Liquid Target Assembly for 6M Irradiation Setup BARC-TIFR Pelletron Accelerator Facility: Design and Testing

S.C. Sharma, Ramjilal, N.G.Ninawe, A.Shanbag[1], C.Sunil[1], M.L.Yadav
P.V.Bhagwat and R. K. Choudhury
Nuclear Physics Division, BARC, Mumbai-85
[1]Health Physics Division, BARC, Mumbai-85
email: scs@tifr.res.in

Introduction

With the objective to produce radioisotopes in liquid and to irradiate semi liquid/ or liquid samples accelerated ion beam has to be brought in air to conduct the experiments, as these samples cannot be kept under vacuum. A liquid-target holding assembly (LTA) has been designed, fabricated and tested. This assembly can be installed at the 6M irradiation [1] setup of BARC-TIFR Pelletron Accelerator Facility. Liquid samples can be irradiated with energetic beams.

Details of assembly and features

The picture of the LTA is shown in figure-1. The entire assembly is mounted on standard 4" NEC flange which can be directly installed at 6M experimental port (figure 2). Accelerated beam enters through a 4mm collimator and passes through a Titanium window which isolates liquid samples from vacuum area.

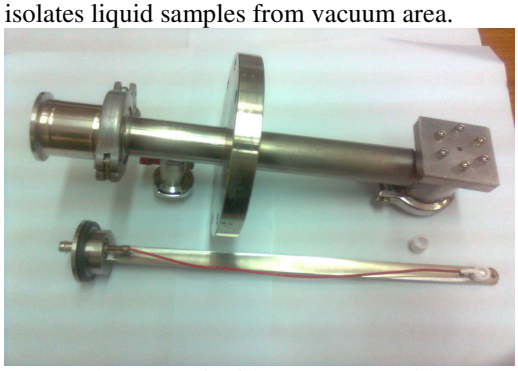

Figure-1: Liquid Target Assembly

Liquid sample can be placed at beam position by inserting a specially designed stem. This stem is joined to housing of LTA with 40 KF coupling; hence sample can be placed at beam position in minimum time period.

Stem has cavity therein to contain liquid to be irradiated. The cavity body in which liquid is irradiated can be selected in such a manner that produced radioisotopes, or reaction byproducts from the irradiation of the liquid target do not react with cavity body. Beam current on sample can be also measured with this stem.

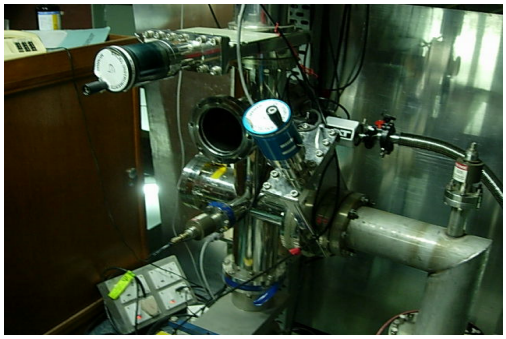

Figure - 2: 6M Irradiation Port

Table 1: LTA –Pellet Parameters

Sample can be irradiated	Solid/semi liquid/ liquid/biological
Window	Titanium
Liquid column	Vertical
Window thickness	50-100 micron
Size of liquid holder	Height – 12mm Diameter – 8mm
Vacuum in 6M chamber	$6x10^{-7}$ Torr.
Cooling	Indirectly by continuous chilledwater close-loop system
Energetic beam can be delivered on samples	*Neutron*, Proton Light Ions like Lithium, Boron
Energy range	4MeV to 22MeV (for proton)
Beam current	1nA to 500nA (for proton)

The liquid target must have sufficient depth or thickness so as to fully absorb the energetic particles from the beam. In this assembly height of liquid can be kept 12 mm which is sufficient to completely absorb [3] maximum energetic Proton beam at 6M port.

When the energetic beam bombards the liquid target, the temperature of the target quickly increases. Heat must be efficiently drawn away from titanium window as well from the liquid sample. Titanium foil and liquid target holder (stem) are cooled indirectly by continuous chilled water cooling close-loop system.

Vacuum safety

To protect the accelerating tubes and beam line from accidental air rush due to rupture of window, two fast closing valves are in existence. In addition manually operated valves at 6m irradiation setup are replaced by pneumatically operated one. These valves are interlocked with a vacuum gauge, installed at 6M chamber. This gives additional vacuum safety to accelerator.

Testing Results

Liquid target assembly is tested using proton beam. Liquid sample Aqueous Gentian Violet (dye solution, 1000ppm) was irradiated with 20MeV Proton beam. Beam current on target was about 20nA. After irradiation the sample was significantly discolored. Subsequent spectrophotometric analysis showed that the optical density of the irradiated dye solution had reduced considerably. The incident protons causes the ionization of water and hence the generation of radicals and species, which lead to degradation of the dye molecules and hence the subsequent discoloration. The aim of this experiment was to study the proton induced degradation of aqueous dye solutions [3]. Final results of this experiment and other utilization of LTA will be presented during the symposium.

LTA is also tested with 20MeV, ~300 nA proton beam current (measured at FC-CB-1) for about 30 minutes on a dummy target.

Conclusion

LTA performance is satisfactory. Proton beam current upto 500nA can be given on liquid targets after doing minor modifications. Light Heavy ions like Boron, Lithium can be also given to irradiate liquids by optimizing Titanium window thickness.

This assembly can also be used to irradiate liquids by neutrons. Energetic high energy neutrons [4] can be produced via Li (p, n) Be reaction by keeping lithium target above titanium window.

Liquid Target Assembly will be used by different groups of BARC and SINP to carry out new type of experiments which were otherwise not possible at Pelletron accelerator facility.

Acknowledgements

The authors wish to thank colleagues at the accelerator facility for their support during the testing. It is pleasure to acknowledge the technical cooperation of Shri SB Salvi, P.C.Bolar and TIFR workshop people.

References

[1] S.C. Sharma, Ramjilal, N.G. Ninawe, S.B. Salvi, A.K. Gupta, P.V. Bhagwat and S. Kailas "Commissioning of 6M irradiation setup at BARC-TIFR Pelletron Accelerator Facility, Mumbai" DAE-BRNS Symposium on Nuclear Physics-2004

[2] SRIM-2008.03

[3] M.A. Rauf & S. Salman Ashraf "Radiation induced degradation of dyes-An overview", Journal of Hazardous Materials 166 (2009) 6–16

[4] M. Bhike, A. Saxena, B.K. Nayak, S. Ganesan, B. Lalremruata, R. Palit, R. Tirpathi, S. Sodaye, A.V.R. Reddy, S. Kailas and R.K. Choudhary "Measurement of (n,p) reaction cross sections with MeV neutrons" DAE Symposium on Nuclear Physics, Vol.-56, P-403, 2006