High yield automated production of the PET radioisotope ^{86}Y using a biomedical cyclotron

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BACKGROUND

^{86}Y ($T_{1/2}$ = 14.74 h, 32% β+) has significant potential in theranostic applications as a simultaneous PET imaging partner to ^{90}Y-labelled antibody therapy. However, the complex and costly nature of producing ^{86}Y has led to this radiometal being difficult for institutes to obtain. The aim of this work was to develop a simple and cost-efficient method for safely producing ^{86}Y. Our approach was twofold: to develop a method of target preparation that would significantly increase the cost efficiency of producing ^{86}Y, and to design and construct an automated purification system that utilises the current Solid Target Laboratory facilities at the Austin Hospital to eliminate radiation handling risks and exposure.

METHOD

Enriched Strontium-86 Oxide ([^{86}Sr]SrO) powder was bombarded with 13MeV protons to induce the ^{86}Sr(p,n)^{86}Y reaction. The SrO was ground, desiccated and then pressed into a central circular cavity of a custom-made Niobium target backing disk (Images 1 and 2). The target was then irradiated at up to 22.5μA for 2-3 hours.

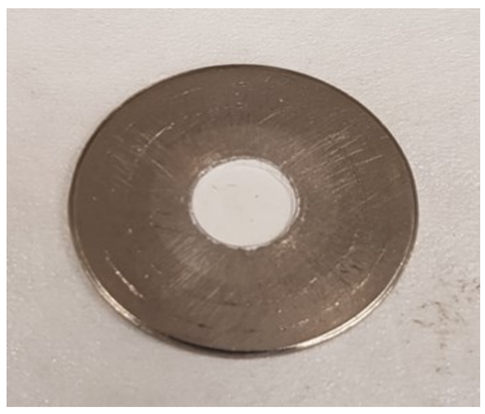

Image 1. [^{86}Sr]SrO powder pressed into cavity of Niobium target disk

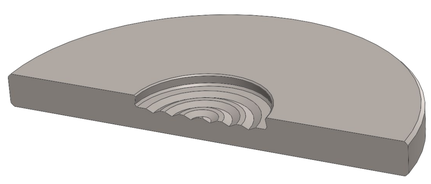

Image 2. Cross-sectional image of Nb target disk showing grooves in the base to facilitate better target material cooling by increasing surface area contact with disk

The irradiated target was then transported directly to the hotcell using an automated pneumatic transfer system and inserted as is into an in-house built module for dissolution and purification (Image 3). For fluidic control, the module uses 2 disposable 5-tap stopcock manifolds which are pneumatically actuated, and reagents and purification column are pre-loaded.

Image 3. In-house built automated ^{86}Y dissolution and purification module that uses a disposable cassette

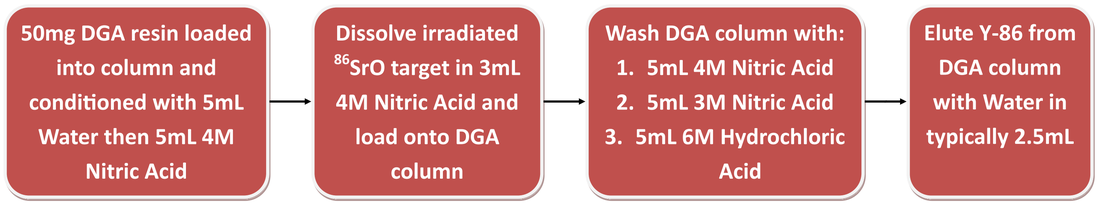

Chart 1. ^{86}Y purification method using DGA resin column

METHOD CONTINUED

The module is controlled by an Arduino microcontroller, with a fully interactive Graphical User Interface (GUI) written in Python (Image 4). The chemical separation method was an adaptation of the method described by Oehlke et al. (2015), and takes approx. 30 minutes to complete (Chart 1).

Reference: Oehlke et al. *Nuclear Medicine and Biology.* **2015**, 42, 842–849.

