Experience with top-of-foil loading [^{18}O]water targets on an IBA 18 MeV cyclotron

L. Silva[a], P.Pace[a], C. Hormigo[a], Y.Litman[a], S. Fila[a], H.Gutierrez[a], G. Casale[a],C. Gonzalez-Lepera[b], R. Srtangis[c]

[a]Laboratorios BACON SAIC, Buenos Aires, Argentina
[b]University of Texas MD Anderson Cancer Center, Houston TX
[c]Cyclotope Houston TX, USA

Introduction

Liquid targets using top-of-foil loading concept have been succesfully employed for routine high current production of ^{18}F and ^{13}N at Cyclotope (Houston,TX), over the past ten years[1,2]. These targets are typically filled with 3.5 ml of water, then pressurized with helium gas at 22 bar and bombarded with 18MeV protons (70–100 µA). Average calculated saturation yield for production of ^{18}F is ~7.8 GBq/µA (210 mCi/µA) using in-house recycled [^{18}O]-water at approximately 93% enrichment.

Reduction of beam power per unit of area is one of the advantages of a tilted entrance-foil geometry. Implementation of this target geometry on the ACSI TR19 cyclotron 25degrees upwards irradiation port results in an almost horizontal target entrance foil. A 6ml total cavity volume target allows variable liquid fill volumes of 1.2–4.5 ml for beam current operation from 30–120 µA, resulting in a very efficient use of the costly ^{18}O-water. In a near horizontal installation as in the mayority of cyclotrons, the fill volume flexibility is drastically reduced, having a minimum fill volume of 3.3 ml.

At the requirement of Laboratorios Bacon, Cyclotope modified the target design with a front mounted collimator compatible with the IBA Cyclone 18/9 cyclotron. A second requirement was to reduce the minimum fill volume for horizontally mounted targets to 2.5 ml or less, while maintaining saturation yield performance. To preserve compatibility with existing IBA targets, the target hardware was modified to operate in self-pressurization mode.

This paper presents the results obtained with high and low volume Niobium target inserts (6ml and 4 ml) mounted near horizontally on the IBA Cyclone 18/9 cyclotron and operated in self-pressurization mode.

We present pressure/current characteristics, target performance (saturation yield, produced activities, maintenance frequency, FDG yields, etc.).

Material and Methods

The following targets manufactured by Cyclotope were tested and routinely used for production at Laboratorios Bacon:

1-High Volume Target CY2 model (“American Standard”), 6ml Niobium cavity.
2-Low Volume Target, CY3a model (“Traful”), 4ml Niobium cavity.
3- Low volume Target, CY3b model (“Ferrum”), 4.1ml Niobium cavity.

Results and Conclusion

The advantages of self-pressurization mode (Laboratorios Bacon setup) are:

- Using the vapor pressure as a performance parameter
- heat removal by boiling/condensation cycle starts at lower temperature (beam current) .

While, the advantages of the pre-pressurized targets (Cyclotope setup) are:

- reduced pressure fluctuations
- performance is basically unaffected by plumbing dead volume
- flexibility to locate instrumentation farther away from radiation fields
- less dependence on fill volume
- potential target leaks can be detected before starting an irradiation

No significant differences were found in target performance when operated in either pressurization mode. The self-pressurizing setup seems to require a sligthly lower fill volume (approximately 5%).

The maximum beam current was limited by the foil rupture pressure (~ 40 bar). Safe maximum operating pressure was determined as 30 bar. No foil rupture was experienced during nine months of daily irradiation of these targets in self-pressurizing mode at Laboratorios Bacon.

The irradiation parameters and target performance for the different targets are shown in Tables 1 and 2 below. The low volume Traful and Ferrum targets have the best saturation activity vs. fill volume, A(sat)/V, relation. Both targets produce 310 ± 31GBq (8.4 ± 0.8 Ci) of high quality fluoride (F-18) in two hours of irradiation at 70 µA. The low volume targets have a low operation pressure (20bar @ 70µA) when compared to the IBA (NIRTA XL) targets. The typical saturation activity for the low volume targets was 592 ± 59 GBq (16 ± 1.6 Ci) of F-18 at 70 µA, 8.5 GBq/µA (228 mCi/µA) using 2.7ml enriched O-18

[1]Corresponding author, E-mail: gcasale@bacon.com.ar

water (98 % +). The maintenance interval (> 10 mA.h) is very conveniente to reduce personnel radiation dose. No reduction in FDG yields was observed during that operation interval.

Target	*I*(μA)	*P*(bar)	*V*(ml)
AMERICAN STANDARD*	90	20	3.8
TRAFUL	70	20	2.7
FERRUM	70	20	2.7
IBA (NIRTA XL)	40	30	2.0

TABLE 1. Targets parameters for self-pressurizing mode on the IBA Cyclone 18/9. Where, *I* is the beam current, *P* is the operating pressure, *V* is the fill volume.

In contrast, operation of the high volume targets in pre-presurization mode at the Cyclotope facility results in a higher maximum beam current limit (135 μA) for the same operating pressure (25 bar). Nevertheless, more O-18 water will be required to irradiate at this high current (4.5 ml vs. 3.0 ml). In self-pressurizing mode, a higher filling volume will reduce the expansion volume and, in consequence, the maximum beam current.

Target	**Nº Runs**	A_{Sat} GBq(Ci)	A_{Sat}/V GBq/ml
AMERICAN STANDARD*	1263	694(19)	**209**
TRAFUL	314	592(16)	**218**
FERRUM	10	592(16)	**218**
IBA XL	>1000	310(8.4)	**155**

TABLE 2. Targets performance for self-pressurizing mode on the IBA Cyclone 18/9. O-18 water enrichment 98 % +. Where, A_{Sat} is the saturation activity and A_{Sat}/V is the performance parameter.

*Operated in pre-pressurized mode and using recycled O-18 water (~ 93 %).

References

1. S. R. Strangis, C. Gonzalez Lepera: *Breaking the 1KW Target Barrier for the Routine Production of F18 With O18-Water*. Conference on the Application of Accelerators in Research and Industry. October 10–15, 2004. Denton, TX.
2. S. R. Strangis and C. Gonzalez Lepera: *Reliable Fluorine-18 [$^{18}F^-$] Production at High Beam Power*. 18th International Conference on Cyclotrons and Their Applications. September 30–October 5, 2008. Catania, Italy.

[1]Corresponding author, E-mail: gcasale@bacon.com.ar