INDEX

CHAPTER 1

1. Introduction 15

1.1. Overview of the thesis 16

1.1.1. Motivation 16

1.1.2. Challenges 17

1.2. Objectives 18

1.3. Structure of the thesis 19

CHAPTER 2

2. Literature review 22

2.1. Engineering plastics 22

2.1.1. PC/ABS Polymer blends 23

2.1.2. Carbon nanotubes 25

2.1.2.1. Synthesis overview 25

2.1.2.2. Properties overview 28

2.2. Polymer-carbon nanotube nanocomposites 30

2.2.1. Preparation and processing of MWCNT nanocomposites 32

2.2.1.1. Compounding of nanocomposites 33

2.2.1.2. Injection molding of nanocomposites 34

2.2.2. Properties of MWCNT nanocomposites 39
2.2.2.1. Morphology of MWCNT nanocomposites and nanofiller functionalization

2.2.2.2. Mechanical properties of MWCNT nanocomposites

2.2.2.3. Electrical properties of MWCNT nanocomposites

2.2.3. Prediction of properties of MWCNT nanocomposites

2.2.4. MWCNT nanocomposites of multiphase blends

CHAPTER 3

3. Materials and experimental method

3.1. Materials

3.1.1. PC/ABS blend

3.1.2. Multi-walled carbon nanotubes (MWCNT)

3.1.3. Surfactants

3.2. Melt processing conditions

3.2.1. Instruments

3.2.2. Nanocomposites processing routes

3.2.2.1. Common nanofiller feeding method

3.2.2.2. Masterbatch dilution method

3.2.2.3. Suspension method

3.3. Sample preparation

3.3.1. Compression molding

3.4. Samples Characterization
3.4.1. Analyses of morphology 68
  3.4.1.1. Light Transmission Microscopy (OM) 68
  3.4.1.2. Scanning Electron Microscopy (SEM) 70
  3.4.1.3. Transmission Electron Microscopy (TEM) 73
  3.4.1.4. Raman spectroscopy 74
3.4.2. Thermal properties 75
  3.4.2.1. Differential Scanning Calorimetry (DSC) 76
  3.4.2.2. Thermo-Gravimetric Analysis (TGA) 78
  3.4.2.3. Dynamic Mechanical Analysis (DMA) 79
3.4.3. Mechanical properties 81
  3.4.3.1. Tensile testing 81
  3.4.3.2. Nanoindentation 84
3.4.4. Rheology 85
3.4.5. Electrical properties 89
3.4.6. Flammability 91

CHAPTER 4

4. Conventional melt mixing 96
  4.1. Study of PC/ABS-MWCNT nanocomposites morphology 96
    4.1.1. Characterization of PC/ABS and MWCNT 96
    4.1.2. Influence of processing method on morphology of
            PC/ABS-MWCNT nanocomposites 99
4.1.3. Influence of MWCNT modification on morphology of PC/ABS-MWCNT nanocomposites 107

4.2. Study of thermal properties of nanocomposites 112

4.2.1. Thermal characterization of PC/ABS 112

4.2.2. Study of thermal behavior of PC/ABS-MWCNT nanocomposites 114

4.3. Mechanical properties of PC/ABS-MWCNT nanocomposites 122

4.3.1. Influence of MWCNT modification on mechanical properties of PC/ABS-MWCNT nanocomposites 125

4.3.2. Comparison between experimental data and theoretical predictions of the nanocomposite tensile modulus 128

4.4. Rheological properties of nanocomposites 133

4.5. Influence of carbon nanotube content on electrical properties of PC/ABS-MWCNT nanocomposites 139

4.6. Preliminary conclusion 143

4.7. Selection of samples with the best balance of properties 145

CHAPTER 5

5. Modification of conventional extrusion 147

5.1. Study of PC/ABS-MWCNT nanocomposites morphology 147

5.1.1. Influence of nanocomposite processing on the morphology of PC/ABS-MWCNT nanocomposites 147
5.1.2. Influence of MWNCT modification on morphology of PC/ABS nanocomposites 155

5.2. Study of thermal properties of nanocomposites processed by suspension method 160

5.2.1. Thermal stability of nanocomposites 160

5.3. Study of mechanical properties in nanocomposites processed by suspension method 168

5.4. Comparison of electrical properties of nanocomposites 171

5.5. Preliminary conclusions 174

CHAPTER 6

6. Injection molding 177

6.1. Processing conditions 177

6.1.1. Common injection molding process 179

6.1.2. Masterbatch dilution in injection molding 180

6.2. Study of MWCNT dispersion 180

6.2.1. Morphology of injection samples 181

6.2.2. Carbon nanotubes location in the sample 189

6.2.3. Orientation of carbon nanotubes 196

6.3. Flammability of injection molded nanocomposites 200

6.4. Mechanical reinforcement in injection molded nanocomposites 204

6.5. Electrical properties of injection molded nanocomposites 214
6.5.1. Recovery of conductive network 219
6.6. Preliminary conclusions 222

CHAPTER 7

7. Modelling of injection molded nanocomposites 225
  7.1. Methodology and basic assumptions 225
  7.1.1. A short description of numerical models 225
  7.1.2. Assumptions used for the calculation 227
  7.2. Calculation results 229
  7.2.1. Comparison between theoretical and experimental data 235
  7.3. Preliminary conclusion 236

CHAPTER 8

8. Conclusions and future research 239
  8.1. Conclusions 239
  8.2. Suggestions for future research 241

9. Literature 244