Measurement of ^{77,79}Se(d, p)^{78,80}Se reactions as a surrogate for ^{79}Se(n,γ)^{80}Se reaction

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To design a facility for decommissioning the spent fuel from nuclear power plants containing long-lived fission products (LLFPs), more nuclear reaction data is needed. Within the ImPACT program, thus far several nuclear reactions of LLFPs produced by BigRIPS impinging on nuclear and proton targets have been measured.[1)] Because of the longer mean free path, the transmutation with neutrons can be applied more efficiently. However, since both the neutron and the LLFPs are unstable, the measurement of the neutron-induced cross section requires a neutron facility, in addition to enriched radioactive targets. Instead, the reaction cross-section can be determined in an indirect way employing a surrogate reaction.

It is generally assumed that the (n,γ) cross section separates into two parts: the formation of the compound state and it's subsequent decay. The first term can be calculated using the optical model potentials with global parameters. On the other hand, the theoretical estimates of the second process are uncertain,and need to be validated by experiments.[2)] The present work aims to determine the γ emission probability from unbound states of ^{80}Se by using the (d,p) reaction as a surrogate for the ^{79}Se$(n,\gamma)^{80}$Se reaction. The method will be tested by measuring the ^{77}Se$(d,p)^{78}$Se reaction, which is the surrogate for ^{77}Se$(n,\gamma)^{78}$Se, which was previously measured.[4)]

The ^{77,79}Se beams were produced using the ^{238}U beam impinging on a 3-mm-thick ^{9}Be target. By using this relatively thin primary target and a thick 15-mm Al degrader at F1, a purity of approximately 40% was achieved. Since the total intensity at F3 was approximately 1 MHz, beam particles were identified by the time-of-flight between F3 and F5 measured with diamond detectors alone. The beam energy was further degraded at F5 using a 3.5-mm-thick Al degrader, resulting in a final value of 26 MeV/nucleon. The OEDO facility[3)] was employed to reduce the spatial spread of the beam, resulting in a beam spot of 30 mm FWHM on the secondary target.

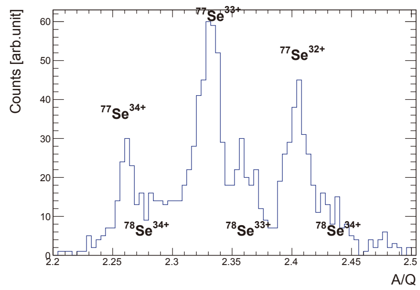

Fig. 1. A/Q spectrum measured at S1 focal plane for the events coincident with the protons detected with TiNA.

The beam from OEDO impinged on a CD_2 target of 4 mg/cm^2 to induce the one-nucleon transfer reaction. The recoiled particles were identified by employing the SSD-CsI(Tl) array, TiNA,[5)] which covered 100 to 150° in the laboratory frame. The excitation energies of the state populated in ^{78}Se (^{80}Se) were determined from the measured four-momenta of the protons and the direction of the incident beam.

The outgoing beam-like particles were identified with the dE-E-Bρ method, shown in Fig. 1, using the momentum determined by the horizontal position at the S1 focal plane. This will allow for a determination of the γ-ray emission probability as a function of excitation energy based on the fraction of (N+1,Z) nuclei to (N,Z) residues detected in coincidence with protons in TiNA. Further analysis is ongoing.

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