

CONTENTS

ACKNOWLEDGMENTS

LIST OF FIGURES

ABSTRACT

CHAPTER 1: INTRODUCTION	1
1. 1 Basic Concepts in Polymers.....	2
1.2 Thermal Transition.....	5
1.3 Free Volume Concept in Polymers.....	6
1.4 Characterization of Free-Volume Properties in Polymers.....	10
1.5 Nanoparticles.....	11
1.6 Nanocomposites.....	13
1.7 Zinc oxide (ZnO) nanoparticles.....	16
1.8 Polyurethane PU.....	17
1.8.1 Thermoplastic polyurethane TPU.....	18
1.8.2 Effects of the soft segment.....	19
1.8.3 Effects of the hard segment.....	20
1.8.4 Effect of Hydrogen bonding in TPU on phase separation.....	20
1.8.5 Waterborne Polyurethane.....	21
1.9 Carbon Nanotubes CNT.....	22
1.9.1 Structure of carbon nanotubes.....	25
1.9.1. (a) The single-walled carbon nanotube structure.....	25
1.9.1. (b) Multi-walled carbon nanotube structures.....	25
1.9.1. (c) Carbon nanofiber.....	27
1.9.2 Functionalizing the surface of Carbon nanotubes.....	27
1.10 Review of previous studies of the samples under investigation....	29
1.11 Layout of the document.....	31

Chapter 2: Theoretical background in Positron Physics	32
2.1 The positron.....	32
2.1.1 Historical remarks.....	32
2.1.2 Positron Annihilation.....	33
2.1.3 Free positrons interaction in condensed matter.....	36
2.2 Positronium.....	36
2.2.1 Positronium wave function.....	37
2.2.2 Annihilation selection rule and decay rates.....	39
2.2.3 Positronium formation in molecular media.....	42
2.2.3.1 The Øre-gap model.....	42
2.2.3.2 The Free Volume Model.....	42
2.2.3.3 The Spur model.....	44
2.2.3.4 The Blob model.....	45
2.2.4 Positronium quenching.....	46
2.3 The idea of Positron annihilation lifetime spectroscopy (PALS)....	47
2.4 Relation between the positronium lifetime and the free-volume-hole size The Tao-Eldrup model.....	48
2.5 Slow Beam Based Doppler Broadening of Energy Spectroscopy....	51
2.6 The Idea of Slow Positron Beam.....	55
2.7 Positron beam interactions with solids and surfaces.....	59
2.7.1 Positron backscattering.....	59
Chapter 3: Experimental Techniques and Data analysis	62
3.1. Materials.....	62
3.1.1 Zinc Oxide Nanoparticles.....	62
3.1.2 Waterborne Polyurethane.....	63
3.1.3 Preparation of WPU/ZnO nanocomposites.....	63
3.2. Preparation of Polystyrene single wall carbon nanotubes PS/SWCNT nanocomposites.....	65
3.2.1 PS/SWCNT Material Preparation.....	66

3.2.2 Carboxylation of SWCNT [SWCNT-COOH].....	67
3.2.3 Preparation of SWCNT-COOH and polystyrene composites.....	68
3.2.4 Grafting PS onto the surface of SWCNT-COOH.....	68
3.2.5 Preparation of SWCNT-g-PS and polystyrene composite.....	70
3.2.6 Preparation of PS/CNF composites.....	70
3.3 The Positron Source.....	71
3.4. The Heat History.....	74
3.5 Positron Annihilation Lifetime Spectroscopy Technique (PALS)....	75
3.6 Data Analysis of the PAL Spectra.....	76
3.7 Structure of Slow Positron Beam at University of Missouri Kansas City (UMKC).....	79
3.7.1 Beam Control, Data Acquisition and Processing System.....	82
3.7.2. Specification of Slow Positron Beam.....	82
3.8 Atomic Force Microscopy (AFM) measurement.....	85
3.9 Fourier Transform Infrared Spectroscopy (FTIR).....	89
3.10 Dynamic Mechanical Thermal Analysis (DMTA).....	95
3.11 Differential Scanning Calorimetry (DSC) measurement.....	97
Chapter 4: Results and Discussions	100
4.1. Waterborne Polyurethane Zinc oxide nanocomposites.....	100
4.1.1. Dependence of positron annihilation lifetime on nanofiller.....	100
4.1.2. Dependence of positron annihilation lifetime on temperature.....	105
4.1.3 Dynamic Mechanical Thermal Analysis (DMTA).....	108
4.1.4 Glass transitions as a function of Zinc Oxide (ZnO) concentrations...111	111
4.1.5 Relationship between free volumes and mechanical properties.....	115
4.1.6. Depth Profile of ZnO/WBPU composites by using Doppler Broadening Energy Spectroscopy (DBES).....	120

4.2 Positron Annihilation Spectroscopy of Polystyrene Filled with Carbon Nanomaterials.....	133
4.2.1 Dependence of o-Ps Lifetime on CNT concentration in PS.....	133
4.2.2 Temperature dependence of Positron Annihilation Lifetime in pristine Polystyrene (PS).....	137
4.2.3 Glass Transitions as a Function of Nanofiller composition in PS.....	141
4.2.4 Free volume distribution as a function of nanofiller concentration....	154
Conclusions:	157
References:	159
Arabic Summary	