EXCITATION FUNCTION MEASUREMENTS OF PROTON INDUCED REACTIONS ON RHODIUM AND INDIUM: YIELDS OF Ru-97, Tc-96, Cd-109, and Sn-113

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The objective of this experiment is to measure the excitation functions of proton-induced nuclear reactions for four radionuclides of value in nuclear medicine. Cross sections of Ru-97 and Tc-96 formed in rhodium targets as well as Cd-109 and Sn-113 formed in indium targets will be determined for proton energies from 40 to 200 MeV. These data will provide a basis for selecting optimal irradiation conditions and calculating thick-target yields for large-scale preparations at the Brookhaven Linac Isotope Producer (BLIP).

Ru-97, Tc-96, Cd-109, and Sn-113 are of considerable interest for biomedical and other applications. Ru-97 is a potential radionuclide for nuclear medicine applications to nuclear oncology because of its desirable physical characteristics ($t_{1/2}$ = 2.9 d, 86% 216 keV gammas) and the high chemical reactivity of ruthenium. In addition, a number of ruthenium compounds have shown promise as useful agents in cancer chemotherapy.[1] The convenient half-life of Tc-96 (4.3 d) makes it a valuable tracer for developing new radiopharmaceuticals of its short-lived isotope, Tc-99m (6.02 h), which has found extensive application in nuclear medicine.[2] Cd-109 ($t_{1/2}$ = 453 d) is in equilibrium with its daughter, Ag-109m ($t_{1/2}$ = 40 s), which emits a single 88-keV gamma ray (3.92% abundant). It is useful as a X-ray fluorescence or radiography source. The nuclear properties of the Cd-109/Ag-109m pair also satisfy the requirements for a generator system which would provide a continuous source of ultrashort-lived medical nuclide for repeated dynamic studies.[3] Sn-113 ($t_{1/2}$ = 114.9 d) is the parent nuclide for the important In-113m generator system. The In-113m generator has been shown to be of value in many nuclear imaging applications.[4] The desirable characteristics of In-113m include a short-half-life of 1.658 h, a mono-energetic gamma emission of 392 keV (65% abundant), and no beta emissions to contribute to the radiation dosage.

The Brookhaven Linac Isotope Producer (BLIP)[5),6] has been in active use for the past few years for preparing large quantities of radionuclides of medical interest. It utilizes the excess beam capacity of a 200-MeV proton Linac that injects protons into the Alternate Gradient Synchrotron, a 33-GeV accelerator used in high-energy physics research. The Linac can generate up to 10 pulses of 200-MeV per second, providing beam currents of 70 to 100 microamperes for radionuclide production. Preparations of clinically useful quantities of Ru-97 and Tc-96 from a rhodium target, and Cd-109 and Sn-113 from an indium target at the BLIP have been demonstrated to be feasible. The principal nuclear reactions involved are Rh-103(p,2p5n) Ru-97, Rh-103(p,3p5n)-Tc-96, In-115(p,2p5n)Cd-109, and In-115(p,3n)Sn-113. The experimental determination of thin-target cross sections of these reactions will allow the selection of optimal bombardment conditions and an estimation of specific radionuclide yields in thick targets.

All cross section determinations will be made by activation of targets followed by measurement of the activity of the desired product with Ge(Li) detector gamma-ray counting. No chemical separations are necessary. Irradiations will be carried out in the external beam of the Indiana University 200-MeV cyclotron. The proton flux will be monitored by means of a Faraday cup. High-purity metal foils of rhodium and indium are used as targets. Excitation functions for all reactions will be measured in the proton energy range of 40 to 200 MeV (12 targets each, at ∿ 15 MeV intervals). The irradiated targets will be shipped to Brookhaven and the radioactive products in the individual rhodium and indium foils measured by gamma-ray spectroscopy using a calibrated Ge(Li) detector.

To date irradiations at 60, 80, 96, 115, 149, 159, 174 and 200 MeV have been made. Analysis of the γ-ray spectra taken over a period of a few months is required before experimental values can be quoted.

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