Production of Lv isotope in the hot fusion reaction of ^{248}Cm+^{48}Ca at E^*=38.4 MeV

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In 2013, a gas-filled recoil ion separator (GARIS) was employed to study the production of Lv (Livermorium, Z=116) isotopes in the hot fusion reaction of ^{248}Cm+^{48}Ca at the excitation energy of compound nucleus E^*=41.5 MeV[1)]. As a result, five correlated decay chains were observed. On the basis of the assignments of the precedent studies[2–4)], two of the events were attributed to the decays of ^{293}Lv (3n), and three of them were assigned to the decays of ^{292}Lv (4n). With the aim of clear identification of these nuclides, we started to measure the excitation function in the reaction of ^{248}Cm+^{48}Ca → ^{296}Lv*.

The experimental setup was almost the same as that used in our previous work[1)] using ^{48}Ca^{11+} beam with 261.6 MeV. In this work, the ^{248}Cm target was irradiated with a 258 MeV ^{48}Ca^{11+} beam from RIKEN heavy-ion linear accelerator RILAC. Total beam dose was 5.0×10^{18} during a net irradiation time of 14.2 days. The average beam intensity on the target was 0.68 particle μA. The reaction products were separated in-flight from projectiles and other by-products using GARIS, and then they were guided into the focal plane detection system after they passed through the time-of-flight (TOF) detector[5)]. The separator was filled with He gas at 73 Pa. Magnetic rigidity for measuring the Lv isotope was set to be 2.174 Tm. Then, the typical trigger rate at the focal plane was 58 cps at 0.89 particle μA.

Seventy-three events, which were anti-coincided with TOF detectors, with energies above 100 MeV were observed. Two events among their fission events were found to be correlated with preceding α-particles and implanted evaporation residue (ER). Observed decay chains are shown in Fig. 1. The first chain, which was observed on September 22, 2014, consists of three consecutive α-decays followed by SF. Decay properties of all nuclides in the first chain agree well with those of the decay chain from ^{293}Lv reported in early works[2–4)]. The second chain consists of two consecutive α-decays followed by SF. Assuming the first α originating from ^{293}Lv is not detected in the second chain, the chain looks the same as the first series because decay properties of two α and SF in the second chain agree well with those of α_2 and α_3 followed by SF in the first one. However, the missing probability is estimated to be 0.3% by considering the dead time for data acquisition and counting rate of the FPD. By the low missing probability, we can not conclude whether the second chain is from ^{293}Lv or the other nuclide that is provided directly (and emitted the 9.71 MeV α-particle).

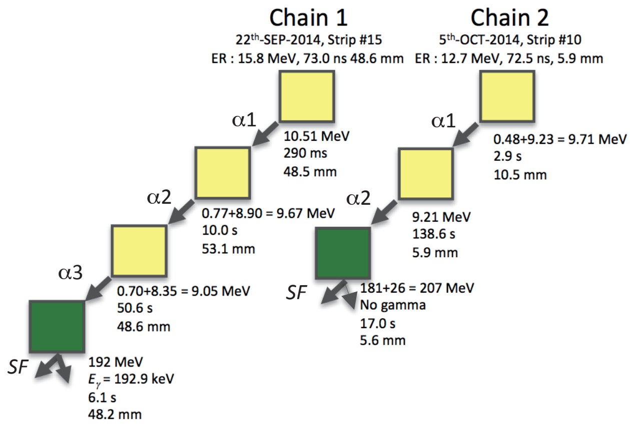

Fig. 1. Observed decay chains. Strip number, kinetic energy, TOF, and position of ER are given as well as decay energy and time, and position for each α-decay and/or SF.

The cross-section was deduced to be $0.9^{+2.1}_{-0.7}$ pb for 3n evaporation channel assuming the transmission of GARIS to be 35%. The cross section agrees well with the previously reported value of $1.1^{+1.7}_{-0.7}$ pb at E^*=40.9 MeV[2,3)]. On the other hand, we did not observe the decay chain originating from 4n. The cross-section limit was 1.64 pb for 4n although the reported value is $3.3^{+2.5}_{-1.4}$ pb.

For further understanding from the reaction mechanism, we will measure the excitation function at an energy higher than 41.5 MeV.

References

1) K. Morita et al.: RIKEN Accel. Prog. Rep. 47, (2014).
2) Yu. Ts. Oganessian et al.: JINR preprint, E7-2004-160, p.1 (2004).
3) Yu. Ts. Oganessian et al.: Phys. Rev. C70, p.064609 (2000).
4) S. Hofmann et al.: Eur. Phys. J. A48, p.62 (2012).
5) D. Kaji et al.: RIKEN Accel. Prog. Rep. 47, (2014).

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