INTRODUCTION

Isotope separation science and technology have grown mainly due to the demands made by nuclear industry. Being one of the most difficult processes, the scientists have kept on innovating to find more efficient processes. The processes developed for isotope production for nuclear fuel cycle are also useful for producing medical isotopes. Lasers with the narrow bandwidth, high intensity, low divergence, pulse duration control are a boon to photochemical separation of isotopes. The CO$_2$ laser has been used for macroscopic production of C-13 isotope. Two processes for B-10 enrichment namely, distillation and ion exchange chromatography, have been developed to a mature level and deployed at the users’ site.
10.1 MOLECULAR LASER ISOTOPE SEPARATION

Laser separation of light and middle-mass isotopes like carbon-13, sulphur-33 and oxygen-18 by selective photochemical methods is of interest to the medical community. The major activities involved in the development areas of these processes are:

a) Laser selective photophysics and photochemistry of various polyatomic molecules

b) Dynamics of infrared multiple photon dissociation (IRMPD) processes probed with elegant time-resolved techniques like infrared fluorescence (IRF), optoacoustic (OA) and uv-visible kinetic spectrometry.

c) Development of required infrared lasers

d) Production of Carbon isotopes

Laser and Plasma Technology Division has developed the process for laser separation of carbon isotopes, and now in the process of developing it for macroscopic production.

Natural carbon consists of two stable isotopes, viz. C-13 (1.11%) and C-12 (98.99%). Carbon-13 is an important isotope as a tracer in chemistry, life science, medicine, and biochemical synthesis. An optimistic projection of hundred-fold increase in the demand is anticipated in view of rapid development of routine medical applications such as breath tests and whole body NMR. There are immediate uses of such isotopes in DAE activities like high resolution spectroscopy, catalyst development, isotopically labelled gas lasers, tracer in biology and making `super' diamonds. In view of the growing demand, Laser & Plasma Technology Division is actively engaged in developing MLIS processes.

The process is based on CO₂ laser induced Infrared Multiple Photon Dissociation (IRMPD) of CF₂HCl molecule. Excitation and dissociation selectivities are extremely high for this system so that CF₂HCl MPD is possible even at fairly moderate pressure (133 mbar) at room temperature yielding C₂F₄ with 50 % ¹³-C.

The prototype facility with the major components is shown in the figure.

Presently, in a production run of 8 hr, the unit provides about 100 mg of Carbon (40% C-13) with 10 Hz CO₂ laser (ca. 20 gm/yr). Overall, this facility has generated database, operating experience and trained manpower in the general area of laser processing of high value and strategic materials. Based on this expertise and infra structure developed, the processes for Laser Separation of Oxygen-18, and Sulphur-33 isotopes are being developed.
10.2 $^{10}$B ISOTOPE ENRICHMENT

- **Exchange Distillation Plant**

Enriched $^{10}$B is essential to Fast Reactor programme. It is also useful for nuclear instruments. The technology of isotopic enrichment of $^{10}$B has reached a mature stage. The plant based on the exchange distillation had been set up by Chemical Engineering Division, operated and ~ 90% $^{10}$B in the form ethyl ether complex was produced. The material was supplied to Nuclear Physics Division, Electronics Division and Electronics Corporation of India for use in neutron counters. Subsequently, the plant was relocated at Heavy Water Project (HWP), Talcher, where it has been made operational. Chemical Engineering Division provided the conversion kit.
(BF₃ ethyl ether complex to BF₃CaF₂ complex), isotopic analysis support and trained the HWP plant personnel in operation of the plant and associated works.

### Ion Exchange Plant

Another process of ¹⁰B enrichment was developed by Chemical Engineering Division based on ion exchange process, namely displacement chromatography. The plant was set up and operated for over a year and ~ 50% B¹⁰ in the form of boric acid was produced. This material was supplied to Electronics Division. Some material of ~ 30% B¹⁰ was supplied to IGCAR, Kalpakkam for their use. This Division provided consultancy to IGCAR and shared the operating experience with their engineers build a bigger plant based on displacement ion chromatography.

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