Cross-section measurement of the ^{248}Cm(^{19}F,5n)^{262}Db reaction

M. Murakami,[*1,*2] S. Goto,[*1] K. Ooe,[*1] S. Tsuto,[*1] R. Aono,[*1] H. Haba,[*2] M. Huang,[*2] J. Kanaya,[*2] S. Shibata,[*2] and H. Kudo[*1]

The isotope ^{262}Db ($T_{1/2}$ = 33.8 s[1]) is used in the chemical studies of element 105, Db. One of the commonly used direct synthetic routes of ^{262}Db is the reaction of ^{19}F with ^{248}Cm. Few cross sections are available for this reaction, but there is a large discrepancy among these data. Dressler et al.[2] reported a production cross section of $0.26^{+0.15}_{-0.09}$ nb at 106.5 MeV. Nagame et al.[3] reported a cross section of 1.3 ± 0.4 nb at nearly the same energy, 106 MeV. The same group also reported a maximum cross section of 1.5 ± 0.4 nb at 103 MeV.[4] Thus, the cross-section data are inadequate, and the optimal beam energy to produce ^{262}Db is not clear. Therefore, we plan to measure the excitation function of the ^{248}Cm(^{19}F,5n)^{262}Db reaction to effectively produce ^{262}Db for the future chemical experiments of Db. First, in this work, we produced ^{262}Db at 102 MeV.

A $^{248}Cm_2O_3$ target of 460-μg/cm^2 thickness and 9-mm diameter was prepared by electrodeposition onto a Be foil of 1.8-mg/cm^2 thickness. $^{nat}Gd_2O_3$ 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 ^{nat}Gd(^{19}F,xn)^{170}Ta reaction. A $^{19}F^{7+}$ beam of 124.9 MeV supplied by the AVF cyclotron was passed through a 3.2-mg/cm^2 Be vacuum window, 0.10 mg/cm^2 of He cooling gas, and the Be backing foil before it entered the target. The primary beam energy was measured using time-of-flight apparatus. The beam energy at the middle of the target was 101.9 MeV, and the energy degradation in the target was estimated to be 1.0 MeV. The average beam intensity was approximately 440 pnA.

The reaction products recoiling out of the target were stopped in 102.0-kPa He gas in the recoil chamber, attached to KCl aerosols generated by sublimation of KCl powder at 640°C, and continuously transported with a flow rate of 2.5 L/min to the rotating wheel detection system MANON (Measurement system for Alpha-particle and spontaneous fissioN ONline) through a 8.6-m Teflon capillary with 1.59-mm inner diameter. MANON has 7 pairs of Si PIN photodiodes, and the counting efficiency of each photodiode was 38%. In MANON, the aerosols were deposited on Mylar foils of 0.5-μm thickness, 40 of which were set on the periphery of a rotating wheel 420 mm in diameter. The gas-jet transport efficiency was estimated to be 53.5 ± 2.0% by comparing the collected yields of ^{170}Ta on the 10-μm Be catcher foil placed immediately behind the target and on the Al foil set to the position of the Mylar foil in MANON. After the aerosol collection, the wheel was stepped at 20-s nominal interval to move the foils between the detector pair. Because the long-lived activities were accumulated during the irradiation, the wheels containing the Mylar foils were replaced every 6 h. While exchanging the wheels, the aerosols were collected on the glass filters in the collection chamber, and the glass filters were subjected to γ-ray spectrometry to verify whether the yields of ^{170}Ta were stable.

Figure 1 shows the sum of the measured α-spectra in the 2nd–7th top detectors, corresponding to a time interval of 20–140 s. A beam dose of 1.91 × 10^{17} was accumulated. In Fig. 1, α events of ^{262}Db (α branch b_α = 48%, α energies E_α = 8.46 MeV (70%) and 8.68 MeV (30%)[1]) and its daughter nuclide ^{258}Lr ($T_{1/2}$ = 3.9 s, b_α = 97.4%, E_α = 8.565, 8.595, 8.621, and 8.654 MeV[5]) are clearly recognized. However, α lines of by-products such as Po isotopes are also observed in the α-energy region of ^{262}Db and ^{258}Lr. Analyses of the time-correlated α-α pairs are needed to extract the decay chains of ^{262}Db $\xrightarrow{\alpha}$ ^{258}Lr $\xrightarrow{\alpha}$. Further analyses of the obtained data are in progress.

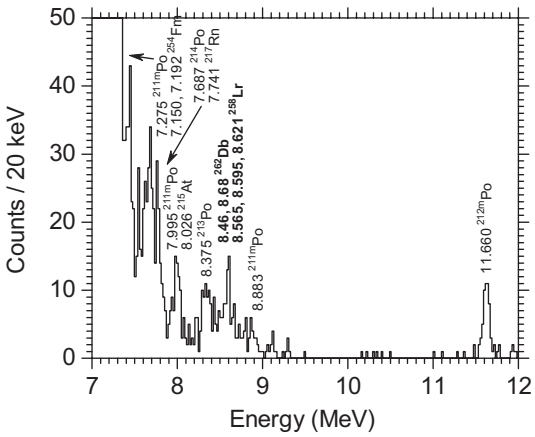

Fig. 1. Sum of α spectra measured in the 2nd–7th top detectors of MANON.

References

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*1 Department of Chemistry, Niigata University
*2 RIKEN Nishina Center