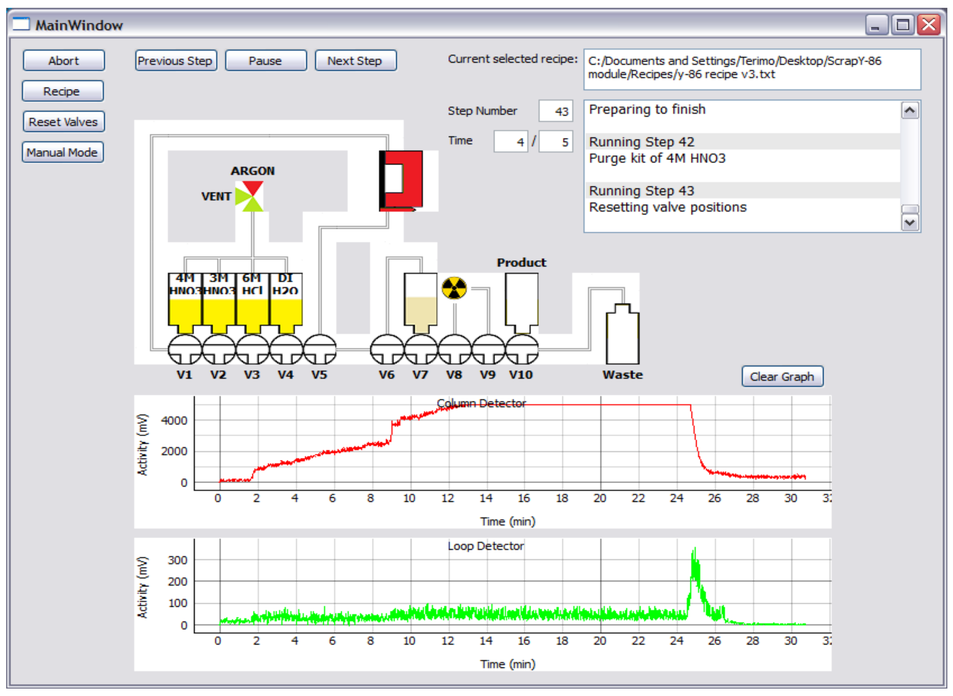

Image 4. GUI for custom ^{86}Y purification module with typical radioactivity profile trends displayed (red trace: DGA column showing trapping of dissolved target onto resin; green trace: eluent of DGA column showing final elution of ^{86}Y from resin)

RESULTS

Measurement of post-irradiation target mass has shown the target can withstand irradiation currents of up to 20μA without material losses. Activities of up to 1800MBq of purified ^{86}Y was produced, using less than 30mg of ^{86}SrO. Typically 75% of the total activity is recovered in the elution volume (waste liquid contained activity either not trapped by the DGA resin or eluted off during the washing steps).

Gamma spectra analysis using a HPGe detector has shown that the final purified solution contains activity fractions of 0.45% ^{87}Y and 0.1% ^{88}Y when normalised against ^{86}Y, hence ^{86}Y purity of 99.45% at EOS.

Test	Target Current (μA)	Irradiation Time (hours)	Mass of ^{86}SrO (mg)	Purified ^{86}Y Obtained (MBq (mCi))	Ratio of ^{86}Y activity to ^{86}SrO mass (MBq/mg)
1	7.5	2	31.2	620 (16.7)	19.9
2	10	3	20	750 (20.2)	37.5
3	17.5	2	17.2	820 (22.1)	47
4	22.5	2	27.4	1820 (49.1)	66.4

Table 1. ^{86}Y Production Test results

CONCLUSIONS

The developed target preparation methodology has allowed for increased yields through stability at higher beam currents and minimising the amount of costly enriched target material needing to be used. Additionally, the methodology allowed for compatibility with an automated purification module, reducing labour, eliminating radiation exposure and ensuring reproducibility. While the pathway has been paved for supply to be commercially feasible in Australia, further work can be done on optimising chemical separation yields.

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