List of Figures and Tables

Chapter-1 Introduction

Figure 1.1: Qualitative curve of the energy loss of an ion in the material as a function of the ion energy, shown on a log-log scale. 12

Figure 1.2: Typical effects of ion irradiation which include electronic excitation, phonons, ionizations, ion pair formation, radical formation and chain scission. 15

Figure 1.3: Polarization in dielectric (macroscopic view). 21

Figure 1.4: (a) Electric dipole (b) Alignment of a dipole (c) Final dipole alignment with field. 22

Figure 1.5: Electronic polarization. 24

Figure 1.6: Polarization mechanisms versus frequency in dielectric material. 26

Figure 1.7: Dielectric constant vs frequency and temperature A clear cast phenolic resin, B plasticized PVC, E polymethyl methacrylate, F, polychlorotrifluoroethane, G nylon, H neoprene, I plasticized ethylcelluloze, L polyurethane foam. 29

Figure 1.8: Dielectric tangent vs frequency and temperature A clear cast phenolic resin, B plasticized PVC, C polyvinyl chloride, D unplasticized PVC, E polymethyl methacrylate, F, polychlorotrifluoroethane, G nylon, H neoprene, I plasticized ethylcelluloze, J epoxy cast resin, K silicone rubber, L polyurethane foam, M polystyrene. 30

Chapter-2

Figure 2.1: Schematic diagram of IUAC Pelletron accelerator. 53

Figure 2.2: Schematic diagram of beam lines at IUAC Pelletron facility. 54

Figure 2.3: Material science irradiation chamber at IUAC Pelletron facility. 55

Figure 2.4: Picture of Two roll mill. 58

Figure 2.5: Sample Holder to measure electrical properties. 72

Figure 2.6: Vickers' Projection Microscope. 75

Figure 2.7. Concept of AFM and the optical lever: (left) a cantilever touching a sample; (right) the optical lever. Scale drawing; the tube scanner measures 24 mm in diameter, while the cantilever is 100 μm long 79

Figure 2 8: The AFM feedback loop. A compensation network (which in my AFM is a computer program) monitors the cantilever deflection and keeps it constant by adjusting the height of the sample (or cantilever). 80

Figure 2.9: Schematic representation of a SEM. 82

Figure 2.10 Schematic of electronic shells. 84

Figure 2.11: FTIR Spectroscopy set up. 89

Figure 2.12: Sketch diagram of DSC measurement. 92

Figure 2.13 Shows the block diagaram of Mossbauer Spectrometer. 96

Figure 2.14. Decay Scheme of Co^{57}. 96

Chapter-3

Figure 3 1(a): AC conductivity versus frequency for pristine pure and dispersed ferric oxalate in PMMA films. 105

Figure 3.1(b). AC conductivity versus frequency for irradiated pure and dispersed ferric oxalate in PMMA films 105

Figure 3.2(a): Dielectric constant versus frequency for pristine pure and dispersed ferric oxalate in PMMA films. 106

Figure 3.2(b): Dielectric constant versus frequency for irradiated pure and dispersed ferric oxalate in PMMA films. 106

Figure 3.3(a): Dielectric loss versus frequency for pristine pure and dispersed ferric oxalate in PMMA films. 107

Figure 3.3(b): Dielectric loss versus frequency for irradiated pure and dispersed ferric oxalate in PMMA films. 107

Figure 3.4(a): Plot of hardness (H_v) versus applied load (P) for pristine pure and dispersed ferric oxalate in PMMA films. 109

Figure 3.4(b): Plot of hardness (H_v) versus applied load (P) for irradiated pure and dispersed ferric oxalate in PMMA films. 109

Figure 3.5 (a): AFM image of pure PMMA film (pristine) (b) dispersed ferric oxalate (10%) in PMMA film (pristine) (c) dispersed ferric oxalate (15%) in PMMA film (pristine) (d) pure PMMA film (irradiated) (e) dispersed ferric oxalate (10%) in PMMA film (irradiated) (f) dispersed ferric oxalate (15%) in PMMA film (irradiated). 110-111

Figure 3.6(a): Mossbauer spectra of dispersed ferric oxalate (10%) in PMMA film (pristine). 113

Figure 3.7(a): AC conductivity versus frequency for pristine pure and dispersed ferric oxalate in PVC films. 116

Figure 3.7(b): AC conductivity versus frequency for irradiated (at the fluence of 1x 10^{11} ions/cm^2) pure and dispersed ferric oxalate compound in PVC films. 116

