Recoil transfer chamber for polonium production, a lighter homolog of livermorium (Z=116)

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The chemistry of superheavy elements is largely unknown. Due to low production rates, chemistry must be performed on a single atom at a time. A method for beginning to study the chemistry of superheavy elements is to use lighter homologs, including polonium (Po, Z=84), the expected lighter homolog of livermorium (Lv, Z=116). Typical superheavy element experiments are performed in the gas phase, so to utilize Po as a lighter homolog, a steady stream of gas phase Po must be produced. In the present work, a recoil transfer chamber (RTC) has been modified to act as a source of gas-phase Po. RTCs are gas stoppers that are used after a physical pre-separator during cyclotron-based experiments to thermalize evaporation residues for the study of the chemistry of superheavy elements and their homologs [1]. Preliminary results on the use of an RTC as a source of Po are presented here.

At Texas A&M University, two RTCs have been fabricated, the "big" RTC and the simple RTC (sRTC). The big RTC was designed to stop product beams from the Momentum Achromat Recoil Spectrometer (MARS), and has been described in previous work [2]. The big RTC consists of two chambers. The first is the main chamber (MC) and consists of a set of ring electrodes and a set of flower petal electrodes, as well as an extraction nozzle. A decreasing electric field can be placed on the electrodes. The second chamber is called the aerosol (AC chamber). Two Canberra large-area (~2000 mm^2), bakeable Si detectors capable of operating at high pressures are in place, one in the MC chamber and one in the AC chamber. A 0.67 μCi ^{228}Th source ($t_{1/2}$ = 1.91 y, ~100% α) is mounted to the front window. The source emanates ^{220}Rn ($t_{1/2}$ = 55.6 s, 100% α), which decays to positively charged ^{216}Po ($t_{1/2}$ = 145 ms, 100% α). The ^{216}Po is extracted by the decreasing electric field created by the electrodes to the extraction nozzle. A helium gas jet carries the activity through the nozzle to the AC chamber, where it can be measured with the AC detector.

The data show that when the electric field is turned on and the pressure is set to the proper values (MC chamber: 228 torr, AC chamber: 218 torr), extraction of ^{216}Po can be observed. A typical ^{228}Th α-spectrum can be seen in Fig. 1a. The ^{212}Po peak has a tail from a summed β^- decay from ^{212}Bi. ^{228}Th and ^{224}Ra are trapped within the source, and while 220Rn is immediately neutralized, it can emanate into the MC. It then decays to charged ^{216}Po, and the latter is extracted because it has a half-life that is short compared to the neutralization time. When the RTC is fully operational, where there is a difference in pressure of 10 Torr between the two chambers, there is a decreasing electric field applied to the electrodes, and the flow rate of He from the system is 2 L/min, ^{216}Po is extracted, as seen in Fig. 1b. The ^{216}Po alpha-peak is broadened and significantly more intense than the rest of the peaks in the spectrum. There are small amounts of the other isotopes in the source present in the spectra (visible at 6200 keV), that are coming directly from the source. This indicates that the primary species being extracted is ^{216}Po, and the other isotopes present in the source are not being extracted in any appreciable quantities. During a typical extraction experiment, the ^{216}Po count rate is >90 s^{-1}. Future work will utilize this source for

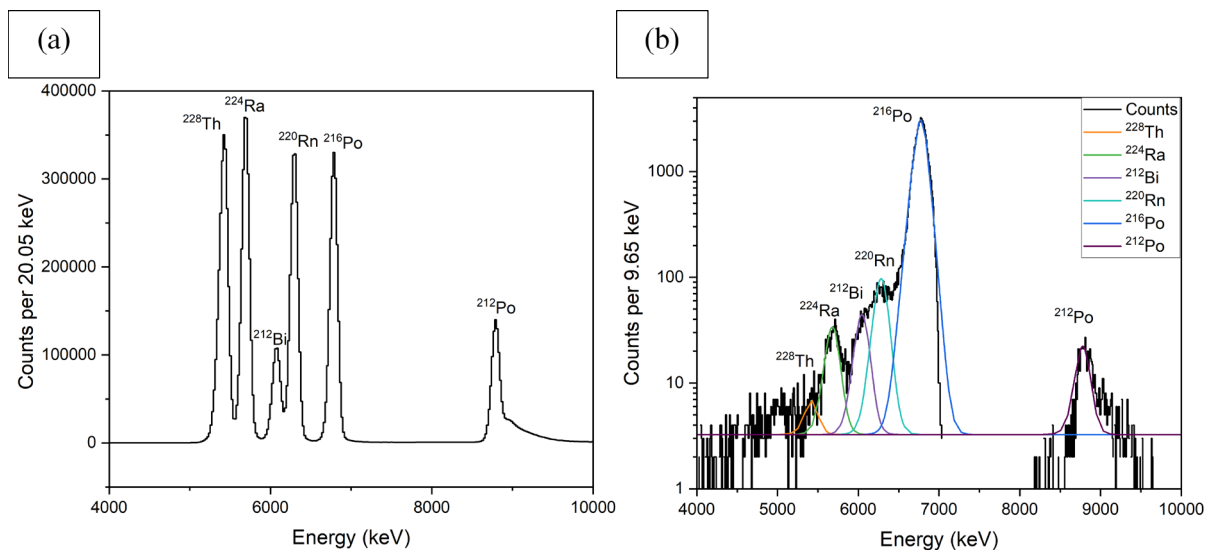chemical experiments on the adsorption of Po onto Si detectors functionalized with a self-assembled monolayer.

Fig. 2. (a) Typical ^{228}Th spectrum. (b) Spectrum of ^{228}Th where the big RTC was fully operational, meaning the gas flow and electric field were turned on. The primary peak is ^{216}Po, with limited amounts of the other nuclides present. The count time was 10 min.

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