PREFACE

The rapid pace of advances in polymers, with only few decades separating their first commercial development from their present pervasive use, has been remarkable. Although progress to date in polymer science can be considered revolutionary, opportunities are abundant to create new polymeric materials and modifying existing polymers as per different applications. Inclusions of nanoparticles in polymers offer to novel materials/ nanocomposites which are proposed important technological advances in the field of battery, gas sensors, photo electronic devices, catalysis, electrochemistry, photoluminescence and separation membranes. However, for most of these highly specialized applications, there is a practical need to disperse the nanoparticles in polymeric materials. As useful feature of polymer host matrices is that they provide the possibility of mediating magnetic interactions between particles in these nanocomposites including dipolar, exchange (isotropic and anisotropic), super exchange and magnetoelastic interactions. Polymers have traditionally been considered as an excellent host matrix for composite materials. Several advanced polymer composites have been synthesized with a wide variety of inclusions like metals, semiconductors, carbon nanotubes and magnetic nanoparticles. Many attractive properties of polymers like non-corrosiveness, light weight, mechanical strength, dielectric tenability and able to provide required immobilisation of the nanoparticles avoiding their coalescence or segregation, thus protecting the novel size-dependent properties of nanomaterials can be utilized along with magnetic and optical properties of nanoparticles to make multifunctional material.

Research in the use of noble nano materials has surged over the last few decades and considerably numerous works have been carried out to understand the nanomaterials and their assemblies. By confinement of materials in nanometre spatial dimensions, small size effect, surface effect, quantum size effect and macroscopic quantum tunnel effect can alter the optical, magnetic, electrical and structural properties of nanomaterials. Whereas, composites are materials in which two or more distinct, structurally complementary substances combine to produce some structural or functional properties not present in any individual component and to combine some of the advantages of the component materials forming some novel ones.

Unlike applications of nanotechnology in the photonics and electronics areas, the use of the polymer nanocomposites in the field of dielectrics and electrical insulation has not attracted a lot of interest until very recently. The current growing need for high-power density and high voltage capacitors, gate dielectrics, memories, sensors, shielding and power-storage devices has stimulated a new wave of research interest in polymer nanocomposites. By incorporating high permittivity inorganic nanoparticles like metal nanoparticles into a polymer matrix with low dielectric loss and high dielectric strength, one may be able to develop new composite materials that have improved dielectric properties (resistivity, dielectric strength, permittivity and dielectric losses) and retain the unique attributes of polymers such as ease of production and often ductilility, etc.. By varying the size and percentage of filler nanoparticles, the polymer nanocomposites may be fabricated with tailored dielectric properties for specific applications.

The high energy ion beam irradiation effects in polymers have fascinated considerable attention for purposes of polymers in radiation environment and also in the improvement of new electronic devices. The deposited energy may be converted into atomic motion and finally leads to the structural and chemical modifications within a cylindrical zone of several nanometers in diameter and new structural arrangements may appear. Swift heavy ion irradiation tends to damage polymers significantly by two ways mainly, electronic excitation and ionization. The nature of defects and the relative radiative sensitivity of different polymers depend on the properties such as their composition and molecular weight, on the charge, mass and energy of the ion and also on the environmental conditions during irradiation. Irradiation effects in inorganic materials are manifested as changes in physical properties such as refractive index, magnetization and hardness. Some of the work reported on the modification of ion beam irradiation on organometallic / metal polymer composites. It is observed that dielectric properties enhances on increasing the organometallic/metal particles content in polymer matrix and also upon ion beam irradiation.

In the present work, three different types of conductive nanoparticles were used as filler viz. silver (Ag), copper (Cu), nickel (Ni). Poly methyl methacrylate (PMMA) and polystyrene (PS) were used as polymer matrices for making polymer nanocomposites. The films were prepared by casting technique. The irradiation effect on these nanocomposite films was studied with respect to ion specie, energy and fluence. For this purpose 120 MeV Si Ni^{10+}, 85 MeV C^{6+}beams were used. AC electrical/dielectric, structural, chemical, thermal, optical, magnetic properties and surface morphology of pristine and irradiated nanocomposites were investigated by means of various techniques.

The present work is categorized into the following chapters:

Chapter 1 will be the general introduction of state of art of the applications of polymer based nanocomposites in packing and shielding application. The importance of ion beam irradiation in the field of nano science and technologies is explained on the basis of energy loss of ion beam in the polymeric samples. This also deals with literature survey with reference to ion beam irradiation of polymeric materials and motivation for present work.

