Development of production method and radiochemical separation of no-carrier-added ^{90}Nb from bulk amount of ^{nat}Zr.

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Introduction: The positron emitter ^{90}Nb is a promising radioisotope for applications in positron emission tomography (PET). One feature of ^{90}Nb is the half-life (14.6 hours), which enables this isotope for the visualization of processes with medium and slow kinetics, such as the pharmacokinetics of nanobodies, polymers and antibodies. Another advantage of ^{90}Nb is its decay parameters: relatively high positron branching of 51% and a rather low β^+-energy of E_{mean}=662 keV (E_{max}= 1.5 MeV), which allows high quality and high resolution images even at low amounts of ^{90}Nb.

Experimental: ^{90}Nb was produced via the ^{90}Zr(p,n)^{90}Nb reaction at the cyclotron MC32NI of the German Cancer Research Center Heidelberg. For irradiation, three discs of natural zirconium (51,45% ^{90}Zr) foil of 10 mm diameter and a thickness of 0,25 mm were used (Figure 1). Irradiation was performed with 20 MeV protons (17.5 MeV at 1st foil), current 5 µA for 1 hour. 24 hours after irradiation, the production yield was measured by gamma spectroscopy.

The separation procedure follows partially the procedure described by S. Busse *et al.* [1]. The zirconium metal target (240-360 mg) was transferred into a 50 ml vial and water (2 ml) was added. Under cooling in a ice bath, 0.63 ml of 48% HF was added in small portions. After complete dissolution, 6 ml 10M HCl and 3.4 ml saturated boric acid were added. The ^{90}Nb fraction was extracted with 5 ml of 0.02M of *N*-benzoyl-*N*-phenylhydroxylamine (BPHA) in $CHCl_3$ by vigorous stirring of the two phases in a 50 ml vial for 20 min. The aqueous phase additionally washed with 3 ml $CHCl_3$. The organic phases were combined and washed with 2 ml of a mixture of 9M HCl/0,001M HF and with 2 ml of pure 9M HCl. The re-extraction was carried out with 5 ml aqua regia.

For a final separation of ^{90}Nb from trace amounts of zirconium an anionic exchange method was employed. The aqueous phase after re-extraction was evaporated to dryness. The residue dissolved in 0.5 ml of a mixture of 0.25M HCl/0.1M oxalic acid and adsorbed on a small Aminex A27 15±2 µm anionic exchange column (20 x 1.5 mm). Elution was performed under slight overpressure of 0.3 bar. After loading, the column was washed with 100 µl 10M HCl. Residues of Zr were removed by washing with 200 µl of a mixture of 9M HCl/0,001M HF. ^{90}Niobium was eluted with 200 µl of a mixture of 6M HCl/0,01M oxalic acid.

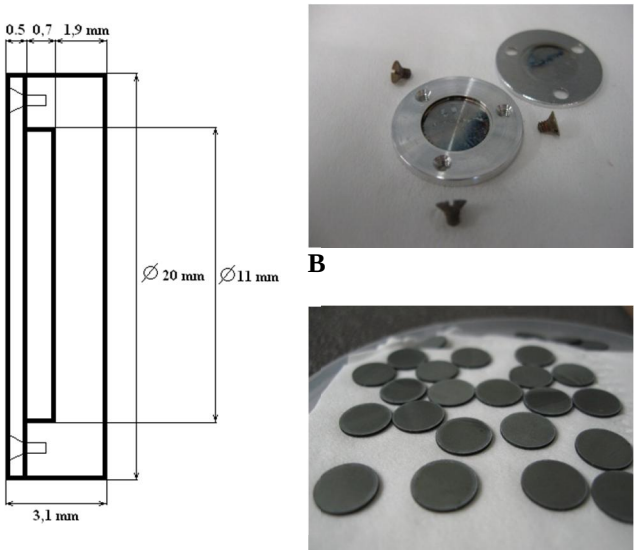

Figure 1. Setup for irradiation: A.- Schematic view of the target holder, B.- The target holder, C.- Zirconium discs Ø 10 mm for irradiation.

Results: Production yield of ^{90}Nb under given irradiation parameters was 145 MBq/µAh. The distribution of activity in the foils was: 49% (1st foil), 40% (2nd foil) and 10% (3rd foil). The results show, that the third foil has only 10% of activity and 30% of the mass of the whole target. To increase the separation factor, only foils 1 and 2 should be used for work-up and separation. The isotopic purity of ^{90}Nb was more then 96%. Minor isotopic impurities were found: ^{89}Zr (0.29%), ^{92m}Nb (1.79%), ^{95}Nb (0.42%) and ^{96}Nb (0.74%). All impurities of zirconium isotopes were efficiently removed by the separation procedure. The extraction steps allow crude separation of ^{90}Nb from target material. In the organic phase more than 99% of ^{90}Nb was found. After the re-extraction procedure the 5 ml aqueous phase contained 90-95% of the ^{90}Nb activity. This led already to a high separation factor for Zr/Nb after both extractions of 10^4. The final anionic exchange separation allowed complete separation from residues of the target material. The final 200 µl of 6M HCl/0,01M oxalic acid contained 80-85% of the activity of ^{90}Nb. The final separation factor for Zr/Nb was $>10^7$ and the final yield of ^{90}Nb was 76-81%.

References

[1] Busse S., Brockmann J., Rosch F. (**2002**) Radiochemical separation of no-carrier-added radioniobium from zirconium targets for application of ^{90}Nb-labelled compounds. *Radiochim. Acta*, 90:411–415.