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# ENERGY-LOSS OF 20-80 MeV $^{12}$C IONS IN POLYMERIC SOLIDS

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## ABSTRACT

The experimental results on the characterization of three polymeric solids in terms of energy-loss of 20-80 MeV $^{12}$C ions in Kapton, Hostaphan and Makrofol-N have been presented and compared with theoretical values.

## KEYWORDS

Energy-loss; $^{12}$C; Kapton; Hostaphan; Makrofol-N

## INTRODUCTION

The knowledge of energy-loss or the way a given impinging heavy ion loses energy as it passes through the impeditive material gives information regarding the material itself. This in turn can be utilized as a pointer to its application in different fields including material science. At present there is a decided paucity of the experimental energy-loss data in elemental and complex media for heavy ions having energy above 1 MeV/A (Dwivedi, 1991; Foroughi *et al.*, 1979; Räisänen *et al.*, 1990 and Srivastava *et al.*, 1996 a,b).

A number of polymeric solids have found applications in the form of windows, backings, absorbers, degraders in many nuclear physics experiments besides in the manufacture of microfilters and single-pore membranes for applications in the field of environmental science, biomedical science and superfluidity (Spohr,1990). It has been reported by Lee *et al.*(1991) that a triple beam of Boron, Nitrogen and Carbon when implanted in Kapton polyimide resulted in hardness of the polymer to such an extent that it was found to be three times harder than steel.

The energy-loss data of $^{12}$C in three polymers obtained in the present work are compared with the values derived from most widely used theoretical prescription TRIM (Biersack and Haagmark, 1980) and the RANGE developed in our group (Dwivedi, 1988) with a view to check their applicability for complex solids.

## EXPERIMENTAL PROCEDURE

The experiments were carried out at the General Purpose Scattering Chamber (GPSC) of the 15 UD Pelletron Accelerator at the Nuclear Science Centre, New Delhi. Fig. 1 shows a schematic diagram of the experimental setup used for irradiation. Different positions are labelled as beam (B), scatterer (S), Faraday cup (FC), target (T) and surface barrier detector (SB). $^{12}$C ions were accelerated to an energy of 90 MeV and the resulting ion beam was directed on a 11.3 mg/cm$^2$ thick Bi scatterer foil. The scattered beam at 20° angle was allowed to enter an irradiation chamber fitted with target ladder and a surface barrier detector. The energy of the $^{12}$C ions on the target was measured to be 80.8 MeV.

The beam current varied beteween 10-20 pnA which corresponds to a fluence of about $10^4$ $cm^{-2}$. Thin foils of Kapton, Hostaphan and Makrofol-N with precisely known thickness were utilized to prepare differential targets in staircase configuration. The range of thickness varied between 20 μm and 280 μm. The energy of the degraded ions after passing through different thickness of polymeric media was determined by a precalibrated surface barrier detector coupled to a multichannel analyzer.

## RESULTS AND DISCUSSION

Table 1 lists some chemical and physical properties of the polymeric materials used in the present study. The channel number corresponding to the peak centroid was determined by NSCSORT peak fitting program and the energy of the transmitted ion passing through a given thickness of the polymer foils was obtained using a calibration curve. The experimental uncertainty in the energy determination arising due to counting statistics and ion straggling was found to vary from 1 to 16 percent.

Table 1 : Some chemical and physical properties of Polymeric Materials used in the present work

| Name | KAPTON | HOSTAPHAN | MAKROFOL-N |
|---|---|---|---|
| Composition | $C_{22}H_{18}O_5N_2$ | $C_{10}H_8O_4$ | $C_{16}H_{14}O_3$ |
| Chemical name | PI | PET | PC |
| Molecular weight | 390 | 192 | 254.3 |
| Density (g/ml) | 1.42 | 1.41 | 1.14 |
| Thickness (μm) | 25 | 20 | 20 |
| Colour | yellow | colourless | light yellow |

PI=Polyimide, PET=Polyethylene terphthalate, PC=Polycarbonate

The transmitted energies of $^{12}C$ ions as a function of the thickness of Kapton, Hostaphan and Makrofol-N are shown in Figs. 2-4 respectively along with the corresponding theoretical values derived from two prescriptions viz. TRIM and RANGE. It is observed from the above plots that the theoretical values obtained from the computer codes TRIM and RANGE are in good agreement with the experimentally determined energy-loss data of $^{12}C$ ions in these complex solids.

