Production-cross-section measurement and new-isotope search for very neutron-deficient RIs produced from ^{78}Kr beam at 345 MeV/nucleon by BigRIPS separator

H. Suzuki,[*1] N. Fukuda,[*1] H. Takeda,[*1] Y. Shimizu,[*1] D. S. Ahn,[*1] T. Komatsubara,[*1] N. Inabe,[*1] K. Kusaka,[*1] Y. Yanagisawa,[*1] M. Ohtake,[*1] H. Sato,[*1] and K. Yoshida[*1]

We performed production-cross-section measurements and new-isotope searches around the proton drip-line with the atomic numbers $Z = 22$–30. Proton-rich radioactive isotopes (RIs) were produced by the projectile fragmentation of a 270-pnA ^{78}Kr beam at 345 MeV/nucleon impinged on a 5-mm-thick Be production target in the BigRIPS separator.[1] Particle identification based on the TOF-$B\rho$-ΔE method[2] was performed in the second stage of BigRIPS. The production rates and momentum distirubions of the RIs were measured.

The production cross sections were deduced from the measured production rates and their transmission efficiencies in BigRIPS, which were simulated with LISE^{++} calculation code.[3,4] In the LISE^{++} simulation, a parameter "coef," which controls the slopes of exponential low-momentum tails in the momentum distribution of the RIs, was adjusted to reproduce the measured distribution. The tails observed in the experiments fell off faster than those calculated using LISE^{++} with the original parametrization. Momentum-peak shifts between the simulations and experimantal results were also taken into account in the calculation by tuning the $B\rho$ values of the dipoles. The tuned $B\rho$ values in the calculation were typically ∼1% higher than the experimental ones. The parameters of the angular distribution were not changed in the code.

Figure 1 shows the production cross sections of RIs obtained in the ^{78}Kr-beam campaign in 2019 (open circles) and 2015 (open squares) with measurements by B. Blank *et al.*[5] (filled triangles). The solid lines in Fig. 1 show the cross sections predicted from the empirical formula EPAX3.1a.[6] The measured cross sections of RIs with a wide range of Z are fairly well reproduced by EPAX3.1a, except in a region around the proton drip-line. There are discrepancies between the cross sections measured by B. Blank *et al.*[5] and the ones in 2019 for Ti and Cr isotopes. It may have been caused by insufficient tunings in the calculation in our preliminary analysis.

No new isotopes were discovered in our measurement for Cr nor Ti isotopes. From the lack of observation of ^{41}Cr and ^{39}Ti and their expected yields, the upper limits of their half-lives were preliminarily estimated to be 70 ns and 90 ns, respectively.

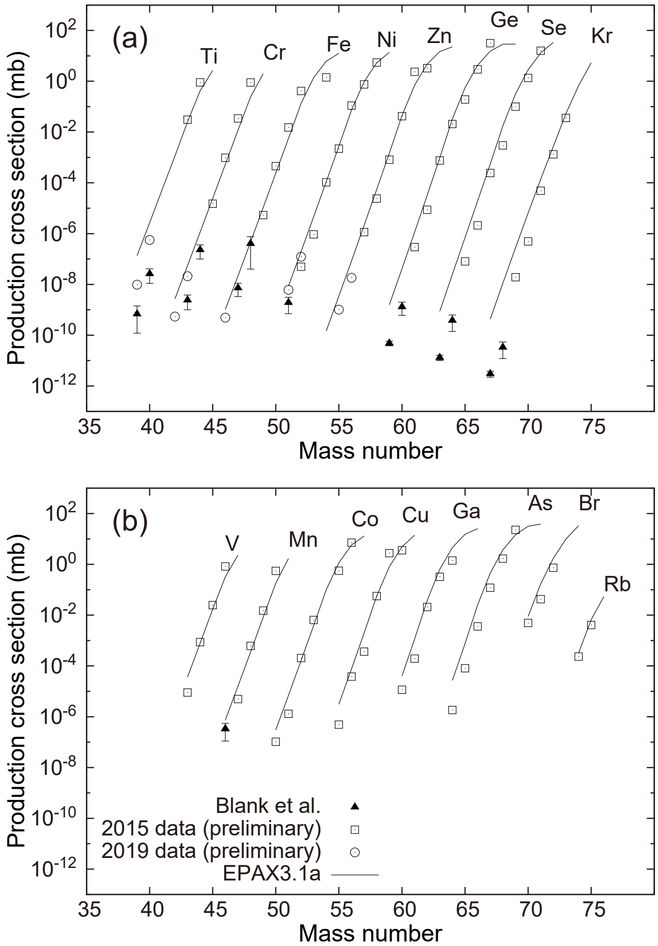

Fig. 1. Production cross sections of RIs produced in the ^{78}Kr + Be reaction at 345 MeV/nucleon. (a) Results for even-Z isotopes. (b) Results for odd-Z isotopes. Filled triangles, open squares, and open circles show the data measured by Blank *et al.*,[5] data measured in 2015, and data measured in 2019, respectively. Solid lines show the values predicted using the EPAX3.1a formula.[6]

[*1] RIKEN Nishina Center

References

1) T. Kubo, Nucl. Instrum. Methods Phys. Res. B **204**, 97 (2003).
2) N. Fukuda *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 323 (2013).
3) O. B. Tarasov, D. Bazin, Nucl. Instrum. Methods Phys. Res. B **266**, 4657 (2008) (references therein; LISE^{++} site, `http://lise.nscl.edu,MichiganStateUniversity`).
4) O. B. Tarasov, Nucl. Phys. A **734**, 536 (2004).
5) B. Blank *et al.*, Phys. Rev. C **93**, 061301(R) (2016).
6) K. Sümmer, Phys. Rev. C **86**, 014601 (2012).