Preparation of ^{249}Cf targets from pre-used material

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For the synthesis of the new element with atomic number Z = 120, the fusion reaction of ^{50}Ti with ^{249}Cf was studied at the gas-filled recoil separator TASCA [1]. Pre-used ^{249}Cf, originating from the decay of ^{249}Bk, was provided by the Lawrence Berkeley National Laboratory to produce suitable targets.

The chemical form of the delivered ^{249}Cf was either the oxide, chloride or the nitrate. In a first step the material was dissolved in 8 M HCl. The ^{249}Cf solution contained Al, Fe, Pb and Ti as impurities. In a first purification step the anion-exchanger BioRad AG MP-1M was applied to remove Al and Fe from the solution. In the second step a cation exchange column with DOWEX 50WX8 was used for the removal of Pb and Ti. Over both purification steps the Cf recovery was almost 100 %.

A rotating target wheel assembly was used, which was previously tested to accept high beam intensities up to 2 µA (particle). Molecular plating (MP) [2] was employed for the preparation of ^{249}Cf layers on ~2.2-µm thick Ti backing foils produced by cold rolling at GSI.

The average foil thickness was determined by weighing, whereas the homogeneity of the foil thickness was checked by α-particle energy-loss measurements over 5 positions per foil. The standard deviation of the foil thickness varied between 0.03 and 0.14 µm.

The deposition parameters for Cf were optimized in experiments with Gd. This also included MP with ^{153}Gd-tracer to verify the homogeneity of the Gd layer using a commercial radiographic imager [3] (FLA 7000 from FUJIFILM Corp.).

The first step in the MP of Cf was the conversion of the Cf chloride into the nitrate by evaporation to dryness and re-dissolution in 8 M HNO_3. An aliquot of the Cf-solution with about 3 mg of ^{249}Cf (455 MBq) was evaporated to dryness in a Teflon™ beaker. The green residue was re-dissolved in a small volume (100 µl) of 0.1 M HNO_3. The solution was transferred into an electrochemical deposition cell (EDC) made of PEEK. The beaker was washed with 3 x 300 µl isopropanol, which was also transferred to the EDC. The EDC was filled up to a volume of 52 ml with isobutanol. For the mixing during the deposition process an ultrasonic stirrer was used [3]. For the MP of ^{249}Cf with a surface of 6 cm^2 a voltage of 200 – 600 V at a maximum current density of about 0.3 mA/cm^2 was applied. The deposition time was 4 – 5 hours. The deposition yield exceeded 90 %. Fig. 1 shows one of the produced target segments.

Figure 1: Cf target-segment

Prior to the production of ~0.5-mg/cm^2 thick ^{249}Cf targets, a thin ^{249}Cf target was prepared. With this target we tested the deposition parameters. Before the deposition, and in 1-h steps during the MP process, 10 µl aliquots of the ^{249}Cf-solution were evaporated to dryness for α-particle spectroscopy. With these measurements the decreasing Cf content in the solution during the deposition was determined as well as the deposition yield.

As a method for the yield determination, γ spectroscopy was used. For this, the thin ^{249}Cf target served as a reference sample. The distance from the target to the γ detector was about 3 m, the dead time was 5%. The data confirmed a thickness of ~0.5-mg/cm^2, and the final analysis of the thickness values, including measurements performed after the element 120 experiment [1], is in progress.

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References

[1] Ch.E. Düllmann et al., this scientific report (2012).
[2] K. Eberhardt et al., Nucl. Instrum. Meth. Phys. Res. A590, 134 (2008).
[3] A. Vascon et al., Nucl. Instrum. Meth. Phys. Res. A655, 72 (2011).