Chemical study of Fl, Cn, their lighter homologs, and Rn at TASCA*

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Chemical studies on superheavy elements (SHE) with closed electron shell configurations, Cn and Fl, address the question of how strong relativistic effects influence chemical properties. This is a challenging task from both physical and chemical points of view due to low production rates and a high background from volatile byproducts disturbing the safe identification of Cn and Fl decay chains. Up to now only a limited number of experiments has been performed, resulting in the identification of only a few decay chains assigned to Cn and Fl isotopes [1-4]. Several attempts on investigation of Fl were performed by a PSI-FLNR collaboration, resulting in the detection of three decay chains from Fl, two chains from ^{288}Fl and one from ^{287}Fl [2,4]. Two Fl atoms, one with the atomic mass number 288 and one with the atomic mass number 289, were observed in an experiment at TASCA [3]. Hence, the determined values of the adsorption enthalpy of Fl on Au are still fairly uncertain due to low statistics.

A new chemistry experiment with Fl was carried out at TASCA in 2014. For the production of ^{288,289}Fl a $^{48}Ca^{+10}$ beam (E_{lab} = 260 MeV) with an intensity of about $5\cdot10^{12}$ particles/s impinged on $^{244}PuO_2$ targets. They were electrodeposited on 2.5 µm thick Ti backing foils and had thicknesses of about 800 µg/cm^2 ^{244}Pu. A beam dose of about $2.6\cdot10^{18}$ was accumulated during 10 days of bombardment. TASCA was operated in the High Transmission Mode and its magnetic settings were adjusted to collect the ions with $B\cdot\rho$ = 2.27 T·m at the exit of TASCA, where a Recoil Transfer Chamber (RTC; 60x40x20 mm^3) was attached. The RTC inner surface was coated with a Teflon™ layer. Three COMPACT detector arrays (COMPACT[3]) were connected to the RTC exit in series. The first array was covered with a SiO_2 layer, and the two following ones with Au layers. All layers were 30-50 nm thick. The first two detector arrays were kept at room temperature (+22 °C). A negative temperature gradient from +22 °C to –162°C was applied along the last detector array. A He/Ar gas mixture (He:Ar = 70:30) was circulated in a gas loop and purified with Hydrosorb™ and Oxysorb™ cartridges and a hot titanium getter. The COMPACT arrays were connected to the RTC and to each other with about 20-cm long PTFE capillaries (2 mm inner diameter). In a preparatory experiment, short-lived Pb and Hg isotopes were produced with ^{144}Sm and ^{142}Nd targets, respectively, and ^{219}Rn was produced as a member of the ^{227}Ac decay chain. Prior to measuring their yields and distributions in COMPACT[3], the rates at which Pb and Hg entered the RTC were measured in a 60x40 mm^2 DSSSD mounted in the RTC position. Transport times and yields to COMPACT[3] were optimized with ^{182,183}Hg, due to much higher production rates compared to Pb isotopes. The use of three detector arrays in series allowed separating species with volatility and reactivity ranging from the non-volatile Pb, over the volatile metal Hg, to the noble gas Rn (Figure 1). Pb was adsorbed under diffusion-controlled deposition in the first COMPACT array. Mercury passed the SiO_2 array and deposited in the second array, on the gold surface, under diffusion controlled deposition. Radon adsorption started on the last detector array at very low temperature. The data on Cn and Fl are currently under evaluation.

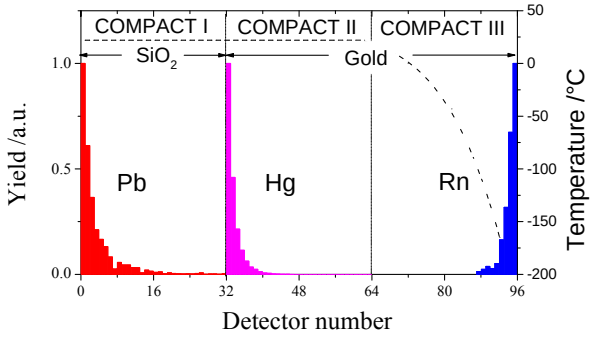

Figure1: Measured Pb, Hg and Rn distributions.

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