

Radiochemical Separation of No-Carrier-Added ^{177}Lu as Produced via the $^{176}\text{Yb}(n,g)^{177}\text{Yb}^{\text{®}}\text{}^{177}\text{Lu}$ Process

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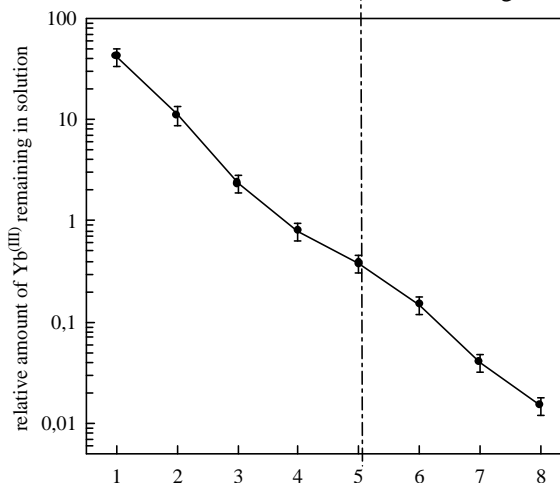
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The β^- emitter ^{177}Lu ($T_{1/2} = 6.71$ d, max. and aver. β^- energies of 421 and 133 keV) is a promising therapeutic radioisotope for the curative treatment of cancer using labelled proteins [1-4]. The decay is accompanied by the emission of low energy γ -radiation with $E_\gamma = 208.3$ keV (11.0%) and 113 keV (6.4%) suitable for simultaneous imaging. Moreover, ^{177}Lu attracted a special interest because of the very high cross section of 2100 barn of the $^{176}\text{Lu}(n,\gamma)^{177}\text{Lu}$ production process. Irradiation of 100 mg of ^{176}Lu at reactors providing 10^{14} n cm⁻² s⁻¹ for 100 h yields specific activities of 1.15 GBq/ μmol , which can be increased by a factor of 35 in the case of 95% isotopically enriched ^{176}Lu . Nevertheless, a minimum amount of stable ^{176}Lu cannot be avoided and might cause some problems concerning the labelling of tumour affine biomolecules. Thus, a no-carrier-added (nca) ^{177}Lu seems to be useful, providing the maximum specific activity of 720 GBq/ μmol ($1.1 \cdot 10^5$ Ci/g).

For this purpose, the alternative production route $^{176}\text{Yb}(n,\gamma)^{177}\text{Yb}$ ($T_{1/2} = 1.9$ h) — $\beta^- \rightarrow ^{177}\text{Lu}$ was investigated, providing a nca state of ^{177}Lu . It was the aim of this work to develop an efficient separation of nca ^{177}Lu from macroscopic amounts of the ytterbium target material despite of the chemical similarity of these neighbored lanthanides. The separation of the nca ^{177}Lu from the macro-amounts of the ytterbium target based on the cementation process, i.e. the selective extraction of Yb by Na(Hg) amalgam from Cl⁻ / CH₃COO⁻ electrolytes [5-8] followed by a final cation exchange purification.

^{177}Lu was produced in a neutron capture reaction on natural or isotopically enriched ytterbium. The isotopic composition of isotopically enriched ^{176}Yb was 0.0034% ^{168}Yb , 0.114% ^{170}Yb , 0.634% ^{171}Yb , 1.157% ^{172}Yb , 1.014% ^{173}Yb , 2.355% ^{174}Yb and 94.72% ^{176}Yb . 200 mg (99.9999% chemical purity) Yb₂O₃ were irradiated for 6 h at the TRIGA II reactor Mainz at a neutron flux of $2 \cdot 10^{12}$ n cm⁻² s⁻¹. 12.4 mg of enriched ^{176}Yb -Yb₂O₃ were irradiated for two days at the HMI neutron source BERII at $2 \cdot 10^{14}$ n cm⁻² s⁻¹, resulting in 8.1 GBq ^{177}Lu at one day after EOB. Sodium amalgam was prepared via electrolysis of a 20% solution of NaOH, as described elsewhere [8]. 200 mg Yb₂O₃ were dissolved in 1.4 ml 4 M HCl. Next, 3 ml 4.5 M CH₃COONa and H₂O were added to a total volume of 6 ml of pH \approx 3.4. 4 ml of Na(Hg) amalgam (0.4% Na) were added and this system is stirred for 90 sec. The amalgam is removed from the system. After 4 of these cycles, about 99% of the ytterbium were removed from the aqueous solution. The nca ^{177}Lu is isolated from this solution by precipitation as the hydroxide using 4 M NaOH. The hydroxide is isolated by centrifugation and dissolved in 2.5 ml 0.1 M HCl. After adding of 2.5 ml 4.5 M CH₃COONa, another 4 cementations are performed in a new vessel. After this procedure, the amount of Yb^(III) is reduced to about 0.01-0.02 % of the initial mass, cf. Figure 1, while about 85 \pm 5% of the nca ^{177}Lu are remaining in the solution.

In conclusion, the radiochemical separation process developed provides radiochemically pure nca ^{177}Lu within a total volume of less than 0.5 mL with an overall separation yield of 75 \pm 5% within 4-5 h, with Yb contaminations of $< 10^{-6}$ %, i.e. < 1 ng Yb^(III) for a



100 mg ^{176}Yb target. It thus can be used to synthesise nca ^{177}Lu labelled radiotherapeutics.

Figure 1: Successive separation of macro-amounts of Yb^(III) in individual cementation cycles

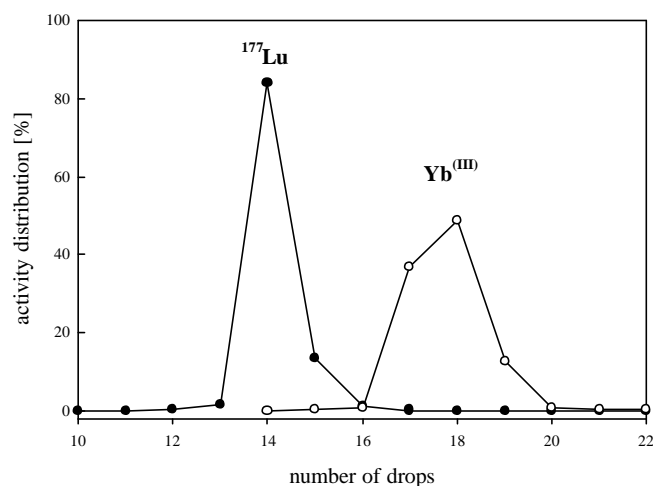


Figure 2: Ion exchange purification ^{177}Lu from Yb^(III) using 0.07 M α -HIB, pH 4.7; column: Aminex A6, 2 mm x 80 mm

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