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Liquid target system for production of ^{86}Y

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Introduction Radionuclide ^{90}Y is a widely used tool for cancer therapy due to its suitable half-life, ready availability in high specific activities at relatively low cost. As it is a pure β^- emitter with no associated γ rays, there is a need for a tracer of ^{90}Y. Promising candidate for these purposes is ^{86}Y, since it is a positron emitter with half-life of 14.74 h. This radionuclide has been usually produced by the (p,n) reaction on enriched ^{86}Sr solid targets ($SrCO_3$) [1]. Handling and processing of those targets have several disadvantages. There is an interesting alternative to this approach, namely irradiation of a liquid target filled with aqueous solution of strontium nitrate [2]. It makes the target processing significantly easier and allows for automation of the process. Separation step can be also simplified, since usual electrolysis can be replaced by filtration of yttrium colloid in alkaline milieu [3].

Materials and methods Strontium carbonate (96.3% ^{86}Sr) was purchased from JV Isoflex, Moscow. Trace select ultra grade HNO_3, HCl and NH_4OH were purchased from Sigma-Aldrich. Puratronic grade $(NH_4)_2CO_3$ was purchased from AlfaAesar. High purity de-ionized water was used (specific resistance 18.2 MΩ/cm).

The main part of target asembly was water cooled chamber (volume 2.4 ml) made out of pure Nb with Ti entrance foil. The concentration of irradiated solution of strontioum nitrate was 35% (w/w). After irradiation, the solution was transfered to separation unit, target was washed with 10 mM nitric acid and water. All parts were collected together, pH was set to 10, filtered through PVDF filter and washed with 50 ml water. Filtrate was collected for Sr recovery. Yttrium was eluted from the filter with 10 ml 1M HCl. Eluate was evaporated to dryness and re-disolved in 100–300 µl of 0.05M HCl as a stock solution for labelling.

Radionuclidic purity and activity of produced yttrium was measured with γ-ray spectrometry (HPGe detector GMX45, Ortec).

Content of chemical impurities (for ^{86}Y – Fe, Cu, Zn, Al, ^{86}Sr) was determined via ICP-MS at the Institute of Chemical Technology Prague. We used two alternative methods for determination of the purity of the produced ^{86}Y: differential pulse voltametry and labelling efficiency of DOTATOC. Ca. 40 MBq of ^{86}Y stock solution was mixed with 20 µg of DOTATOC in 300 µl of 0.4 M sodium acetate and heated in for 30 min at 80 °C. The labelling yield was monitored with TLC, using silica gel plates (Merck, Germany) developed with 10 % NH_4OAc aq. / MeOH = 1:1, R_f = 0.46, and measured on a Cyclone autoradiography system (Perkin-Elmer).

Enriched ^{86}Sr was recovered by precipitation of strontium carbonate with ammonium carbonate [1]. The precipitate was decanted with water and acetone. Strontium carbonate was than dissolved in concentrated nitric acid, evaporated to dryness and re-dissolved in water for further irradiations.

Results The yield of irradiation was 33 MBq/µAh. It corresponds well to the published data [1] and given content of ^{86}Sr in the target matrix. Radionuclide purity was excellent (^{86}Y>99.4 %, ^{87}Y<0.55 %, ^{88}Y<0.025 %). Separation yield was more than 90 %, about 4–5 % is left on the filter. Less than 0.1 % of ^{86}Y stays in filtrate. Also losses during evaporation of 1M HCl are under 1 %. Table 1 shows comparison of methods used for determination of copper concentration as a example of impurity. Labelling efficiency reflects well the copper concentration.

TABLE 1 Comparison of different analytical methods for estimating the copper content in the product

Batch	Polarography [µg/ml]	ICP-MS [µg/ml]	Labelling efficiency
1	8.7	8.9	51.0 %
2	5.7	5.3	77.3 %
3	0.5	0.4	96.6 %

Recovery of enriched strontium was nearly quantitative, all solution used in recycling process were collected and reprocessed.

Discussion/Conclusion This work presents a compact, fully automated system for production of ^{86}Y in activity and quality suitable for radiopharmaceuticals production. Transport of irradiated target matrix via a capillary to a separation unit minimizes problematic handling of radioactive material and losses of expensive enriched ^{86}Sr. It also reduces significantly personnel radiation burden.

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