Comparison of actinides production in direct and 2-step targets

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The use of light ions to induce fission in uranium targets is an important process to produce rare isotopes in an ISOL type of facility. The irradiation of the uranium (generally UC_x) can be performed by two main target types: (1) the direct irradiation, and (2) the two-step irradiation. In the direct irradiation the uranium carbide target is directly hit by the accelerated beam of light ions. In the two step target a converter or primary target is used to produce neutrons that in turn produce fission in a secondary UC_x target that surrounds the primary target. One advantage of the two-step target is that it decouples the heat deposition by the accelerated beam from the extraction of the produced isotopes, allowing active cooling of the primary target while the secondary can be kept at the optimum temperature for extraction of the products.

This paper compares the production of a direct UC_x target with a similar two-step target. The yields are compared quantitatively and qualitatively. The fact that the particles inducing fission have very different energy in the two types of target implies quite different isotope production distributions for the two cases.

In this abstract we consider a primary beam of 500-MeV protons. Calculations were done with the MCNPX code using the LAQGSM nuclear model. The target configurations were the direct 18-cm long, 1.4-cm diameter, 5.076-g/cm^3 UC_2 target; and the two-step with a 18-cm long, 1.4-cm diameter full density tantalum primary target and an 18-cm long, 2.7-cm ID, 6.7-cm OD, 5.067-g/cm^3 UC_2 secondary target. The yields of fission products in the direct target are about twice as large as those from the 2-step, but they are much less neutron-rich on the average. The yields of neutron-rich rare isotopes are greatly enhanced in the two-step geometry due to the lower average excitation energy of the fissions. On the other hand, yields of high-Z spallation products including actinides are much higher from the direct target.

The conclusion is that for production of neutron-rich isotopes the two-step target is considerably better than the direct target in and around the peaks of the asymmetric fission products yield distribution. The two-step mechanism produces such isotopes with significantly less background of other isotopes and also produces much less radiological contamination. However, for proton rich isotopes and for products in the spallation region of the production the direct target is preferable.

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