Production cross sections of residues in ^{50}Ti-induced reactions

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Excitation functions for the synthesis of *xn* evaporation residues were measured in ^{50}Ti-induced reactions with ^{159}Tb, ^{160}Gd, and ^{162}Dy targets. These data complement the data previously collected for ^{48}Ca-induced reactions with ^{159}Tb and ^{162}Dy, where ^{48}Ca + ^{162}Dy forms the same compound nucleus (CN) as ^{50}Ti + ^{160}Gd. Collectively, the measured excitation functions permit a systematic evaluation of the influence of nuclear properties of the projectile, target, and product nuclei on the evaporation channel production cross section. Such information may be of interest in the field of superheavy elements, where constraints on available targets makes a switch from ^{48}Ca to ^{50}Ti a necessary step to reach elements with Z > 118 [1].

The data were collected at the Texas A&M University Cyclotron Institute. A ^{50}Ti beam with an energy of 5.0 MeV/u was delivered by the K500 cyclotron to the MARS spectrometer [2], prepared by sputtering an enriched metal sample. The beam energy was varied with ^{nat}Al degraders positioned upstream of the targets. Particle separation relied on differences in magnetic rigidity and velocity of recoiling nuclei. The transmitted reaction products were detected at the focal plane of the spectrometer by a 16-strip position-sensitive silicon detector. An MCP detector located upstream served to discriminate implantation events from α-decay events occurring in the silicon detector.

Preliminary excitation functions for the 4*n* evaporation channel (having highest product yield) measured in reactions of ^{50}Ti with ^{159}Tb, ^{160}Gd, and ^{162}Dy are shown in Fig. 1 as red squares. These are compared to complementary reactions of ^{48}Ca with the same targets, shown in the figure as black circles.

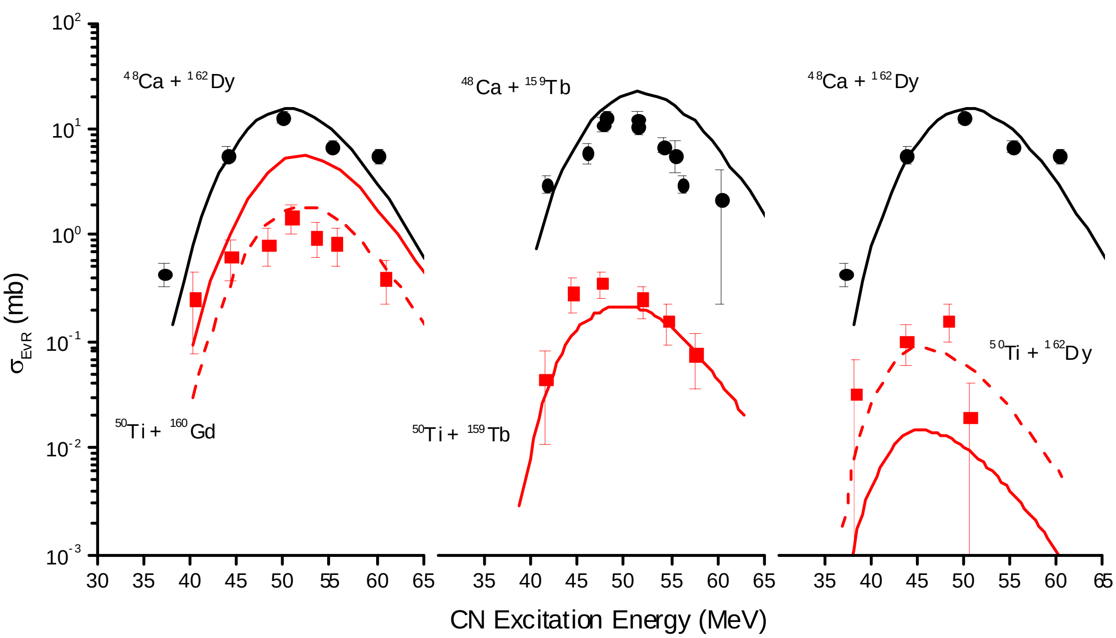

FIG. 1. Excitation functions for the 4*n* evaporation channel in reactions of ^{48}Ca and ^{50}Ti with ^{160}Gd, ^{159}Tb, and ^{162}Dy targets. The identical CN is produced in reactions in the left panel. The center and right panels show reactions on identical targets. The curves are theoretical predictions (see main text). The compound nucleus excitation energy is given for the center-of-target projectile energy.

The solid curves represent theoretical predictions and are largely based on the framework discussed in [3]. The dashed curves are obtained by uniformly scaling the solid curves down by a factor of 3 for the ^{50}Ti + ^{160}Gd reaction and up by a factor of 6 for the ^{50}Ti + ^{162}Dy reaction. The scaling shows the rough magnitude of over- or under-prediction of the model, while also demonstrating very satisfactory predictions for the shape and the peak of each excitation function. The agreement between theory and data is generally good for all reactions, considering the inherent uncertainties entering the calculation. Theoretically, the production cross section is given by the product of the capture cross section, amalgamation probability (P_{CN}) leading to a CN, and survival probability against fission. The greatest uncertainty is associated with the calculation of P_{CN} as it is the least well-understood stage of the mechanism. A phenomenological expression was used for P_{CN} [4], where for the ^{48}Ca reactions the estimates were constrained by pertinent literature data [5]. This information was extended to the ^{50}Ti reactions, for which no applicable literature data is available and where the greater Coulomb interaction of the projectile-target pair should further reduce P_{CN}. A major uncertainty in the survival probability comes from lack of experimental data on fission barrier heights, B_f, relevant to the present reactions. A 0.5 MeV change in B_f can reflect as up to an order-of-magnitude change in the calculated cross section (especially true for excited nuclei with similar neutron emission and fission decay widths) [6].

The analysis of the ^{50}Ti data is presently ongoing. These preliminary results show a moderate decrease in production cross section for the ^{50}Ti reactions relative to the ^{48}Ca reactions. Naturally, the properties of the CN, not just the projectile, determine the cross section. However, the present results indicate that even in synthesizing the same CN, that the increased symmetry of the ^{50}Ti reaction significantly suppresses the residue production cross section.

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