Preparation of ^{249}Bk targets

J. Runke[1], R.A. Boll[2], Ch.E. Düllmann[1,3,4], K. Eberhardt[3,4], B. Kindler[1], B. Lommel[1], C. Mokry[3], J.B. Roberto[2], K.P. Rykaczewski[2], P. Thörle-Pospiech[3], N. Trautmann[3], A. Yakushev[1]

[1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany; [2]Oak Ridge National Laboratory, Oak Ridge, TN, USA; [3]Johannes Gutenberg-Universität Mainz, Germany; [4]Helmholtz-Institut Mainz, Germany

In the year 2012 two long experiments to synthesize the elements 119 and 117 have been performed at the gas-filled recoil separator TASCA at GSI. In both experiments ^{249}Bk was used as the target material, which was bombarded with ^{48}Ca for the synthesis of element 117 and ^{50}Ti to search for the new element 119.

For this, a ^{249}Bk target-wheel was used [1]. 12.7 mg ^{249}Bk in form of the nitrate were provided by Oak Ridge National Laboratory. The target segments were produced by Molecular Plating (MP) with high deposition yields at the Institute for Nuclear Chemistry at the University of Mainz [2,3].

The total amount of ^{249}Bk was delivered in four quartz vials covered with a Teflon septum. This septum was penetrated with a syringe containing 100 µl 0.1 M HNO_3 to dissolve the ^{249}Bk nitrate prior to the MP. After complete dissolution, the solution was transferred into the electrochemical deposition cell (EDC). The quartz vial was washed with 1 ml isopropanol and this solution was also transferred to the EDC. Finally 51 ml isobutanol were added.

The EDC [3,4] is made from polyether-etherketone (PEEK). On one side of the EDC, the target backing - a thin (~2 µm) Ti-foil produced by cold rolling and glued on an Al frame at the GSI Target Laboratory - was mounted and acted as the cathode. As an anode, a Pd-foil in the same geometry as the target frame was used. The EDC was clamped between two water cooled Ti blocks. For the mixing of the ^{249}Bk solution, an ultrasonic stirrer was applied. The deposition parameters for ^{249}Bk were similar to those for ^{249}Cf targets produced in 2011 [5], i.e., a current density of 0.3 mA/cm^2 was applied, resulting in voltages of 300 to 600 V. After deposition times of 3 to 4 hours target thicknesses of 354±18 – 508±25 µg/cm^2 with deposition yields exceeding 90 % were obtained.

The deposition yield and kinetics were determined by α-particle and γ-ray spectroscopy. Prior to the start of the deposition and then in one hour steps during the deposition, 10 µl aliquots of the supernatant solution were evaporated to dryness and measured by α-particle spectroscopy. Due to the rather short half-life of ^{249}Bk, its daughter, ^{249}Cf, is also present in the solution. Because both isotopes have α branches with significantly different α-particle energies, the deposition of both elements can be followed simultaneously in this way. The deposition kinetics of ^{249}Bk and ^{249}Cf are very similar. This allows the determination of the ^{249}Bk target thickness also via the γ-rays from ^{249}Cf, which is not possible for ^{249}Bk directly due to the absence of suitable γ-lines. For the determination of the deposition yield by γ-ray spectroscopy, a thin ^{249}Bk target was used as reference sample. The results of the yield determination by α-particle and γ-ray spectroscopy are in good agreement with each other. The average thickness of the target on the day of production was 463±23 µg/cm^2. The target segments were delivered to GSI and mounted on a target-wheel as shown in Fig. 1. The produced ^{249}Bk targets were able to resist a high total beam dose with beam intensities of over 4 particles microAmp for a long time.

Figure 1: ^{249}Bk target-wheel

Acknowledgments:
We are very thankful to the Oak Ridge National Laboratory for providing ^{249}Bk. The authors thank the Target Laboratory at GSI for providing the Ti-backing foils and the Mechanical Workshop of the Institute for Nuclear Chemistry in Mainz for the construction of the plating cells. This work was supported by the Helmholtz Institute Mainz.

References

[1] Jäger E, et al. (2012) submitted to J. Radioanal. Nucl. Chem.
[2] Eberhardt K, et al. (2008) Nucl. Instrum. Meth. Phys. Res. A 590:134-140
[3] Runke J, et al. (2012) submitted to J. Radioanal. Nucl. Chem.
[4] Haba H, et al. (2006) RIKEN Accel. Prog. Rep. 39:109
[5] Düllmann ChE, et al., GSI Sci. Rep. 2011 (2012), p. 206, PHN-NUSTAR-SHE-02