

# Model Experiments for the chemical investigation of element 112

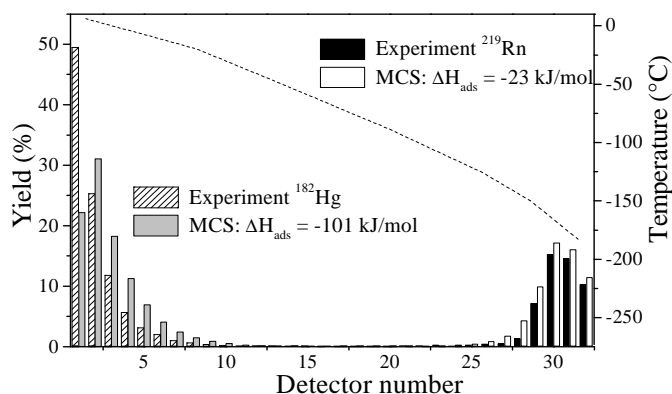
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The systematic order of the periodic table suggests that element 112 (E112) belongs to group 12, hence its electronic ground state configuration is assumed to be Rn:6d<sup>10</sup>7s<sup>2</sup>. Direct relativistic effects may result in a stronger binding of the electrons in the spherical relativistic s and p<sub>1/2</sub> orbitals. Due to this strong relativistic shell stabilization of the 7s orbital Pitzer [1] suggested in 1973 that E112 could behave as chemically inert as a noble gas. However, indirect relativistic effects imply a destabilization of the 6d electron orbitals, leading to a possible transition metal behaviour of element 112. In 1976 Eichler [2] predicted a noble metallic behaviour of E112, more similar to Hg. Therefore, the primary scientific goal of the chemical investigation of E112 must be the differentiation between a noble metallic character and a noble-gas like behaviour. The amount of the adsorption enthalpy of E112 on a metallic surface is decisive on whether a van der Waals interaction or a metallic bond with the surface is observed. Hence, an advanced version of the chemical separator IVO [3] suitable for the chemical investigation of the element 112 was developed. The set-up was tested on-line with short-lived Hg-isotopes, produced in nuclear fusion reactions of <sup>20</sup>Ne and Yb (enriched in <sup>168</sup>Yb) at the PHILIPS cyclotron at Paul Scherrer Institute, and with <sup>219</sup>Rn emanating from an <sup>227</sup>Ac source. The inner surface of the newly designed recoil chamber of IVO is completely covered by a quartz insert to inhibit an adsorption of a potentially metallic E112 on metal surfaces.

Dried 1 l/min He carrier gas flushes an <sup>227</sup>Ac source before entering the recoil chamber. Products of the heavy ion induced nuclear fusion reaction recoiling backwards out of the target are thermalized in this gas. Only gaseous products are swept out of the recoil chamber through an open quartz column. Subsequently, they were transported to a nearby oven with a quartz wool filter heated up to 850°C through a connected PFA-capillary. Aerosol particles produced in beam induced sputtering processes in the target material and in the beam dump are stopped in this filter. The volatile products pass this filter and a connected 10 m long PFA-capillary to a Ta-Ti-getter heated up to 1000 °C. Trace amounts of water are removed from the carrier gas by this getter. Subsequently, the remaining gaseous products enter the COLD thermochromatography. The new version of this device consists of 32 silicon PIN-photodiodes with 10 x 9.8 mm<sup>2</sup> active area mounted in a row at a distance of 1.6 mm opposite to an Au surface and forming a rectangular gas chromatographic column. Thus, a spectroscopy of  $\alpha$ - or SF-decay from atoms adsorbed on the Au surface is provided in 2- $\pi$  detection geometry. A temperature gradient from 6 °C to -183 °C is applied to the detector array (see Fig.1, dashed lines). The whole detector set-up is placed into a steel box, which is evacuated to 1 mbar in order to isolate it thermally and to eliminate the moisture from the surrounding air.

Similar to mercury the formation of a metal bond with a metallic Au surface is expected for element 112 [4]. Therefore, gold was selected as chromatographic surface. Furthermore, its chemical inertness to oxidation provides a clean metallic chromatographic surface. An over-all transport efficiency of 80 % was determined for <sup>186-190</sup>Hg at a transport time of less than 25 s. Separation factors of about 10<sup>6</sup> have been determined for lanthanides (model elements for the heavy actinides) in experiments with <sup>156</sup>Yb, produced in the reaction <sup>142</sup>Nd(<sup>20</sup>Ne, 6n). The deposition distributions of Hg and Rn in the detector array (grey and black bars, respectively) are shown together with results from Monte Carlo simulations (dashed and white bars, respectively) in Fig.1.



**Fig. 1:** Thermochromatograms of <sup>182</sup>Hg and <sup>219</sup>Rn on Au at a carrier gas flow of 1 l/min .

The spontaneous, diffusion controlled deposition of Hg ( $\Delta H_{\text{ads}} = -101$  kJ/mol [5]) on Au is well reproduced by a Monte Carlo simulation of gas chromatography. For Rn the deposition pattern is reproduced best assuming an adsorption enthalpy of  $\Delta H_{\text{ads}} = -23$  kJ/mol. In earlier thermochromatographic experiments with Rn in ice columns an adsorption enthalpy of -20 kJ/mol was determined [6]. The low adsorption interaction in the recent experiment indicates ice formation at least on the detectors 25-32 which are at temperatures below -135°C. This dew point corresponds to water contents in the carrier gas of less than 10 ppb. About 55 % of the Rn is deposited on the detector. Thus, the new COLD device encloses the adsorption range from metallic to Rn-like behaviour of element 112. Experiments to chemically investigate element 112 applying the described set-up are scheduled for February/March 2003 at GSI Darmstadt.

## References:

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