set-up and the detection technique is given in [6]. The measured distribution of ^{185}Hg and ^{220}Rn is presented in Fig. 1. Applying a kinetic Monte-Carlo based model of gas adsorption chromatography, a quantification of the adsorption enthalpy of Hg and Rn is possible. The deposition pattern of Hg on Au allows the determination of a lower limit of $-\Delta H_{ads}^{Au}(Hg) < 80$ kJ/mol, in good agreement with literature values [6]. The deposition pattern of ^{220}Rn is reproduced best assuming an adsorption enthalpy of $-\Delta H_{ads}(Rn) = 22 \pm 1$ kJ/mol, indicating an ice coverage at the cold end of the detector array. Moreover, analysis of the time dependent change of the α-spectra resolution of the detector yielded evidence for an ice layer formation at temperatures below about -90°C (see Fig. 2). 11 high energy (E > 35 MeV) events were measured during 16.8 days of experiment, at 3 expected background events. Their distribution along the detector array is presented in Fig. 2. A clear accumulation of 7 events was observed in the detectors #29-31. As no indications for actinide elements – possible transfer products of the ^{238}U with ^{48}Ca reaction – were found neither in the COLD nor in quartz wool filters situated just after the recoil chamber, most of the observed events have been tentatively assigned to the decay of ^{283}112. Presumably caused by ice layer the measured energies of the 7 events were lower than expected. Therefore, we interpret our result only as an indication for the observation of SF ^{283}112. A Monte-Carlo based statistical approach yielded the adsorption enthalpy of element 112 on ice surface $-\Delta H_{ads}^{ice}(E112) = 25 \pm 5$ kJ/mol (95% c.i.). Unfortunately, the adsorption of element 112 on ice does not allow conclusions about a chemical similarity either to Rn or to Hg. From the observed non adsorption of element 112 on gold down to temperatures of -90°C, an upper limit adsorption enthalpy of element 112 on Au $-\Delta H_{ads}^{Au}(E112) < 48$ kJ/mol was determined. This result reveals again a significantly weaker interaction of element 112 with Au compared to Hg.

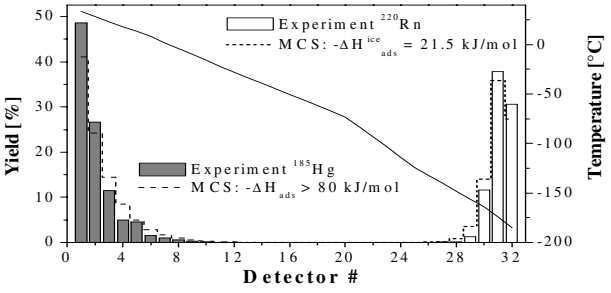

Fig. 1: Thermochromatogram of ^{185}Hg and ^{220}Rn (bars) measured along the detector array. Monte-Carlo simulations (dashed lines) are in good agreement with the experimental results. The temperature gradient is indicated (solid line).

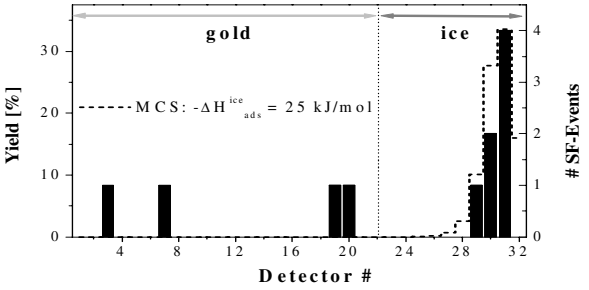

Fig. 2: Distribution of SF-fragments (black bars, right-hand scale) measured along the COLD. Monte-Carlo simulation is shown (dashed line, left-hand scale).

The upper limit of the adsorption enthalpy allows the estimation of an upper limit of the standard sublimation enthalpy of element 112 $\Delta H^0_{(g)}(E112) < 33$ kJ/mol [7], which is considered as a measure of its volatility. This result reveals element 112 to be more volatile compared to its homologue Hg and gaseous at standard conditions.

References

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