A Study of Irradiation Conditions of Mercury Target with Protons to Obtain Thallium-201

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Introduction

The radionuclide ^{201}Tl is used in Nuclear Medicine to identify myocardial ischemia or myocardial infarct. It is a cyclotron-produced radioisotope, obtained indirectly from the decay of ^{201}Pb or directly by irradiating mercury with deuterons or protons.

The usual technique to prepare ^{201}Tl makes use of the nuclear reaction ^{203}Tl(p,3n)^{201}Pb $\rightarrow$ ^{201}Tl, which requires proton energy of around 28 MeV. Due to the limited proton energy of IPEN's CV-28 cyclotron (24 MeV), studies on the irradiation conditions of natural mercury oxide pellets and drops of natural metallic mercury were made in the energy range of 24 to 19 MeV.

Experimental Techniques

Targets of natural mercury oxide pellets with thickness of 815 mg/cm², 509 mg/cm² and 445 mg/cm², and drops of natural metallic mercury with 445 mg/cm² were used in the studies.

The targets of 815 mg/cm² and 509 mg/cm² were irradiated with incident proton beam energy of 24 MeV and 20 MeV, respectively, using a steel target holder with back water cooling.

For the thin target irradiation (HgO: 445 mg/cm² and Hg°: 445 mg/cm²) a target holder made of aluminum was fabricated and it was water-cooled in the front and in the back of the target (Fig. 1).

The incident beam energy on the target was reduced to 19 MeV due to the water layer and the target windows.

The target thickness (445 mg/cm²) and the incident proton beam energy (19 MeV) were chosen to minimize the production of other radioisotopes of thallium, which could lead to impurities in the ^{201}Tl product.

The range calculations of protons in the targets and in the materials used to degrade the proton beam energy were made using the data tables of WILLIAMSON *et al.* [1].

Table 1: Production yields (EOB) of ^{200}Tl, ^{201}Tl and ^{202}Tl in the irradiation of natural mercury oxide pellets with protons.

Target Thickness (mg/cm²)	Incident Proton Energy (MeV)	Final Proton Energy (MeV)	Yield (EOB) (MBq/µAh)		
			^{200}Tl	^{201}Tl	^{202}Tl
HgO (815)	24	14	20,2	14,5	0,36
HgO (509)	20	14	12,0	9,5	0,19

Table 2: Production yields (EOB) of ^{200}Tl, ^{201}Tl and ^{202}Tl of thin natural mercury target (445 mg/cm²) irradiated with protons of 19 MeV.

Thickness (mg/cm²)	Incident Proton Energy (MeV)	Final Proton Energy (MeV)	Yield (EOB) (MBq/µAh)		
			^{200}Tl	^{201}Tl	^{202}Tl
HgO (445)	19	13	11,8	9,5	0,19
Hg (445)	19	13	11,9	9,5	0,19

