Production of ^{262,263}Db in the ^{248}Cm(^{19}F,xn)$^{267-x}$Db reactions at $E_{\mathrm{lab}} = 96$ MeV

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The isotope ^{262}Db ($T_{1/2}$ = 33.8 s[1)]) is often used in the chemical studies of element 105, Db. At RIKEN, the decay properties of ^{262}Db produced in the ^{248}Cm(^{19}F,5n)^{262}Db reaction were recently studied with a gas-jet transport system coupled to the gas-filled recoil ion separator GARIS.[1)] In this study, however, ^{263}Db produced in the 4n channel was not observed at 97.4 MeV and 103.1 MeV. The upper-limit cross sections of ^{263}Db were rather smaller than those predicted by the HIVAP code, which reproduced the 5n channel fairly well. Therefore, in this work, we investigated the production of Db isotopes at a lower energy of 96 MeV, at which the predicted excitation function for ^{263}Db exhibits the maximum.

A ^{248}Cm$_2$O$_3$ target of 460 μg/cm^2 thickness was prepared by electrodeposition onto a Be backing foil of 1.8-mg/cm^2 thickness. $^{\mathrm{nat}}$Gd$_2$O$_3$ of 23-μg/cm^2 thickness was admixed with the target material to simultaneously produce ^{170}Ta ($T_{1/2}$ = 6.76 min) via the $^{\mathrm{nat}}$Gd(^{19}F,xn)^{170}Ta reaction. A ^{19}F^{7+} beam was supplied by the AVF cyclotron. The beam energy at the middle of the target was 96.2 MeV, and the energy degradation in the target was estimated to be 1.0 MeV. The average beam intensity was 450 pnA.

The reaction products recoiling out of the target were continuously transported by a He/KCl gas-jet system to the rotating wheel detection system MANON. The transport efficiency was estimated to be 74%. Other details of the measurement were similar to those in our previous study.[2)]

We searched for time-correlated α-α event pairs at the α-energy range of $8.0 \leq E_\alpha \leq 9.0$ MeV. On setting the time window to 25 s, 16 α-α correlations were found. Figure 1(a) shows the two-dimensional arrays of these α-α correlations. In Fig. 1(a), 74 α-α correlations assigned to the decay chain $^{262}\mathrm{Db} \xrightarrow{\alpha} {}^{258}\mathrm{Lr} \xrightarrow{\alpha}$ in the previous experiment[1)] are compared. The α-particle spectra of the parent and daughter nuclides are shown in Figs. 1(b) and (c), respectively. For the parent α spectrum, the 8.46-MeV α line of ^{262}Db is seen, while the 8.68-MeV α line was not very clear owing to the low counting statistics. On the other hand, the α lines of ^{258}Lr were clearly found in the daughter α spectrum.

In Fig. 1(a), a solid box indicates the gated α-energy range of the parent ^{262}Db (8.26–8.83 MeV) and the daughter ^{258}Lr (8.36–8.80 MeV). Fourteen events are found in this energy region. The deduced half-life of the daughter nuclide, $T_{1/2} = 4.5^{+1.7}_{-1.0}$ s, is in agreement with the reported half-life of ^{258}Lr, $T_{1/2}$ = 3.9 s.[3)] Thus, these events are attributed to the α decay chain $^{262}\mathrm{Db} \xrightarrow{\alpha} {}^{258}\mathrm{Lr} \xrightarrow{\alpha}$. The expected number of random correlations was evaluated to be 0.3 in this energy region. Regarding all 14 events as true ones, the production cross section of ^{262}Db is derived as $\sigma = 0.25^{+0.08}_{-0.07}$ nb. This cross section is consistent with the previously reported one, $\sigma = 0.23^{+0.18}_{-0.11}$ nb at 97.4 MeV.[1)]

Only one α-α correlation was found around the energy regions of ^{263}Db and its α-decay daughter ^{259}Lr, as shown by an arrow in Fig. 1(a). Although this number of the event, one, is comparable with the expected number of random events, the deduced half-life of the daughter nucleus, $T_{1/2} = 3.1^{+14.8}_{-1.4}$ s, is consistent with the reported half-life of ^{259}Lr ($T_{1/2}$ = 6.2 s[3)]). If this event is regarded as a true one, the cross section of ^{263}Db is deduced to be $\sigma = 0.031^{+0.072}_{-0.026}$ nb, which is one order of magnitude smaller than that of ^{262}Db as well as the HIVAP predictions.[1)]

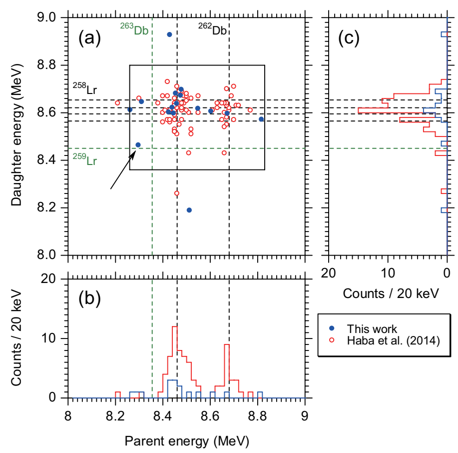

Fig. 1. (a) Two-dimensional representation of time-correlated events. (b) α spectrum of parent nuclei. (c) α spectrum of daughter nuclei.

References

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