Production of ^{266}Bh in the ^{248}Cm(^{23}Na, 5n)^{266}Bh reaction and its decay properties†

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The decay properties of the neutron-rich and long-lived isotopes ^{267}Bh and ^{266}Bh, which are located around the deformed shell at $Z = 108$ and $N = 162$, were studied in the ^{249}Bk(^{22}Ne, 5;4n)$^{266,\,267}$Bh,[1] ^{209}Bi(^{70}Zn, n)^{278}Nh $\rightarrow$ ^{274}Rg $\rightarrow$ ^{270}Mt $\rightarrow$ ^{266}Bh,[2] ^{243}Am(^{26}Mg, 3n)^{266}Bh,[3] and ^{248}Cm(^{23}Na, 5;4n)$^{266,\,267}$Bh[4] reactions. However, the reported decay properties such as α energies and half-lives of the isotopes are not in good agreement. In this work, we investigated the excitation functions and decay properties of ^{266}Bh and ^{267}Bh via the ^{248}Cm(^{23}Na, 5;4n)$^{266,\,267}$Bh reactions using the GARIS gas-jet and MANON setups.[5]

$^{248}Cm_2O_3$ targets of 256–290 μg/cm^2 thicknesses on 2-μm Ti backing foils were bombarded with a ^{23}Na^{7+} beam extracted from the RIKEN Heavy-Ion LINAC. The beam energies at the middle of the target were 121.2, 125.9, 130.6, and 135.3 MeV. The typical beam intensity was 3 pμA. The evaporation residues (EVRs) of interest were separated in-flight from the beam particles and the majority of the nuclear transfer products by GARIS. At the focal plane of GARIS, the EVRs passed through a Mylar vacuum window foil of 0.7-μm thickness and entered the gas-jet chamber, where the EVRs were thermalized in He gas, attached to KCl aerosol particles, and transported through a Teflon capillary (2.0-mm *i.d.* × 10-m length) to the rotating wheel apparatus MANON for α/SF-spectrometry. In MANON, the aerosol particles were deposited on a Au-coated (5 nm) Mylar foil of 0.5-μm thickness, forty of which were set on the periphery of a rotating wheel. The wheel was stepped to position the foils between 15 pairs of Si PIN photodiodes (Hamamatsu S3204-09). The step intervals of MANON were set to 5.0, 8.5, and 15.0 s.

We searched for time-correlated α-α and α-SF event pairs in a time window of 340 s. Consequently, a total of 23 chains were assigned to ^{266}Bh, its daughter nuclide ^{262}Db, and granddaughter ^{258}Lr, while no chain was assigned to ^{267}Bh. The α-particle energies of ^{266}Bh disperse widely in the range of E_α = 8.62–9.40 MeV. The reported α groups of E_α = 9.29 MeV,[1] E_α = 9.08 and 9.39 MeV,[2] E_α = 9.03 MeV,[3] and E_α = 8.82, 8.84–8.99, and 9.05–9.23 MeV[4] for ^{266}Bh are all within our α-energy range, except for E_α = 9.77 MeV.[2] The half-life of ^{266}Bh was measured to be $T_{1/2} = 10.0^{+2.6}_{-1.7}$ s, which is an order of magnitude longer than the previously reported values of $T_{1/2} \simeq 1$ s[1] and $T_{1/2} = 0.66^{+0.59}_{-0.26}$ s,[3] and 5 times longer than $T_{1/2} = 2.1^{+2.9}_{-0.8}$ s.[2] As shown in Fig. 1, the excitation function for the ^{248}Cm(^{23}Na, 5n)^{266}Bh reaction was measured for the first time, and it indicates a maximum of $\sigma = 57 \pm 14$ pb at 130.6 MeV. The excitation function was reproduced by the statistical model code HIVAP.[6] The upper-limit cross section of $\sigma \leq 14$ pb was also derived for the ^{248}Cm(^{23}Na, 4n)^{267}Bh reaction at 121.2 MeV.

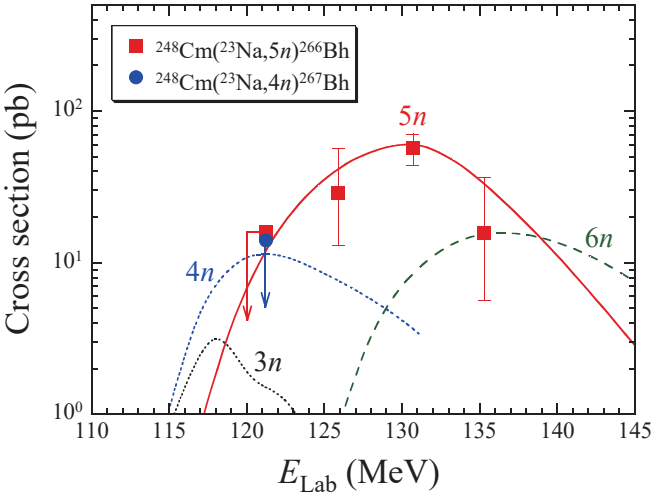

Fig. 1. Cross sections for the ^{248}Cm(^{23}Na, 5;4n)$^{266,\,267}$Bh reactions as a function of the laboratory-frame energy $E_{\rm Lab}$. The curves are the HIVAP calculations[6] for the ^{248}Cm(^{23}Na, $x n$)$^{271-x}$Bh reactions (x = 3–6).

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