A novel approach to medical radioisotope production of ^{99}Mo using inverse kinematics

M.R.D. Rodrigues,[1] G.A. Souliotis,[2] A. Bonasera,[1,3] V.E. Iacob,[1] N. Nica,[1] B. Roeder,[1]
G. Tabacaru,[1] D. Scriven,[1] and J. Mabiala[4]
[1]*Cyclotron Institute, Texas A&M University, College Station, Texas*,
[2]*Laboratory of Physical Chemistry, National and Kapodistrian University of Athens, Greece*,
[3]*Laboratori Nazionali del Sud, INFN, Italy*,
[4]*Prairie View A&M University, Prairie View, Texas*.

A novel method for the production of important medical radioisotopes has been developed. The approach is based on performing the nuclear reaction in inverse kinematics, namely sending a heavy-ion beam of appropriate energy on a light target (e.g. ^{1}H, d, ^{3,4}He) and collecting the isotope of interest. A successful test of this concept was performed at Cyclotron Institute, Texas A&M University with the production of the theranostic radionuclide ^{67}Cu ($T_{1/2}$ = 62 h) through the reaction of a ^{70}Zn beam at 15 MeV/nucleon with a hydrogen gas target [1]. The ^{67}Cu radionuclide alongside other coproduced isotopes, was collected after the gas target on an aluminum catcher foil, them their γ-activity was measured off-line. Moreover, along with the production of the radionuclide of interest in inverse kinematics, additional radioisotopes can be generated by using the forward-focused neutrons from the reaction and allowing them to interact with a secondary target. The main requirement to obtain activities appropriate for preclinical studies is the development of high-intensity heavy-ion primary beams.

Pursuing the investigation of an alternative production method in inverse kinematics for isotopes that are important in nuclear medicine and are in high demand worldwide, where the production in reactors is not enough to supply the demand, the well-known ^{99}Mo/^{99m}Tc generator system [2] was the next goal. The ^{99m}Tc as a 140 keV γ-ray emitter (I_γ = 89%) with a half-life of $T_{1/2}$ = 6.01 h, is considered to be an ideal radiotracer and it is estimated to be used in approximately 85% of all nuclear medicine diagnostic scans worldwide [3]. The ^{99m}Tc is produced via β-decay of ^{99}Mo ($T_{1/2}$ = 65.94 h).

The ^{99}Mo was produced with a primary beam of ^{100}Mo accelerated by the K500 to an energy of 12 MeV/nucleon impinging on ^{4}He gas cell-target. The experiment took place at MARS recoil separator. The cryogenic gas-cell target has a length of 10 cm and has at the entrance and exit 4 μm thick, 19.0 mm diameter Havar windows. The target temperature was kept at T = 77 K during all the irradiations. The gas-cell target, the aluminum catcher foils and a Faraday cup to monitor the beam current, were set up in the MARS target chamber. A 127 μm thick aluminum catcher foil was mounted in a target frame with a 12.7 mm diameter hole and positioned after the gas-cell target. In order to measure the neutron yield produced during the irradiation, ten neutron detectors were positioned around the chamber. Three aluminum catcher foils were irradiated. The foils 1, 2, and 3 were irradiated for 12h, 13h, and 8h, with average current beam of 6 nA, 19 nA, and 16 nA and gas-cell pressures of 102, 213, and 1008 Torr, respectively. After 2.5 h of the end of irradiation, γ decay spectra of the foils were measured with HPGe detectors. Fig. 1 presents for instance a partial γ decay spectrum for foil 3. The foil was positioned at 50 mm from the detector and the spectrum was acquired for 16 h. The peaks associated with ^{99}Mo and the most intense impurities are indicated.

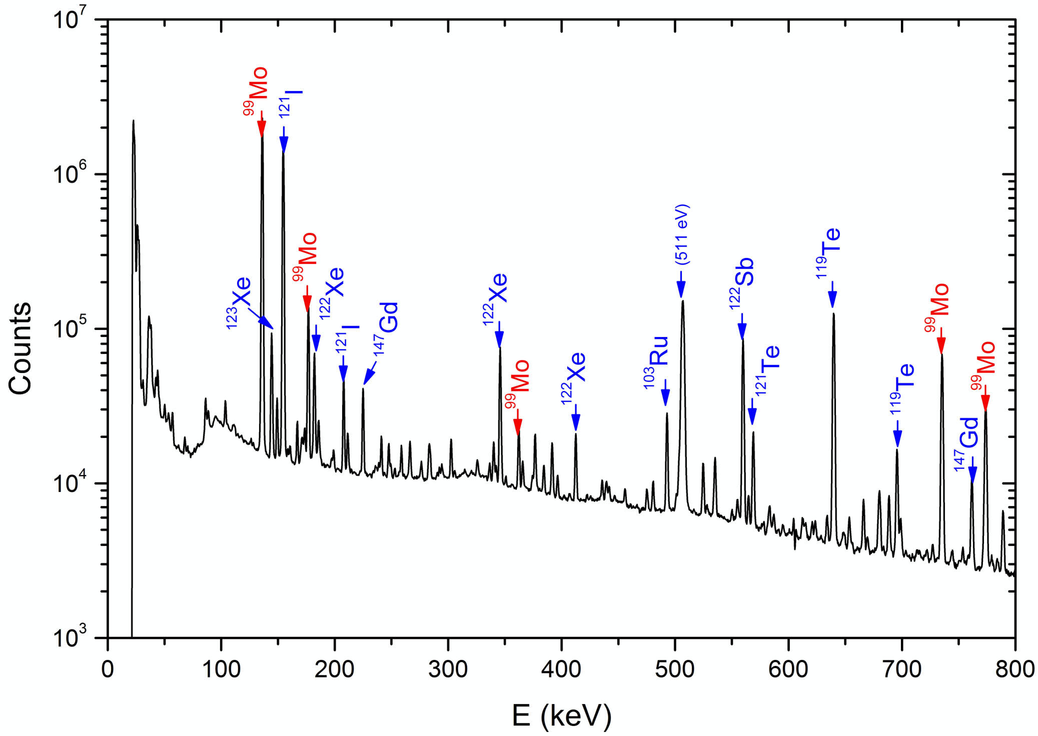

Fig. 1. Experimental γ decay spectra from foil 3.

As seen in Fig. 1, prominent γ peaks associated to the β-decay of ^{99}Mo and dominated by 140.5 keV (89.4% relative intensity) indicate that the reaction used has a good production of ^{99}Mo. The analysis is underway. The activity of ^{99}Mo and the impurities will be determined. The analysis of the neutron production will also be completed.

In addition to the ^{99}Mo production study from the ^{100}Mo + α reaction, a preliminary test was performed with the Ru isotopes production using MARS to separate the particle of interest. The MARS was tuned to optimize the focus of ^{100,99}Ru. The acquisition was done with an ΔE- E (55 and 500 μm) silicon detector telescope and the neutron detectors were put in coincidence with the MARS acquisition.

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