COMPACT Coupled to TASCA for Element 114 Chemistry*

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The unambiguous identification of new superheavy elements (SHE) is a very difficult task for both, physicists and chemists due to very low production rates, absence of a link to known isotopes, and unknown chemical, and decay properties. Chemical studies of SHE are of great importance because they can identify the proton number of the studied isotopes. Coupling of chemistry setups to physical recoil separators allows chemical experiments with extremely high sensitivity due to a strong suppression of unwanted byproducts in the preseparator [1]. At GSI, the new gas-filled separator TASCA has been put into operation in 2008. It is designed specifically for chemical studies of transactinides produced in nuclear fusion reactions of ^{48}Ca beams with actinide targets [2].

The highest cross section for SHE formation was observed in the reaction ^{48}Ca+^{244}Pu [3,4] leading to element 114 (E114). First attempts to chemically identify E114 were performed by a PSI-FLNR-LLNL collaboration in Dubna, and an unexpectedly low adsorption enthalpy of element 114 on gold was reported [5], in contradiction with theoretical predictions of the trend in the binding energy, E_b, Pb>>E114>Hg>E112 [6]. These studies were performed without preseparation, and the relatively high counting rate from unwanted byproducts led to controversially discussed results. An attempt to observe E114 in the chemistry experiment after preseparation failed [7].

A chemistry experiment with E114 was carried out at TASCA in 2009. Because the lifetimes of even the longest-lived E114 isotopes, ^{288,289}114, are short [4], TASCA was operated in the Small Image Mode (SIM) [2], which focuses fusion products into a small area of about ~30x40 mm^2. The lower transmission efficiency of SIM (~35%) compared to HTM (~60%) is compensated by the smaller volume of the Recoil Transfer Chamber (RTC), which allows a faster transport of products to a detection setup. During the experiment on the synthesis of ^{288,289}114 [4], the operation of TASCA in SIM was successfully tested with a focal plane detector. A beam dose of $0.98 \cdot 10^{18}$ ^{48}Ca ions at E*(^{292}114)=42 MeV was acquired and two ^{288}114 decay chains were observed. In the preparation of the experiment two RTCs made of Teflon™ were tested: a "small" one with a volume of 14 cm^3 and a "large" one with 29 cm^3. Transport times and yields to COMPACT [8] were optimized for both chambers with short-lived Hg and Pb isotopes produced with ^{40}Ar and ^{48}Ca beams. Transport times of 0.6 s and 0.8 s were measured at a gas flow rate 1.3 l/min for the "small" and "large" RTC, respectively. Three different He/Ar gas mixtures with ratios of 30:70, 50:50, and 70:30 were explored. The last one was selected for the E114 chemistry experiment. Two similar COMPACT detectors connected in series were used; each detector consisted of 32 pairs of 1x1 cm^2 PIN diodes covered with a 35-nm thick gold layer. The first detector, kept at the room temperature, was connected directly to the RTC exit via a 2-cm long Teflon™ tube. The second detector, connected via a 30-cm long Teflon™ capillary, was placed downstream of the first one; a temperature gradient from +20 to –162 °C was applied along it. The use of two detectors in series allows detecting species in a wide range of volatilities – from the non-volatile Pb to the noble gas Rn (Fig. 1). With this setup the adsorption enthalpy of short-lived ^{288,289}114 on gold was measured with relatively high efficiency under background-free conditions. The data are under evaluation.

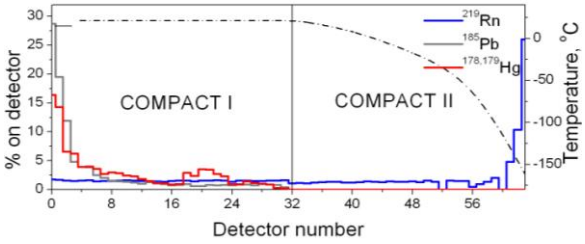

Figure1:Pb, Hg and Rn distributions in COMPACT.

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