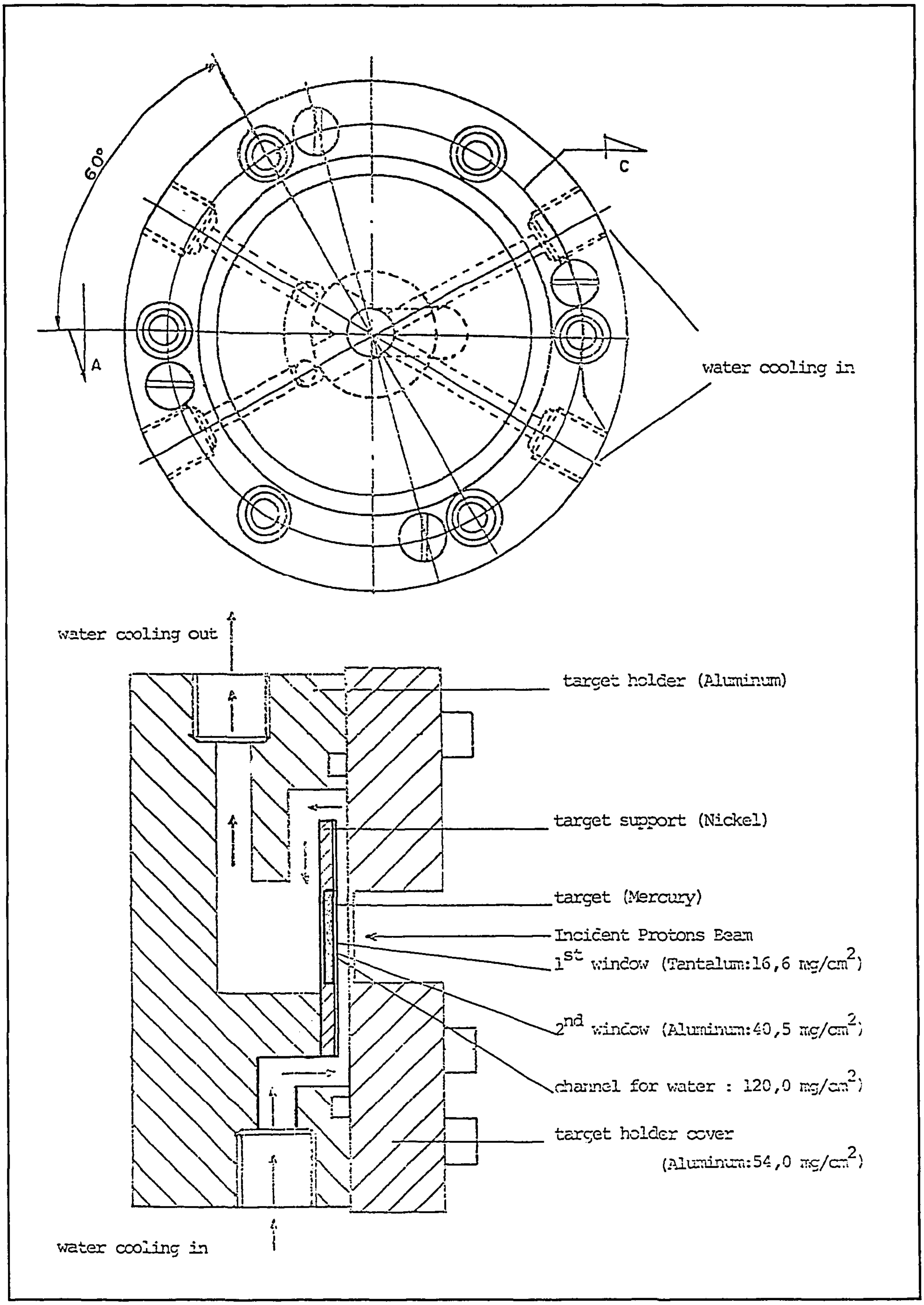

Figure 1: Aluminum target holder with water cooling in the front and the back of the target.

Results

Table 1 and Table 2, respectively, give the production yields of ^{200}Tl, ^{201}Tl and ^{202}Tl at the end of bombardment for the HgO thick target and the HgO, Hg thin targets.

Conclusions

The results showed that ^{201}Tl had a high level of radionuclidic impurities. This is due to the fact that only natural mercury targets were used: ^{204}Hg (7%), ^{202}Hg (30%), ^{201}Hg (13%), ^{200}Hg (23%), ^{199}Hg (17%) and ^{198}Hg (10%).

At the end of the bombardment of a 445 mg/cm^2 thickness (6 MeV thickness) target of natural metallic mercury with 19 MeV protons provide a yield of around 10 MBq ^{201}Tl/μAh.

If one employs a 98.6% enriched ^{202}Hg target under the irradiation conditions mentioned above, the ^{201}Tl yield will be around 33 MBq/μAh. This yield value is smaller than the one obtained by BIRATTARI *et al.* [2]: 51 MBq/μAh (after the decay time of 60 h from the EOB for a 98.6% enriched ^{202}Hg, 6 MeV target thickness) and by DMITRIEV [3]: 46 MBq/μAh (at the end of the bombardment of a 95 % enriched ^{202}Hg, 4 MeV target thickness).

The EOB yield of ^{201}Tl obtained in this work shows the necessity of improvement in the target support so that all the mercury target is focused by the proton beam. This work was useful for learning more about cyclotron irradiation techniques with respect to target, target holder fabrication and cooling system.

References

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[2] C. Birattari, M. Bonardi and A. Salomone, ^{201}Tl production studies by ^{203}Tl(p,3n)^{201}Pb and ^{202}Hg(p,2n) nuclear reactions. J. Lab. Comp. Radiopharm. 19, 1330-1332 (1982).

[3] P.P. Dmitriev, Scope for application of ^{123}Te(p,n)^{123}I and ^{202}Hg (p,2n)^{201}Tl reactions to produce ^{123}I and ^{201}Tl for nuclear medicine. Sov. At. Energy 64, 137-140 (1988).