

Contents

	Page No.
Title Page	i
Dedication	ii
Declaration	iii
Certificate by the Supervisor	iv
Acknowledgement	v
List of Symbols	vi
Abstract	viii
Contents	ix
 Chapter 1: Introduction	 1–16
1.1 Types of Nanofillers	1
1.1.1 Graphites	2
1.1.2 Carbon Nanotubes	3
1.1.3 Carbon Nanofibers	5
1.2 Surface Modification of Carbon Nanofillers	7
1.3 Polymer Nanocomposites	8
1.3.1 Definition of Nanocomposites	8
1.3.2 Nanocomposites vs. Traditional Filled Polymers	8
1.3.3 Preparative Methods	9
1.3.4 Applications	11
1.4 Literature: Carbon Nanofillers for Polymer Nanocomposites	11
1.4.1 Expanded Graphite	11
1.4.2 Carbon Nanotubes	12
1.4.3 Carbon Nanofibers	13
1.5 EVA Based Nanocomposites	14
1.6 Scope and Objectives	15
 Chapter 2: Experimental	 17–32
2.1 Introduction	17
2.2 Materials	17
2.2.1 Ethylene Vinyl Acetate Copolymer	17
2.2.2 Carbon Nanofillers	18
2.2.3 Other Chemicals	18
2.3 Modification of Natural Graphite	18
2.3.1 Mixed Acid/High Temperature Treatment	19
2.3.2 KMnO ₄ / Mixed Acid Treatment	19
2.3.3 Amine Treatment	19
2.4 Functionalization of MWCNTs and CNFs	19
2.4.1 Carboxylation	19
2.4.2 Amine Treatment	20
2.4.3 Silane Treatment	20
2.5 Surface Treatment with High Energy Radiations	20
2.5.1 Electron Beam Irradiation	20
2.5.2 Gamma Irradiation	21
2.6 Preparation of Nanocomposites	21
2.7 Characterization of Nanoparticles and Nanocomposites	24
2.7.1 Fourier Transform Infrared Spectroscopy	24
2.7.2 Particle Size Analysis	24

2.7.3 X-ray Diffraction Studies	24
2.7.4 Surface Energy Measurements	25
2.7.5 Raman Spectroscopy	26
2.7.6 X-ray Photoelectron Spectroscopy	26
2.7.7 Atomic Force Microscopy	27
2.7.8 Transmission Electron Microscopy	28
2.7.9 Scanning Electron Microscopy	28
2.7.10 Rheological Studies	29
2.7.11 Dynamic Mechanical Thermal Analysis	29
2.7.12 Swelling Study	30
2.7.13 Measurement of Mechanical Properties	31
2.7.14 Measurement of Thermal Conductivity	31
2.7.15 Thermal Degradation Study	31
2.7.16 Measurement of AC Conductivity	32
Chapter 3A: Natural Graphite: Surface Modification, Characterization and Studies of its Nanocomposites Based on EVA Copolymer	33–48
3A.1 Introduction	33
3A.2 Results and Discussion	34
3A.2.1 Characterization of Fillers	34
3A.2.1.1 FTIR Spectra and Particle Size Analysis	34
3A.2.1.2 X-ray Diffraction and Surface Energy Measurements	37
3A.2.2 Analysis of EVA-Graphite Nanocomposites	38
3A.2.2.1 X-ray Diffraction and Morphological Study	38
3A.2.2.2 Dynamic Mechanical Thermal Analysis and Solvent Swelling Properties	40
3A.2.2.3 Measurement of Mechanical Properties	42
3A.2.2.4 Study on Rheological Behavior	43
3A.2.2.5 Thermal Conductivity	45
3A.2.2.6 Thermo-oxidative Degradation Study	46
Chapter 3B: Characterization of Expanded Graphite and Preparation of its Nanocomposites Based on EVA Copolymer	49–59
3B.1 Introduction	49
3B.2 Results and Discussion	49
3B.2.1 Particle Size and X-ray Diffraction Study	49
3B.2.2 Morphological Study	51
3B.2.3 Measurement of Mechanical Properties	52
3B.2.4 Measurement of Dynamic Mechanical Properties	53
3B.2.5 Solvent Swelling Study	55
3B.2.6 Thermal Conductivity	56
3B.2.7 Thermogravimetric Analysis	57

Chapter 4: Surface Modification and Characterization of Multiwalled Carbon Nanotubes and the Properties of their EVA Based Nanocomposites	61–78
4.1 Introduction	61
4.2 Results and Discussion	62
4.2.1 Characterization of MWCNTs	62
4.2.1.1 Thermogravimetric Analysis	62
4.2.1.2 Morphological Study	63
4.2.1.3 X-ray Diffraction Study	64
4.2.1.4 Raman Spectroscopy	66
4.2.1.5 X-ray Photoelectron Spectroscopy	67
4.2.2 Characterization of EVA-MWCNT Nanocomposites	70
4.2.2.1 Morphological Analysis	70
4.2.2.2 Dynamic Mechanical Thermal Analysis	71
4.2.2.3 Swelling Study	73
4.2.2.4 Mechanical Properties	74
4.2.2.5 Thermal Conductivity	76
4.2.2.6 Thermogravimetric Analysis	76
Chapter 5A: Surface Modification of Carbon Nanofibers and their Characterization	79–95
5A.1 Introduction	79
5A.2 Results and Discussion	80
5A.2.1 Morphological Analysis by SEM and AFM	80
5A.2.2 Thermal Degradation Study of CNFs	83
5A.2.3 Elemental Analysis by XPS	86
5A.2.4 Raman Spectroscopy	91
5A.2.5 X-ray Diffraction Study	94
Chapter 5B: Preparation and Properties of Carbon Nanofiber Reinforced EVA Nanocomposites	95–108
5B.1 Introduction	95
5B.2 Results and Discussion	98
5B.2.1 Morphological Study by TEM	98
5B.2.2 Mechanical and Dynamic Mechanical Analysis	99
5B.2.3 Swelling Study	105
5B.2.4 Thermal Conductivity	106
5B.2.5 Thermogravimetric Analysis	107
Chapter 6: Electrical Properties of EVA Nanocomposites Reinforced with Expanded Graphite, Multiwalled Carbon Nanotubes and Carbon Nanofibers	109–121
6.1 Introduction	109
6.2 Results and Discussion	111
6.2.1 Measurement of AC Conductivity	111
6.2.2 Effect of Filler Loading on AC Conductivity	114
6.2.3 Effect of Filler Loading on AC Resistivity	116
6.2.4 Analysis of Dielectric Constant	117
6.2.5 Effect of Filler Loading on Dielectric Constant	119
6.2.6 Effect of Pressure on AC Conductivity	121

Chapter 7: Influence of Matrix Polarity on the Properties of EVA Nanocomposites Reinforced with Expanded Graphite, Multiwalled Carbon Nanotubes and Carbon Nanofibers	123–140
7.1 Introduction	123
7.2 Results and Discussion	124
7.2.1 Morphological Study	124
7.2.2 Mechanical Properties	127
7.2.3 Swelling Study	131
7.2.4 Dynamic Mechanical Thermal Analysis	132
7.2.5 Thermal Conductivity	136
7.2.6 Thermogravimetric Analysis	138
Chapter 8: Summary and Conclusions	141–144
References	145–158