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Gas phase chemical studies of superheavy elements using the Dubna Gas-Filled Recoil Separator – stopping range determination

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The use of the Dubna Gas-Filled Recoil Separator (DGFRS) [1] as a pre-separation device for gas phase chemistry experiments with elements 112 and 114 led us to the task of reevaluating the stopping force (STF) of superheavy elements (SHE). In the experiment the DGFRS and the IVO-system [2] were separated by a thin Mylar window of variable thickness so that the evaporation residues (EVR) can pass it. The reaction product collection chamber (RPC-chamber), filled with gaseous argon and mounted behind the Mylar foil, had to be as small as possible to increase the transport efficiency to the thermochromatography detector COLD. Due to scarce availability, we measured STF data for Hg, Rn, and No in Mylar and gaseous argon at energies of around 30 to 50 MeV. These data were used for an extrapolation to the STF of the SHE 114.

Stopping force measurements

A 265 MeV Ca-48 beam was delivered from the U-400 cyclotron at the Joint Institute of Nuclear Research (JINR) in Dubna, Russia. The beam was passed through a 1.6 μm Ti window, a 1.6 μm Ti target backing into the target materials. Three different target materials were irradiated: neodymium oxide (nat. Nd₂O₃, 0.30 mg/cm²), dysprosium oxide (nat. Dy₂O₃, 0.33 mg/cm²) and lead (208Pb, 0.42 mg/cm², 1 μm Cu degrader in front). The mainly produced EVR's in the fusion of Ca-48 with target nuclei are according to HIVAPSI [3] Hg-185, Rn-206 or No-254, respectively. The EVR's were separated in the DGFRS according to their mass to charge ratio and guided on an exchangeable Mylar foil of 2, 3 or 5 μm thickness separating the RPC-chamber from the DGFRS. The RPC-chamber had a depth of 18 mm and was filled with thermalizing argon gas of a pressure between 0.0 and 0.4 bar. In the center of the focal plane of the separator at the back wall of the RPC-chamber a 20 x 20 mm silicon detector (PIN-diode) was mounted to detect the signals and the alpha decays of implanted products. Different data points were gained by varying the Mylar foil thickness and the argon gas pressure.

Extrapolation to element 114

For the extrapolation of the stopping range to 114 we used the assumption of proportionality of the STF of a heavy ion to the velocity dependent effective charge (q_{eff}) and the equivalent STF of a proton (epSTF) [4]. These epSTF 's which are uncorrected for any other STF terms, were plotted against $1/\ln(Z)$ an empirically established dependence of the STF on Z of the heavy ion. The obtained values were compared with the stopping code SRIM 2008 [5] and finally used to setup the gas chromatography experiment with elements 112 and 114. The results are accepted for publication [6].

References

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