Figure 3.7(c): AC conductivity versus frequency for irradiated (at the fluence of 1x 10^{12} ions/cm^2) pure and dispersed ferric oxalate compound in PVC films. 117

Figure 3.8(a): Plot of dielectric constant versus frequency for pristine pure and dispersed ferric oxalate compound in PVC films. 118

Figure 3.8(b): Plot of dielectric constant versus frequency for irradiated (at the fluence of1x 10^{11} ions/cm^2) pure and ferric oxalate dispersed compound in PVC films. 118

Figure 3.8(c): Plot of dielectric constant versus frequency for irradiated (at the fluence of 1x10^{12} ions/cm^2) pure and ferric oxalate dispersed compound in PVC films. 119

Figure 3.9(a): Plot of dielectric loss versus frequency for pristine pure and dispersed ferric oxalate compound in PVC films. 121

Figure 3.9(b): Plot of dielectric loss versus frequency for irradiated (at the fluence of 1x 10^{11} ions/cm^2) pure and ferric oxalate dispersed compound in PVC films. 121

Figure 3.9(c): Plot of dielectric loss versus frequency for irradiated (at the fluence of 1x 10^{12} ions/cm^2) pure and ferric oxalate dispersed compound in PVC films. 122

Figure 3 10(a): Plot of hardness (H_v) versus applied load (P) for pristine pure and dispersed ferric oxalate compound in PVC films. 123

Figure 3.10(b): Plot of hardness (H_v) versus applied load (P) for irradiated (at the fluence of 1x 10^{11} ions/cm^2) pure and dispersed ferric oxalate compound in PVC films. 124

Figure 3.10(c): Plot of hardness (H_v) versus applied load (P) for irradiated (at the fluence of 1x 10^{12} ions/cm^2) pure and dispersed ferric oxalate compound in PVCfilms. 124

Figure 3.11(a): AFM image of pure PVC film (pristine) (b) dispersed ferric oxalate (5%) in PVC film (pristine) (c) dispersed ferric oxalate (15%) in PVC film (pristine) (d) AFM image of pure PVC film (irradiated at the fluence of x 10^{11} ions/cm^2) (e) dispersed ferric oxalate (5%) in PVC film (irradiated at the fluence of 1x 10^{11} ions/cm^2) (f) AFM image of dispersed ferric oxalate (15%) in PVC film (irradiated at the fluence of 1x 10^{11} ions/cm^2) (g) AFM image of pure PVC film (irradiated at the fluence of x 10^{12} ions/cm^2) (h) AFM image of dispersed ferric oxalate (5%) in PVC film (irradiated at the fluence of 1x 10^{12} ions/cm^2) (i) AFM image of dispersed ferric oxalate (15%) in PVC film (irradiated at the fluence of 1x 10^{12} ions/cm^2). 126-128

Figure 3.12(a): SEM micrograph of dispersed ferric oxalate (15%) in PVC film (pristine). 129

Figure 3.12(b): SEM micrograph of dispersed ferric oxalate (15%) in PVC film (irradiated at the fluence of 1x 10^{11} ions/cm^2). 129

Figure 3.12(c): SEM micrograph of dispersed ferric oxalate (15%) in PVC film (irradiated at the fluence of 1x 10^{12} ions/cm^2). 129

Figure 3.13(a): AC conductivity versus frequency for pristine pure and dispersed Ni-DMG compound in PMMA films. 132

Figure 3.13(b): AC conductivity versus frequency for irradiated pure and dispersed Ni-DMG compound in PMMA films. 132

Figure 3.14(a): Dielectric constant versus frequency for pristine pure and dispersed Ni-DMG compound in PMMA films. 134

Figure 3.14(b): Dielectric constant versus frequency for irradiated pure and dispersed Ni-DMG compound in PMMA films. 134

Figure 3.15(a): Dielectric loss versus frequency for pristine pure and dispersed Ni-DMG compound in PMMA films. 135

Figure 3.15(b): Plot of dielectric loss versus frequency for irradiated pure and dispersed Ni-DMG compound in PMMA films. 136

Figure 3.16(a): Plot of hardness (H_v) versus applied load (P) for pristinee pure and dispersed Ni-DMG compound in PMMA films. 137

Figure 3.16(b): Plot of hardness (H_v) versus applied load (P) for irradiated pure and dispersed Ni-DMG compound in PMMA films. 138

Figure 3.17(a): AFM image of pure PMMA film (pristine) (b) dispersed Ni-DMG compound (10%) in PMMA film (pristine) (c) dispersed Ni-DMG compound (15%) in PMMA film (pristine) (d) pure PMMA film (irradiated) (e) dispersed Ni-DMG compound (10%) in PMMA film (irradiated) (f) dispersed Ni-DMG compound (15%) in PMMA film (irradiated). 139-140

