

Development of an advanced version of the IVO-setup for future experiments with elements 112 and 114

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Relativistic effects are believed to be very strong in the region of the super heavy elements, thus, strongly affecting their chemical properties. According to their position in the periodic table, elements 112 and 114 should behave like noble metals but a noble gas character induced by the relativistic effects can not be excluded. Relatively stable isotopes of elements 112 and 114 were produced in Dubna with ^{48}Ca induced fusion reactions using ^{238}U and $^{242,244}\text{Pu}$, respectively, as targets [1]. A first experiment to investigate the chemical properties of element 112 was performed in February and March 2003 [2] using $^{283}\text{112}$ ($T_{1/2} = 5$ min, SF [3]) produced in the nuclear fusion reaction of ^{48}Ca with ^{238}U . The produced isotopes were adsorbed and detected in the COLD thermochromatography device. The results indicated a very volatile element 112. A drawback of the experiment was the ice layer, formed in the cold part of the set-up, on which element 112 was absorbed. The adsorption enthalpies of Hg, Rn, and element 112 are too close to each other in order to make statements about similarity of element 112 either to Rn or to Hg. Although, the non adsorption of element 112 on the free gold surface down to temperatures of about -90°C yield evidence for its very inert and volatile behavior. The ice layer interfered also an unambiguous determination of the energy of the spontaneous fission fragments from the decay of $^{283}\text{112}$ [2]. Hence, the next steps towards a further experiment must be: 1. to improve the COLD device to a 4- π -detection system, 2. to tighten the device and 3. to decrease the water content in the carrier gas.

A 4- π -COLD system with gold covered PIN Diodes is under development at PSI. Hence, we used for the first test experiments the 2- π -COLD, as it was used during the experiments with element 112. A first approach to a carrier gas with lower water content is the use of a gas-loop (see Figure 1). In order to keep the amount of water as low as possible the whole set-up is evacuated before the experiment. Once the system is filled with Ar-gas, the pump, the pressure sensor, and the buffer provide a constant gas flow up to 1.5 l/min. Getter ovens (Ta, 1000°C) are used to keep the gas loop dry during the experiment. Additionally, the investigation of short lived nuclides of element 112, produced in the reaction of ^{48}Ca with ^{244}Pu via the decay of isotopes of element 114 require a very small recoil chamber of only about 9 ml volume. In order to stop the recoiling products of the nuclear reaction in such small volume, Ar is used because of its higher stopping power compared to pure He, which was used before. The buffer is used in order to reduce the pulsation in the carrier gas caused by the metal bellow pump. A trap filled with charcoal is used in the gas loop, in order to trap all Rn isotopes, which are able to pass the COLD detector.

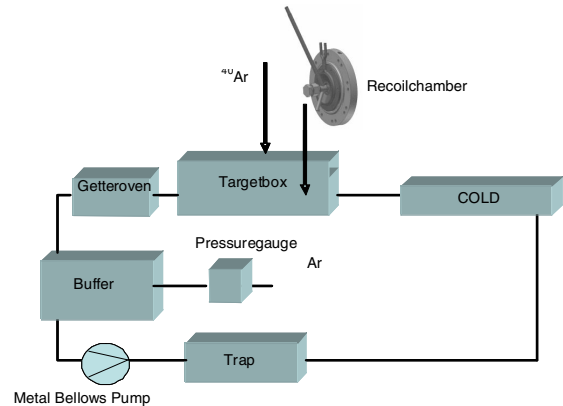


Fig. 1: Gas-loop set-up for future experiments with the elements 112 and 114

First experiments were done using ^{219}Rn ($T_{1/2} = 3.96$ s), which emanates from a ^{227}Ac -source. Rn was adsorbed at a temperature of about -180°C (see Figure 2). A Monte-Carlo simulation yielded an adsorption enthalpy of -20 kJ/mol, which is typical for the adsorption of Rn on ice.

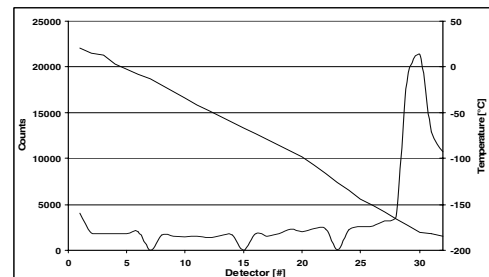


Fig. 2: Thermochromatogramm of ^{219}Rn on Gold/Ice

Notable is also the slight increase of in-flight decayed Rn at the beginning of the channel, which is probably induced by turbulences of the gas flow at the entrance of the COLD channel. The α -spectroscopic resolution in the last detectors remained in the order of 60 keV for more than 10 h experimental duration, indicating much less water content in the whole system compared to the experiments in [3]. Further experiments are envisaged at the PSI Philips cyclotron using model nuclides produced in the nuclear reaction $^{152}\text{Gd}(^{40}\text{Ar},6n)^{186}\text{Pb}(\alpha, 4.8\text{s}) \rightarrow ^{182}\text{Hg}(\alpha, 11\text{s})$.

References

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- [2] S. Soverna et al., see this report.
- [3] Yu. Ts. Oganessian et al., Eur. Phys. J. A (2004).