Enhanced Production of Neutron-Rich Rare Isotopes in Peripheral Collisions at Fermi Energies


The cross sections and velocity distributions of projectile-like fragments from the reactions of 25 MeV/nucleon $^{86}$Kr + $^{124}$Sn, $^{112}$Sn have been measured using the MARS recoil separator at Texas A&M, with special emphasis on the neutron rich isotopes [1]. This work is an extension of our previous work on the reaction 25 MeV/nucleon $^{86}$Kr + $^{64}$Ni reported elsewhere [2]. Proton-removal and neutron pick-up isotopes have been observed with large cross sections. A model of deep-inelastic transfer (DIT) [3] for the primary interaction stage and the statistical evaporation code GEMINI [4] for the deexcitation stage have been used to describe the properties of the product distributions. The results have also been compared with the EPAX [5] parametrization of high-energy fragmentation yields.

A large enhancement in the production of neutron-rich projectile residues is observed in the reaction of the $^{86}$Kr beam with the neutron rich $^{124}$Sn target relative to the predictions of the EPAX parametrization of high-energy fragmentation, as well as relative to the reaction with the less neutron-rich $^{112}$Sn target (Fig. 1). The data demonstrate the significant effect of the target neutron-to-proton ratio (N/Z) in peripheral collisions at Fermi energies.

The hybrid DIT/GEMINI model appears to account for part of the observed large cross sections. The DIT simulation indicates that the production of neutron-rich nuclides in these reactions is associated with peripheral nucleon exchange in which the neutron skin of the neutron-rich $^{124}$Sn target nucleus may play an important role. Similar conclusions have been drawn from recent calculations for the 25 MeV/nucleon $^{86}$Kr + $^{64}$Ni reaction [1,2].

From a practical viewpoint, such reactions between massive neutron-rich nuclei offer a novel and attractive synthetic avenue to access extremely neutron-rich rare isotopes towards the neutron-drip line.
Applications are investigated for the Texas A&M Cyclotron Institute upgrade and, in the far future, for the Rare Isotope Accelerator Facility (RIA).

References