Chapter 2 presents a brief review of the concept of polymer composites and general descriptions of the experimental methods and tools used are given in this chapter. The working principles and operation of Pelletron Accelerators has been conversed. Three different types of conductive nanoparticles were used as filler viz. silver (Ag), copper (Cu), nickel (Ni). Poly methyl methacrylate (PMMA) and polystyrene (PS) were used as polymer matrices for making polymer nanocomposites. Different characterization techniques have been used to do off-line analysis of the pristine and irradiated samples. These techniques with their proper specifications and operating principle have been described.

Chapter 3 This chapter describes the comparative study of characterization of conductive filler, silver (Ag) dispersed PMMA and PS polymers nanocomposites. These composites were irradiated with 85 MeV C^{+6} ions and 120 MeV Si^{+10} ions at fluences of $1x10^{11}$ and $1\ x10^{12}$ ions/cm^2. The various results of experimentations before and after ion beam irradiation are explained. Scientific explanations of various properties e.g., structural, optical, thermal, electrical properties and surface morphology of conductive composites are given. The results obtained from various characterization techniques show the dependence of different properties of composites upon matrix, ion beam irradiation and filler concentrations. Structural properties were studied by means of X-ray diffraction. The band gap of materials decreases with filler concentrations and also upon irradiation. Thermal property of the composite was studied by DSC analysis and it reveals about the glass transitions temperature (Tg). The glass transition temperature increases on increasing the filler concentration and decreases upon ion beam irradiation with fluences in PMMA and increases in PS nanocomposites. The average surface roughness of the composites also changed as revealed from SEM studied. The results of all characterization techniques have been correlated to give a better and clear view of dielectric, structural, mechanical, chemical, thermal properties and surface morphology. It was observed that dielectric properties and microstructure of polymer composites enhanced after irradiation.

Chapter 4 illustrates the study of characterization of conductive filler, Copper (Cu), dispersed PMMA and PS polymers nanocomposites. These composites were irradiated with 85 MeV C^{+6} ions and 120 MeV Si^{+10} ions at fluences of $1x10^{11}$ and $1 x10^{12}$ ions/cm^2. The various results of experimentations before and after ion beam irradiation are explained. Scientific explanations of various properties e.g., structural, optical, thermal, surface morphology and electrical properties of conductive composites are given. The results obtained from various characterization techniques show the dependence of different properties of composites upon ion beam irradiations and filler concentrations. The structural, thermal, dielectric analysis was carried out by X-ray diffraction, DSC and Impedance phase gain analyzer respectively. The surface morphology of the composites is studied by SEM. It was observed that dielectric properties of polymer composites enhanced after irradiation. The results give the chain scissioning in Cu/PMMA composites and cross linking in the Cu/PS composites.

Chapter 5 describes the study of characterization of conductive filler, nickel (Ni), dispersed PMMA and PS polymers nanocomposites. These composites were irradiated with 85 MeV C^{+6} ions and 120 MeV Si^{+10} ions at fluencies of $1x10^{11}$ and $1 x10^{12}$ ions/cm^2. The various results of experimentations before and after ion beam irradiation are explained. We have studied changes in the optical, structural, dielectric, magnetic and thermal properties of composites due to swift heavy ion irradiation by means of UV–visible spectroscopy, X-ray diffraction, differential scanning calorimetry, impedance gain phase analyzer and SQUID. The ion beam irradiation of polymer nanocomposites leads to chain scission and cross linking, which leads to increase the free radicals, unsaturation etc. As a result of that there are changes in magnetic and dielectric properties. The magnetic properties enhanced after irradiation which may be attributed to the exchange dipolar interaction of particles in the matrix and generation of free radicals. AC electrical and dielectric properties of PMMA/Ni and PS/Ni nanocomposites were studied over a wide range of frequency as a function of filler concentrations. Both the dielectric constant and the electrical conductivity of the composites increased with the increase of Ni content. These phenomena could be interpreted from interfacial polarization of heterogeneous system.

Chapter 6 This chapter summarizes the results obtained by $Si^{10+}$and C^{6+} beam irradiations. It also gives conclusions derived from the present work. Future perspectives, as well as possible extension of the present work have been explained.

*The references are numbered in square bracket in the text and are listed at the end of the respective chapters.