Off-line single-atom gas chromatographic adsorption studies of lead and bismuth

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Complementing the experiments with the superheavy elements Fl and Mc, off-line gas chromatographic studies with their lighter homologs Pb and Bi using ^{211}Pb ($t_{1/2}$ = 36.1 min) and ^{211}Bi ($t_{1/2}$ = 2.14 min) were carried out. These radioisotopes were available as decay products of a ^{227}Ac source, which emanated the short-lived volatile ^{219}Rn. This, along with its progenies were flushed through a gas-filled volume, which served for thermalizing Fl and Mc evaporation residues in the corresponding on-line experiments. The “miniCOMPACT” gas chromatograph comprising a column of 16 pairs of silicon-dioxide-coated PIN diode detectors forming a narrow channel was used. Single Pb and Bi atoms entering the miniCOMPACT undergo diffusion and adsorption/desorption steps, depending on their volatility and reactivity towards the detector surface material. Finally, the alpha decays of ^{211}Bi mark the final positions of these atoms in the column. By employing the spatial resolution along the column, internal chromatograms were obtained and were recorded as a function of experimental parameters like carrier gas type (He, Ar, SF_6, O_2), gas flow rate (1 - 3 L/min) and pressure (500 - 1000 mbar), thus characterizing the novel miniCOMPACT detector array and aiding to optimize the conditions for experiments with superheavy elements. The obtained chromatograms were compared to Monte-Carlo-Simulations to extract the interaction strength expressed in the form of the adsorption enthalpy. Pb and Bi showed the expected high reactivity towards the silicon dioxide surface of the miniCOMPACT; correspondingly, lower limits were extracted for the absolute values of the adsorption enthalpies. Furthermore, experiments with oxygen as a reactive gas were carried out. No measurable differences in the distribution were found. Due to the strong interaction, lower limits for these values were obtained.