Chapter-4

Figure 4.1(a): AC conductivity versus frequency for pristine pure and dispersed Ni-DMG in PMMA films. 146

Figure 4.1(b): AC conductivity versus frequency for irradiated (at the fluence of 1x 10^{11} ions/cm^2) pure and dispersed Ni-DMG in PMMA films. 147

Figure 4.1(c): AC conductivity versus frequency for irradiated (at the fluence of 1x 10^{12} ions/cm^2) pure and dispersed Ni-DMG in PMMA films. 147

Figure 4.2(a): Dielectric constant versus frequency for pristine pure dispersed Ni-DMG in PMMA films. 150

Figure 4.2(b): Dielectric constant versus frequency for irradiated (at the fluence of 1x 10^{11} ions/cm^2) pure and dispersed Ni-DMG in PMMA films. 150

Figure 4.2(c): Dielectric constant versus frequency for irradiated (at the fluence of 1x 10^{12} ions/cm^2) pure and dispersed Ni-DMG in PMMA films. 151

Figure 4.3(a): Dielectric loss versus frequency for pristine pure and dispersed Ni -DMG in PMMA films. 151

Figure 4.3(b): Dielectric loss versus frequency for irradiated (at the fluence of $1x10^{11}$ ions/cm^2) pure and dispersed Ni-DMG in PMMA films. 152

Figure 4.3(c): Dielectric loss versus frequency for irradiated (at the fluence of $1x10^{12}$ ions/cm^2) pure and dispersed Ni-DMG in PMMA films. 152

Figure 4.4(a): Plot of hardness (H_v) versus applied load (P) for pristine pure and dispersed Ni-DMG compound in PMMA films. 154

Figure 4.4(b): Plot of hardness (H_v) versus applied load (P) for irradiated (at the fluence of 1x 10^{11} ions/cm^2) pure and dispersed Ni-DMG compound in PMMA films. 154

Figure 4.4(c): Plot of hardness (H_v) versus applied load (P) for irradiated (at the fluence of 1x 10^{12} ions/cm^2) pure and dispersed Ni-DMG compound in PMMA films. 155

Figure 4.5: XRD diffraction pattern for Ni-DMG compound. 157

Figure 4.6(a): XRD diffraction pattern for pure PMMA film (Pristine). 158

Figure 4.6(b): XRD diffraction pattern for pure PMMA film (at the fluence of 1x 10^{11} ions/cm^2). 158

Figure 4.6(c): XRD diffraction pattern for pure PMMA film (at the fluence of 1x 10^{12} ions/cm^2). 159

Figure 4.7(a): XRD diffraction pattern for 5% Ni- DMG compound dispersed in PMMA film (Pristine). 159

Figure 4.7(b): XRD diffraction pattern for 5% Ni- DMG compound dispersed in PMMA film for irradiated at the fluence of 1x 10^{11} ions/cm^2. 160

Figure 4.7(c): XRD diffraction pattern for 5% Ni- DMG compound dispersed in PMMA film for irradiated at the fluence of 1x 10^{12} ions/cm^2. 160

Figure 4.8(a): XRD diffraction pattern for 20% Ni- DMG compound dispersed in PMMA film (Pristine). 161

Figure 4.8(b): XRD diffraction pattern for 20% Ni- DMG compound dispersed in PMMA film for irradiated at the fluence of 1x 10^{11} ions/cm^2. 161

Figure 4.8(c): XRD diffraction pattern for 20% Ni- DMG compound dispersed in PMMA film for irradiated at the fluence of 1x 10^{12} ions/cm^2. 162

Figure 4.9(a): XRD diffraction pattern for 40% Ni- DMG compound dispersed in PMMA film (Pristine). 162

Figure 4.9 (b): XRD diffraction pattern for 40% Ni- DMG compound dispersed in PMMA films for irradiated at the fluence of 1x 10^{11} ions/cm^2. 163

Figure 4.9(c): XRD diffraction pattern for 40% Ni- DMG compound dispersed in PMMA film for irradiated at the fluence of 1x 10^{12} ions/cm^2. 163

Figure 4.10(a): AFM image of pure PMMA film (pristine) (b) dispersed Ni-DMG (40%) in PMMA film (pristine) (c) pure PMMA film (irradiated at the fluence of 1 x 10^{12} ions/cm^2) (d) dispersed Ni-DMG (40%) in PMMA film (irradiated at the fluence of 1x 10^{12} ions/cm^2). 167

