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Short Research Article

Production yields of ^{117m}Sn from natural antimony target in proton energy range 145–35 MeV†

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Introduction

Due to its chemical and nuclear properties ^{117m}Sn ($T_{1/2}$ 14.0 d; γ 159 keV, 86%; conversion electrons 127, 129, and 152 keV, 65, 12, and 26%, respectively) is a promising radionuclide for therapy of bone cancer and other diseases. Stannic complexes with ^{117m}Sn, particularly ^{117m}Sn(4+)-DTPA[1] effectively reduce pain from metastatic disease to bone without inducing adverse reactions related to bone marrow. Up to now, reactor-produced ^{117m}Sn with specific activity $\leqslant$20 Ci/g was available. However, it is inadequate to scale up to therapeutic doses for treating bone metastases, and much too low for radioimmunotherapy. No-carrier-added isotope is required for these applications and may be produced by proton irradiation of antimony via (p, 2p3n) or (p, 2p5n) nuclear reactions.

Results and discussion

Experimental cross-sections of ^{117m}Sn and other radionuclides generated in antimony by protons in the energy range 145–35 MeV were determined by irradiation at the INR accelerator. Two initial proton energies, 158 and 94 MeV, were used to diminish the influence of energy straggling. Radioisotopes of Sn, Sb, Te, and In were observed. A method of high-temperature separation of the radionuclides was developed to improve the accuracy of γ-spectrometry measurements. The volatility of Sn in elemental or oxide forms is lower than volatility of Te, Sb and In. Separation was performed at 1200°C in air, or at 1100°C in purified helium streams. Te and Sb were quantitatively sublimed in air, while Sn and In isotopes stayed at the starting position. Consequent heating in helium stream at different temperatures allowed us to recover pure Sn and separate it from In.

Along with experimental determination the cross-sections were also calculated theoretically on the basis of cascade-evaporation and ALICE models. The estimation of isomer cross-sections was based on a new developed systematics.[2] In Figure 1 the experimental and calculated cross-sections of ^{117m}Sn are compared. INR accelerator is able to produce (in the proton energy range 145–35 MeV) up to 5 Ci of no-carrier-added ^{117m}Sn at the end of irradiation. The main chemically inseparable impurity in ^{117m}Sn is ^{113}Sn ($T_{1/2}$ 115 d; γ 392 keV, 64%). Table 1 demonstrates the production yields of ^{117m}Sn along with the impurity ^{113}Sn for two proton energy ranges.

So, a reasonable compromise between the ^{117m}Sn yield and ^{113}Sn impurity should be determined based on the therapeutic application and the associated requirements.

The specific activity of ^{117m}Sn depends mainly on the amount of stable tin which is also generated during irradiation of antimony. Experimentally determined specific activity in one proton energy range (110–70 MeV) is in good agreement with the theoretical calculations (Figure 2). The specific activity (about 1000 Ci/g) is proposed to be acceptable for radio-

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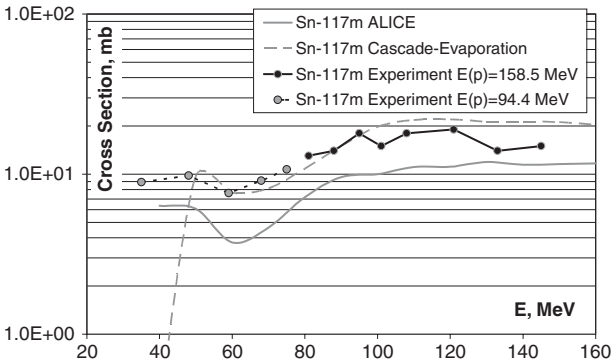

Figure 1 Cross-sections of ^{117m}Sn.

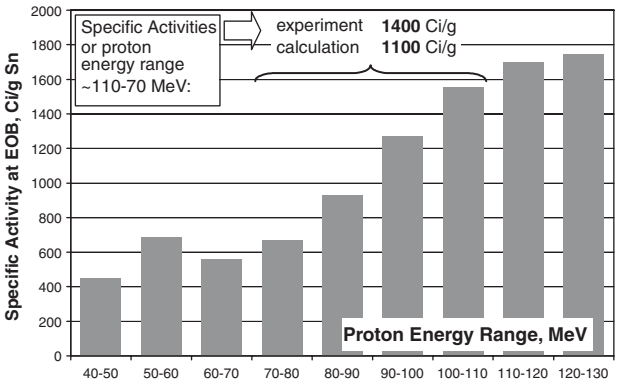

Figure 2 Calculated ^{117m}Sn specific activity.

Table 1 ^{117m}Sn yield and ^{113}Sn impurity for two proton energy ranges

Proton energy range (MeV)	^{117m}Sn yield (mCi/μA h)	^{113}Sn impurity (%)
35–59	0.052	1.3
35–145	0.60	15

immunotherapy of bone cancer and other prospective applications.

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