ACCELERATOR BASED APPLICATIONS AT BARC-TIFR PELLETRON ACCELERATOR FACILITY

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Abstract

The 14 UD Pelletron Accelerator, set up as a collaborative effort between Bhabha Atomic Research Centre and Tata Institute of Fundamental Research, has been operational since it's inception in 1989. Apart from basic research, various accelerator based programmes including accelerator mass spectrometry, production of track-etch membranes, production of radio isotopes, irradiation damage studies are being pursued. This contribution will describe the details of currently ongoing programmes.

ACCELERATOR MASS SPECTROMETRY

Accelerator mass spectrometry (AMS) is an ultra sensitive method of counting individual atoms having sufficiently long half life and available in low abundance. The medium energy tandem accelerator of this kind is an ideal machine to carry out AMS studies with heavy species like ^{36}Cl, ^{129}I etc. Cosmogenic radio isotope ^{36}Cl is widely being detected using AMS as it has got applications in ground water research, radioactive waste management, atmospheric ^{36}Cl transport mechanism studies of Arctic Alpine ice core etc [1]. As the interfering isobar in the ^{36}Cl detection is ^{36}S, a split anode ionization chamber, being the most suited one, was developed indigenously [2]. The detector was calibrated using very low yields of ^{35}Cl and ^{37}Cl (keeping source parameters low) from the natural sample. The source parameters were optimised and Mass 36 was injected and transported through the machine up to the detector. Background ^{36}S (coming from the ion source as an impurity or memory effect) is identified in the detector. Recently, a beam chopper required for this measurement has also been developed.

^{36}Cl was produced by irradiating sodium chloride (NaCl) with thermal neutrons at Apsara reactor, BARC by the nuclear reaction ^{35}Cl(n, γ)^{36} Cl. The irradiated sample was used to prepare the ion source sample.

The distinct peaks of ^{36}Cl and ^{36}S can be seen in the signals from anode 2 and Silicon detector (Fig.1). The yield of ^{36}Cl in the detector and the ^{35}Cl beam intensity in the Faraday cup located in close to the detector was measured. The ratio ^{36}Cl / ^{35}Cl in the sample is found to be ~ $1.5*10^{-10}$.

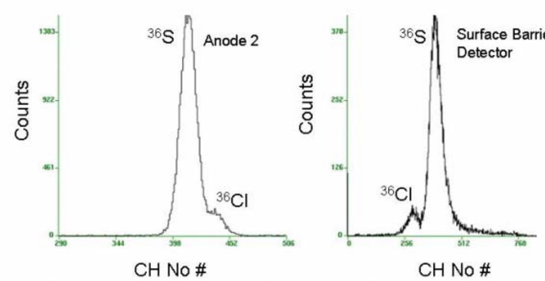

Figure 1: Spectra from Anode 2 and Silicon Detector.

PRODUCTION OF TRACK-ETCH MEMBRANES

Microporous membranes with features such as well defined and uniform pore size and pore density, uniform thickness, high tensile strength, inertness to toxic environments are in good demand for growing number of scientific and technological applications. Track Etch Membranes (TEMs) made by irradiating polymer films with heavy ions using accelerators are well known. Heavy ion accelerators provide greater flexibility to produce TEMs of a wide range as they can provide heavy ions of different atomic number (Z), kinetic energy (E) and particle flux. The damage size created by the heavy ions is of the order of 50 – 80 A^o. Chemical etching is essential to enlarge the pore size to micron range. Pore densities of the order of 10^6 to 10^8 pores/cm^2 and pore size of the order of 0.2 to 1.0 micron are required for many applications. Large scale industrial application needs membranes of large area and in bulk quantity.

The polymer films of 25 micron thickness were used. A magnet [3] was used to scan the heavy ions from the accelerator in horizontal direction and the polymer film was moved in vertical direction using a roller mechanism. The scanner magnet gives a peak magnetic field of 1.35 KGuass. To get larger deflection, higher charge states of the desired ions are produced using post-stripper. The deflection, at the exit of the scanner is few centimeters which is then widened using a horn chamber of one metre length. At the end of the scanner, deflection up to 25 cms is achieved. The film is wound on a perspex shaft of 19 mm diameter and is continuously unwound on to another roller which is driven by a D.C motor from outside the chamber. Coupling is done using a vacuum rotary feedthrough. The linear speed of the film is kept at 60 cms/min. The beam is defocused in vertical direction to get almost uniform particle distribution. Fig. 2 shows scanning electron microscope (SEM) photograph of membrane.

