Superheavy Element Flerovium is the Heaviest Volatile Metal

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Electron shells of superheavy elements (SHE), i.e., elements with atomic numbers $Z \geq 104$, are influenced by strong relativistic effects caused by the high value of Z. Early atomic calculations for element 112 (copernicium, Cn) and element 114 (flerovium, Fl) predicted them to have closed and quasi-closed electron shell configurations, respectively, and to be noble gas-like due to very strong relativistic effects [1]. Recent fully relativistic calculations studying Cn and Fl in different environments suggest them to be less reactive compared to their lighter homologues in the groups, but still exhibiting metallic character (see, e.g., [2]). Experimental gas-chromatography studies on Cn have, indeed, revealed a metal-metal bond formation with gold [3]. In contrast to this, for Fl, the formation of a weak physisorption bond with gold was inferred from first experiments [4].

A gas chromatography experiment on Fl at TASCA was conducted subsequently to the study of the reaction ^{244}Pu(^{48}Ca; 3,4n)^{289,288}Fl [5]. The coupling of chemistry setups to a recoil separator promises extremely high sensitivity due to strong suppression of background from unwanted species. TASCA was operated in the Small Image Mode, focusing the products into a Recoil Transfer Chamber (RTC) of 29 cm^3, from where they were flushed within 0.8 s to a detection setup (Fig. 1). Two COMPACT detectors [6] connected in series were used; each detector consisted of 32 pairs of 1x1 cm^2 PIN diodes covered with a 35 nm gold layer. The first detector was connected directly to the RTC exit and kept at room temperature.

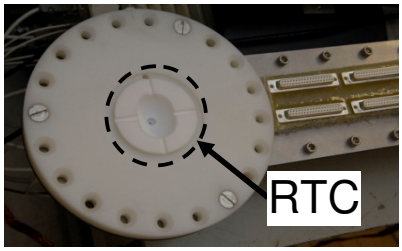

Fig.1: First COMPACT with the attached RTC.

A negative temperature gradient from +20 to −162 °C (Fig. 2, panel a) was applied in the second detector channel placed downstream to the first one. The use of two detectors in series allowed the detection of species in a wide volatility range – from the non-volatile Pb, the nearest homolog of Fl in the group, to the noble gas Rn. Two decay chains, one from ^{288}Fl and one ^{289}Fl were detected. Both decays from Fl isotopes occurred in the first detector channel at room temperature. The positions of decay chain members are shown in Fig. 2 (e) together with the Monte Carlo simulated deposition peak for ^{285}Cn (dashed line). Distributions of Pb, Hg, and Rn (Fig. 2, b-d) are also shown for comparison. The observed behavior of Fl in the chromatography column is indicative of Fl being less reactive than Pb. The evaluated lower limit of the adsorption enthalpy $-\Delta H_{ads}^{Au} > 48 kJ/mol$ reveals formation of a metal-metal bond with Au, which is at least as strong as that of Cn, and thus demonstrates the metallic character of Fl.

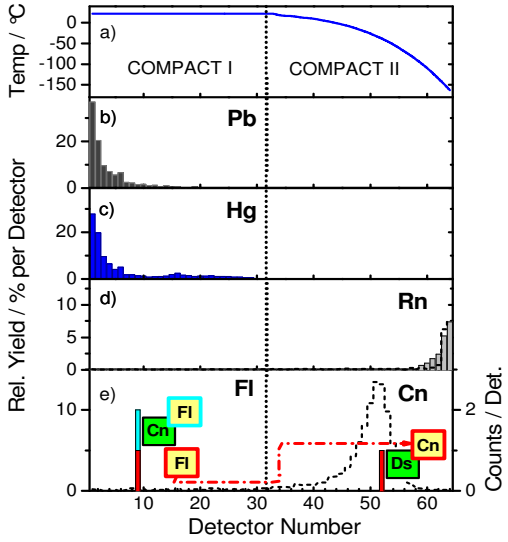

Fig. 2: The observed gas-chromatography behavior of Fl and Cn in COMPACT compared to those of Pb, Hg and Rn.

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