In conclusion it can be said that the experimental measurement on energy-loss carried out in the present work has demonstrated the applicability and reliability of theoretical data obtained from the commonly used computer codes in the case of $^{12}C$ ions between 80-20 MeV. It can be further stated that the energy-loss profiles of 80-20 MeV $^{12}C$ ions in three polymeric solids determined in the present work have provided useful basic data for planning deep implantation (upto 200 μm) with energetic carbon ions.

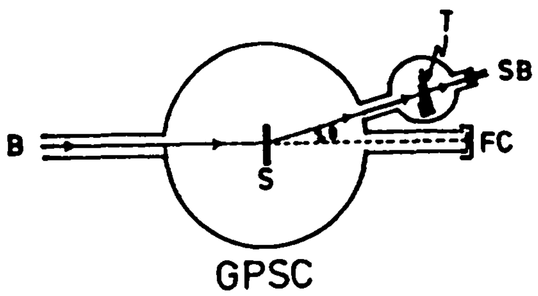


Figure 1: Schematic diagram of the experimental setup used for irradiation at the General Purpose Scattering Chamber (GPSC).

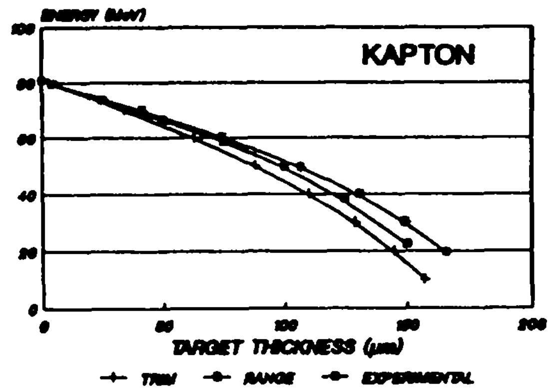


Figure 2: Experimental and theoretical energy-loss data for $^{12}C$ in Kapton.

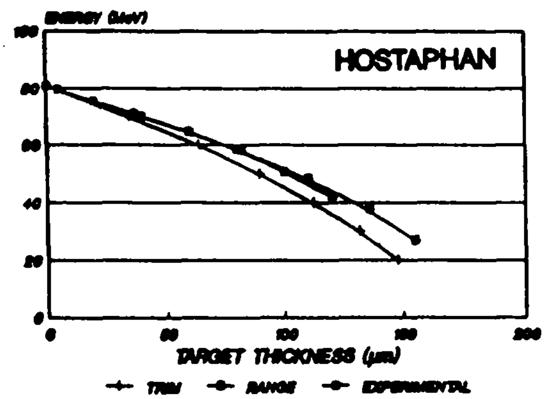


Figure 3: Experimental and theoretical energy-loss data for $^{12}C$ in Hostaphan.

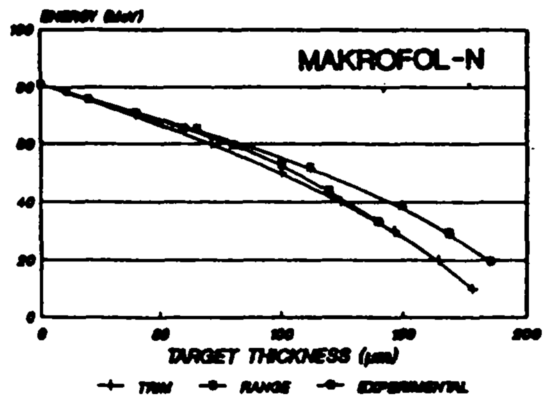


Figure 4: Experimental and theoretical energy-loss data for $^{12}C$ in Makrofol-N.

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