PRODUCTION OF NO CARRIER ADDED ^{64}Cu & ^{55}Co FROM A NATURAL NICKEL SOLID TARGET USING AN 18MeV CYCLOTRON PROTON BEAM

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INTRODUCTION: There is growing interest in the Australian research community for new PET radioisotopes with relatively long half lives. ^{64}Cu is a candidate, since; (i) it can be produced in cyclotrons found in a medical setting; (ii) the translational energy of its emitted positron is moderate (0.65MeV), and; (iii) its half life is sufficiently long (12.7h) to be used to radiolabel a range of molecular targeting agents (including monoclonal antibodies) and for the isotope to be transported across continents.

The RAPID Lab produces [^{18}F]FDG on a daily basis (~4500 doses per year), plus other clinical radiopharmaceuticals based on biogenic PET isotopes. The radioisotopes for these products are produced using standard targetry of an 18/9 MeV IBA cyclotron. As the productions of ^{64}Cu and ^{89}Zr both require an external beam, the RAPID team has devised a purpose built solid targetry system to suit this setting. The new targetry system consists of a 30cm long external beam line fitted with a 50μm Havar vacuum window plus an independent vacuum and cooling system (chilled water plus helium) for the target and beam degrader. Proton energies and currents can be controlled between 4–17.3MeV (using beam degraders) and 10-30μA, respectively.

The preferred approach for the production of ^{64}Cu using a medium-energy cyclotron uses enriched ^{64}Ni as the target in the reaction ^{64}Ni(p,n)^{64}Cu. A yield of 248MBq/μA.h has been reported [2]. However, for a natural nickel (^{nat}Ni) target the yield is considerably less, since the abundance of ^{64}Ni in ^{nat}Ni is only 0.91%. This study investigated the production and purification of the radionuclides ^{64}Cu, ^{55}Co and ^{57}Co, (the latter two arising from ^{58,60}Ni[p,α]^{55,57}Co) using a ^{nat}Ni thin-foil target, as a preliminary 'proof-of-principle' study prior to the bombardment of more expensive isotopically enriched targets formed by electroplating ^{64}Ni onto a gold substrate.

METHODS: A high purity ^{nat}Ni foil (99.99%) of nominal thickness 50μm and 15mm diameter was weighed on a 5-decimal-place balance to determine true average thickness prior to proton bombardment. Three separate runs were performed. The target foil was cooled by both chilled water and helium. The accessible proton beam energy of 17.3 MeV was moderated to 11.7MeV at the target surface by using a 1020μm graphite degrader placed in the collimator of the solid targetry beam line.

Bombardment elapsed times were 8, 19, and 20 minutes with beam currents of 10.4, 19.1 and 14 μA, respectively. Beam currents were uncorrected for secondary electron emission. At end of bombardment (EOB) the irradiated nickel target was left to decay for 3-4 hours to remove the short half-life radioisotopes ^{60}Cu & ^{61}Cu.

The target was then dissolved in concentrated acids at 100^{o}C and then loaded on to either a cation or an anion exchange column (1x 20cm). Nickel from the target plus Cu and Co radioisotopes were separately eluted using a range of solvents mixed with

hydrochloric acid. The fractions containing the radioisotopes of Cu and Co were characterized for radionuclidic purity and activity by calibrated gamma spectrometry (cryo-HPGe gamma spectrometer; Genie2000 software).

RESULTS: The table summarises the activities for ^{64}Cu, ^{57}Co and ^{55}Co for each ^{nat}Ni target for 3 consecutive runs. It compares the activity for each radioisotope (corrected to EOB) with values calculated using reaction cross sections reported in the literature [1, 2 and 3].

Table: Activities for ^{64}Cu, ^{55}Co and ^{57}Co, as a percentage of their respective predicted values calculated using published reaction cross sections plus targetry and beam parameters.

Nickel Foil Thickness	Proton Energy; Current	Irradiation Time	^{64}Cu	^{55}Co	^{57}Co
(μm)	(MeV; μA)	(min)	(% of Predicted Activity) [using ref. 2]	(% of Predicted Activity) [using ref. 1]	(% of Predicted Activity) [using ref. 3]
46	11.7 ; 10.4	8	80.2	94.8	86.4
47	11.7 ; 14.0	20	84.4	84.8	88.7
47	11.7 ; 19.1	19	64.7	78.6	97.2

CONCLUSION: We have performed preliminary 'proof-of-principle' experiments (prior to the use of an enriched target) on the production of Cu and Co isotopes using a ^{nat}Ni target and a medium-energy cyclotron in a medical setting. The activities produced are in reasonable agreement with predicted activities. For the three runs, activities of ^{64}Cu ranged from 64.7 to 84.4% of the predicted values calculated from [2]. Activities of ^{55}Co and ^{57}Co varied from 78.6% to 94.8% and 86.4% to 97.2%, respectively, of those values calculated from [1,3]. Work is proceeding to understand the variability in results between runs, particularly in the ratio of ^{55}Co to ^{57}Co, since these isotopes are eluted under identical chemical conditions.

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