Figure 4 11(a) SEM micrgraph of pure PMMA film (pristine) (b) dispersed Ni-DMG (5%) in PMMA film (pristine) (c) dispersed Ni-DMG (40%) in PMMA film (pristine) (d) pure PMMA film (irradiated at the fluence of 1x 10^{11} ions/cm^2) (e) dispersed Ni-DMG (5%) in PMMA film (irradiated at the fluence of 1x 10^{11} ions/cm^2) (f) dispersed Ni-DMG (40%) in PMMA film (irradiated at the fluence of 1x 10^{11} ions/cm^2) (g) pure PMMA film (irradiated at the fluence of x 10^{12} ions/cm^2) (h) dispersed Ni-DMG (5%) in PMMA film (irradiated at the fluence of 1x 10^{12} ions/cm^2) (i) SEM micrograph of dispersed Ni-DMG (40%) in PMMA film (irradiated at the fluence of 1x 10^{12} ions/cm^2). 168-170

Chapter-5

Figure 5.1: FTIR spectra of pristine and irradiated polyimide films. 179

Figure 5.2: Plot of hardness (H_v) versus applied load (P) for pristine and irradiated polyimide films. 180

Figure 5.3: Conductivity versus frequency for pristine and irradiated polyimide films. 183

Figure 5.4: Plot of dielectric loss versus frequency for pristine and irradiated polyimide films. 183

Figure 5.5: Plot of dielectric constant versus frequency for pristine and irradiated polyimide films. 184
Figure 5.6: TGA thermograms of pristine and irradiated polyimide films. 185
Figure 5.7: DSC thermograms of pristine and irradiated PI films. 186
Figure 5.8: FTIR spectra of pristine and irradiated PC films. 189
Figure 5.9: Plot of hardness (H_v) versus applied load (P) for pristine and irradiated PC films. 192
Fig 5.10: AC conductivity versus frequency for pristine and irradiated PC films. 192
Figure 5.11: Variation of tan δ with frequency for pristine and irradiated PC films. 193
Fig 5.12: Plot of dielectric constant versus frequency for pristine and irradiated PC films. 193
Figure 5.13: TGA thermograms of pristine and irradiated PC films. 194
Figure 5.14: DSC thermograms of pristine and irradiated PC films. 195
Figure 5.15: FTIR spectra of pristine and irradiated PES samples. 200
Figure 5.16: Hardness (H_v) versus applied load (P) for pristine and irradiated PES samples. 201
Figure 5.17(a): AC conductivity versus frequency for pristine and irradiated PES samples. 202
Figure 5.17(b): Dielectric loss versus frequency for pristine and irradiated samples. 203
Figure 5.17(c): Dielectric constant versus frequency for pristine and irradiate PES samples. 204
Figure 5.18: TGA thermograms of pristine and irradiated PES samples. 206
Figure 5.19 ln [ln(m_0/m)] versus 1000/T (K^{-1})for the pristine and irradiated PES samples. 206
Figure 5.20: DSC thermograms of pristine and irradiated PES samples. 207
Figure 5.21: The FTIR spectra of pristine and irradiated blend samples. 211
Figure 5.22: Hardness (H_v) versus applied load (P) for pristine and irradiated samples. 212

Figure 5.23(a). AC conductivity versus frequency for pristine and irradiated samples. 215
Figure 5.23(b). Dielectric loss versus frequency for pristine and irradiated samples. 215
Figure 5.23(c): Dielectric constant versus frequency for pristine and irradiate samples. 216
Figure 5.24: TGA thermograms of pristine and irradiated samples 217
Figure 5.25: ln [ln(m_0/m)] versus 1000/T (K^{-1}) for the pristine and irradiated blend samples. 218
Figure 5.26: DSC thermograms of pristine and irradiated samples 219

List of Tables

Chapter-2

Table 2.1: Thickness of the polymers 59
Table 2.2: Details of the irradiation of the polymers. 60

Chapter-3

Table-3.1: Mossbauer parameter of dispersed ferric oxalate (10%) in PMMA film. 113

Chapter-4

Table-4.1: XRD parameters for Ni-DMG compound. 164
Table-4.2: XRD parameters for pristine and irradiated 5% Ni-DMG compound dispersed PMMA films. 164
Table-4.3: XRD parameters for pristine and irradiated 20% Ni-DMG compound dispersed PMMA films. 165
Table-4.4: XRD parameters for pristine and irradiated 40% Ni-DMG compound dispersed PMMA films 165