SYNOPSIS

HEAVY ION IRRADIATION INDUCED CHANGES IN POLYMERS AND $C_{60}$. 

The advent of heavy ion accelerators has given rise to numerous applications in material technology, which is emerging as a new field with possibilities of engineering new materials. Heavy ion beams has become a versatile handle in studying and characterizing materials because of its possibilities of varying and controlling the ion species and their energies to a great extent. Over the years accelerator based studies on materials has played a vital role in the progress of material science. With the advances in technology the field is now wide open with immense possibilities for inter-disciplinary research and developments.

Energetic Heavy ions passing through a material lose their energy mainly by inelastic scattering with the target electrons. This energy loss can be varied by choosing appropriate ions and their energies. This provide a flexibility to engineer properties of the material, so that the desired optical, electrical and mechanical properties can be obtained.

Owing to their inherent properties like its lightness, high corrosive resistance, high electrical resistivity etc., polymers are at present fast replacing metals and alloys in many applications and detailed studies on their properties has therefore assumed great importance. The only major disadvantage is their limited mechanical strength [1].
The interaction of ion beam with polymers have been extensively studied in the past many years and it has been found that bombardment of heavy ions drastically changes the electrical, mechanical and thermal properties in them [2-4]. The breaking of bonds, formation of free radicals, excited species, and a secondary chemical processes take place, which modify their properties and structures [5, 6]. Along the ion trajectory, cylindrical zones of defects called latent tracks are formed. These tracks consists of atomic displacements, broken molecular chains, free radicals etc. If the dose is high such that track overlapping takes place then the material is changed to such an extent that it can be considered to be as a new material. The range of such radiations in polymers is extremely small and therefore microscope observations are required to measure the tracks, holes or abrasions. The density of ionization and the radius of the core region depend on the projectile and its velocity and has been observed that three parameters are needed viz., atomic number, velocity and fluence to give satisfactory physical aspects of ion irradiation in polymers [7].

The hydrogen content in materials effects its electrical, mechanical, chemical and spectroscopic properties in materials. Therefore the detection of hydrogen in a material and the determination of concentration at various depths is of great importance. It is known that the hydrogen content of hydrogenous materials decreases with incident ion fluence. It is therefore possible to tailor the properties of materials by altering hydrogen concentration using ion beams. Polymers have different strengths of hydrogen concentrations which play an important role in their properties. Therefore in this work we have investigated the hydrogen loss behavior in different polymers using the technique known as Elastic Recoil Detection Analysis (ERDA).

Buckminsterfullerene (C_{60}) has exhibited properties that prompt possible widespread technological applications [8]. The interaction of energetic ions with C_{60} may be of particular relevance to C_{60} applications as a new material, as well
as problems related to the occurrence of $C_{60}$ in space [9]. With the above information there has been a great interest among researchers on the question of stability of $C_{60}$ and the products which arise on irradiation with ion beams. The possibility of metal doped $K^+$ fullerene for application in high temperature superconductivity prompted researchers [10-11] to attempt low energy ion implantation. However this led to the damage and destruction of $C_{60}$. Several workers[12-15] also investigated the process of damage of $C_{60}$ at low energies, where the elastic collision process dominated. From their work [15] it was evident that complete destruction of $C_{60}$ takes place when the product of the nuclear energy loss and the ion dose exceeds a critical value of $0.04 - 0.12eV/\text{Å}^3$. The natural question then arises about the fate of $C_{60}$ when they are exposed to a large electronic excitation. There are a few studies [16-18] on this aspect but the complete understanding of the process has not been achieved. We have therefore taken the interest to characterize the induced modification on $C_{60}$ at high electronic excitation using different ions and energies.

This thesis consists of seven Chapters. **Chapter I** introduces the problem and also outlines the interpretations and limitations by earlier workers working on relevant and related systems.

**Chapter II** describes in general the mechanism and the effect that takes place in the material when an energetic ion interacts with matter.

In **Chapter III**, we describe the irradiation parameters and the experimental techniques used to characterize the induced modification on the irradiated Polymers and $C_{60}$ thin films.

**Chapter IV** describes on the investigation of hydrogen loss under heavy ion irradiation in different Polymers using various energetic heavy ions and to determine the dependence of this loss on the electronic stopping power and the
relationship between the loss and the chemical composition such as their different bonding. The non-destructive nuclear technique Elastic Recoil Detection Analysis was used for the study.

In Chapter V we try to analyze the Physical and Chemical induced modification on the irradiated Polymers by swift heavy ions. The radiochemistry and melting behavior of semicrystalline polyethylene terephthalate (PET) polymer irradiated by 180 MeV Ag ion was studied. For the characterization study we have employed techniques of Differential Scanning Calorimetry (DSC), Fourier Transformed Infra-red Spectroscoopy (FTIR) and X-ray diffraction spectrometer. The effect on polyvinyledyene fluoride (PVDF) by irradiation with 180 MeV Ag ions and 95 MeV Ni ions at various fluences have also been described in this chapter.

In Chapter VI we describe the effect of heavy ion irradiation on C\textsubscript{60}. Thin films of C\textsubscript{60} of thickness ~500nm deposited on float glass substrates were subjected to swift heavy ion irradiation spanning the region from 2 to 11keV/nm of electronic excitation, using 189 MeV \textsuperscript{107}Ag\textsuperscript{13+} 110 MeV \textsuperscript{58}Ni\textsuperscript{17+} 50 MeV \textsuperscript{28}Si\textsuperscript{5+} ions. Studies on the irradiated films were investigated using the techniques of Raman and Photoluminescence spectroscopy. To get more information on the effect of energetic heavy ions on C\textsubscript{60}, techniques of X-ray diffraction (XRD), Atomic force microscopy (AFM) and Fourier transformed infra-red (FTIR) spectroscopy were also utilized to study the topographic morphology, the crystalline structure and in the chemical modifications.

Finally a summary of the thesis and the important conclusions are given in Chapter VII along with the prospective for future scope on this field.
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