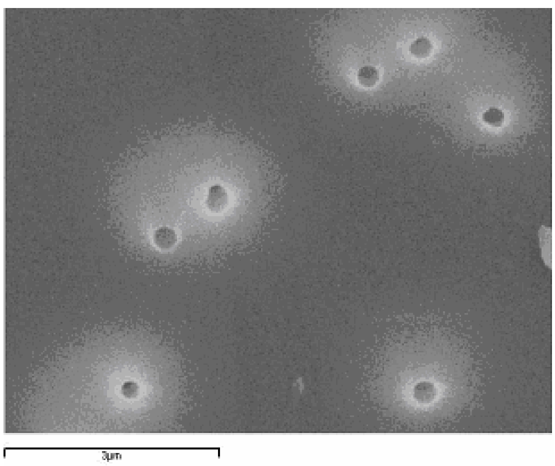

Figure 2: SEM Patograph of Membrane.

These membranes are being used to immobilize antibodies against specific analyte at Radiation Medicine Centre, Mumbai and for purification of gases at University of Rajasthan, Jaipur. Also, trial experiments are in progress at Desalination Division, BARC for water filtration. Besides these, the membranes were already used as Supported Liquid Membranes (SLM) in separating various Actinides and metals [4].

IRRADIATION SET UP

Drift space above analyzing magnet is modified to accommodate a Proton Beam Irradiation Setup at 6 meter level at this facility. This setup is capable of delivering proton beam in the energy range of 2 MeV to 26MeV and current in µA range. The shielding at this level is such that radiation is within permissible limit when proton beam with high energy and µA current is accelerated. In order to study radiation effects on metals at a higher temperature a hot target assembly is developed which can go upto 500 ^{0}C.

Radionuclides such as 52Mn, 67Ga, 96Tc, and 236Pu are produced for radiopharmaceutical applications. This setup is also being used for production of monoenergetic neutrons by Proton beam on Lithium Target. Same setup is being used to irradiate the target by a heavy ion beam having different charge states (which means essentially different energies corresponding to the terminal voltage) at the same time.

Figure 3: Proton Irradiation Set up.

This setup (Fig.3) is being used by various groups of BARC, TIFR, SINP and various universities to carry out experiments. The target assembly features can be modified/designed as per user's requirement.

LARGE AREA PROTON IRRADIATION SET UP

Large area Proton beam of diameter one inch and more is needed for irradiation of many devices e.g. electronic chips for space applications, which are of size more than 1 cm, need to be tested for their life time in radiation environment.

A large area proton beam of size 25 mm to 40 mm diameter in air was made available to ISRO for testing their on-line electronic devices. Proton beam flux of 10^6 to 10^{10} particles/cm^2 was achieved. The proton beam from the accelerator is focussed on to a gold foil of 1mg/cm^2 thickness which scatters the proton beam. The scattered beam passes through a drift tube of length 1 metre at the end of which the size of the beam will be more than 50 mm diameter. A Titanium window of 12 mm diameter at the entrance of the drift tube isolates the high vacuum on the accelerator side from the rough vacuum in the drift tube. And, Titanium window of 50 mm diameter at the exit of the drift tube isolates the atmosphere from rough vacuum in the tube. This way even if the large titanium foil breaks accidentally the second titanium window will protect the accelerator vacuum. The thickness of the titanium film was 22 microns. The drift tube is maintained at a vacuum of 10^{-3} Torr. The size and energy of the scattered beam was evaluated using SRIM 2003 program. The size of the beam was observed using a plastic scintillator (Fig. 4). The focussing of the beam was altered to get uniform distribution as far as possible. A current measuring device to monitor current as a function of distance from the centre of the scattered beam was made.

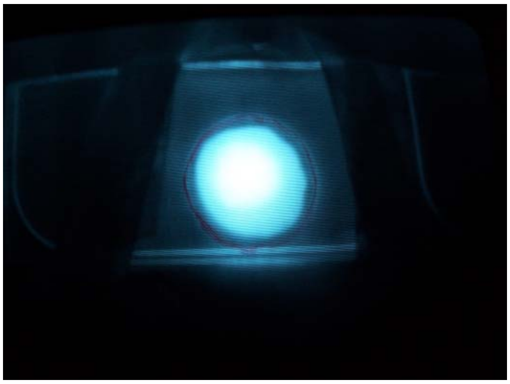

Figure 4: Scattered Proton Beam on Plastic Scintillator.

The experiment was conducted with 100 picoamps on 1cm^2 area in the centre as one cm^2 was the size of the chips to be irradiated (Fig. 4). More than 80 chips, mostly opto-couplers, were tested and found to be in agreement with the manufacturer's data.

RADIATION BIOLOGY

A thin window (20µ) of Titanium is placed at 30^0 N beam line to bring out ion beam in air. This facility has been used by users from BARC and TIFR.

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