^{44}Ti: Investigation of target preparation, irradiation and yields in the ^{45}Sc(p,2n) process

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Introduction: Recently, the ^{68}Ge/^{68}Ga radionuclide generator has shown significant potential for molecular imaging [1,2]. The high positron branching of 89% and the kit-type of radiopharmaceutical syntheses offer excellent parameters for the routine use of ^{68}Ga labelled tracers in nuclear medicine using state-of-the-art positron emission tomography (PET). A clinical breakthrough was achieved demonstrating the superior possibilities of ^{68}Ga-DOTA-octreotide derivatives for localising neuroendocrine tumours, in particular if PET/CT is used. However, the physical half-life of ^{68}Ga of T½ = 68 min might limit the spectrum of clinical applications of ^{68}Ga labelled radiodiagnostics. Thus, radionuclide generator systems providing positron emitting daughters of extended physical half-life are of new interest. Table 1 shows the most interesting radionuclide generator systems. We identified the ^{44}Ti/^{44}Sc radionuclide generator as extremely relevant. The physical half-life of ^{44}Sc is T½ = 3.93 h, its positron branching is 94%.

Table 1:
Overview on radionuclide generators relevant to PET

generator			mother	daughter			
			$T_{½}$	$T_{½}$	β^+_{branch} (%)	E_{β}+ (MeV)	main use
^{82}Sr	/	**^{82}Rb**	25.6 d	1.27 min	95.0	1.41	perf.
^{140}Nd	/	**^{140}Pr**	3.37 d	3.39 min	51.0	0.544	perf.
^{118}Te	/	**^{118}Sb**	6.00 d	3.6 min	74.0	0.882	perf.
^{122}Xe	/	**^{122}I**	20.1 h	3.6 min	77.0	1.09	(label.)
^{128}Ba	/	**^{128}Cs**	2.43 d	3.62 min	69.0	0.869	perf.
^{134}Ce	/	**^{134}La**	3.16 d	6.4 min	63.0	0.756	perf.
^{62}Zn	/	**^{62}Cu**	9.26 h	9.74 min	97.0	1.28	label.; perf.
^{52}Fe	/	**^{52m}Mn**	8.28 d	21.1 min	97.0	1.13	perf.
^{68}Ge	/	**^{68}Ga**	270.8 d	1.135 h	89.0	0.74	perf. →label.
^{110}Sn	/	**^{110m}In**	4.1 h	1.15 h	62.0	0.623	label.
^{44}Ti	/	**^{44}Sc**	47.3 a	3.927 h	94.0	0.597	label.
^{72}Se	/	**^{72}As**	8.4 d	1.083 d	88.0	1.02	label.

A crucial issue in the development of ^{44}Ti/^{44}Sc radionuclide generator systems consists in the production of ^{44}Ti. The ^{45}Sc(p,2n)^{44}Ti process seems to be an effective nuclear reaction, however, due to the long physical half-life, cyclotrons of high proton flux are mandatory. It was the aim of this work to investigate this production route in terms of target preparation, irradiation and estimation of the radionuclide product spectrum and the ^{44}Ti yield.

Cyclotron description: The cyclotron RIC-30 is in operation since 1993. The accelerator it is placed in a specially designed building, with established basic, general technical and accessory equipment including: cyclotron RIC-30, control system of accelerator; extraction system and transport of beam to the remote targets with the beam extraction into the atmosphere and vacuum chamber; the set of internal target devices and systems for the installation of external targets; means and devices for radiation safety, monitoring-measuring equipment, the means of storage and information processing, other technical equipment. The RIC-30 is an isochronous sector-focusing one-dee cyclotron with pot electromagnet intended [1] for the production of radionuclides on the internal and external beams with the aid of the appropriate target devices. The proposed and achieved performances of the cyclotron are 28 (28.5) MeV p-energy, and 60 (5-10) and 500 (250) μA external and internal p-fluxes.

Target: A metallic Sc target was developed. Sc was melted in 150 to 220 μm thick layers onto copper backings of sophisticated structure for optimum heat transfer (Fig. 1).

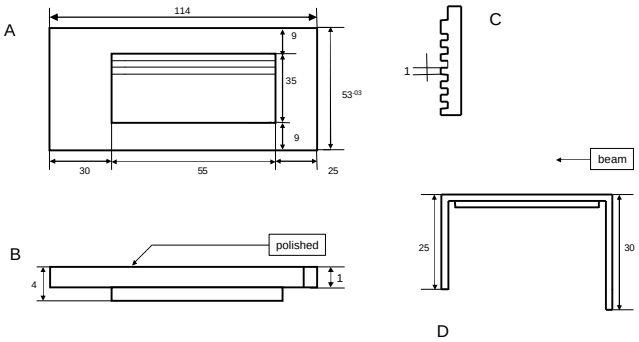

Figure 1: Dimensions of the target backing

Irradiations: First irradiations have been performed for a 150 μm Sc layer at 150 μA for 1 x 10 h and 1 x 5 h (2250 μAh), yielding 4.56 MBq ^{44}Ti corresponding to 0.002 MBq/μAh. However, ^{65}Zn was co-produced at 232 MBq.

Conclusion: The developed target system seems to be capable to withstand long-term irradiations at up to 200 μA. In order to reduce the ^{65}Zn contaminations, new targets are under development with increased Sc layer thickness and / or intermediate layers of Ag.

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