

Contents

Chapter 1	Polymer Chemistry	1
1.1	Basic Concepts	1
1.2	The History of the Concept of the Macromolecule	2
1.3	Classification of Polymers	4
1.4	Structure and Properties of Polymers	6
1.4.1	Poly(ethylene)	6
1.4.2	Poly(propylene)	7
1.4.3	Poly(methyl methacrylate)	8
1.4.4	Poly(styrene)	9
1.4.5	Poly(vinyl chloride), PVC	10
1.4.6	The Nylons	11
1.4.7	Epoxy Resins	13
1.4.8	Phenol-Formaldehyde Polymers	14
1.4.9	Amino Resins	14
1.4.10	Poly(tetrafluoroethylene), PTFE	15
1.4.11	Polyurethanes	16
1.4.12	Poly(ether ether ketone)	17
1.4.13	Silicones	18
1.4.14	Naturally Occurring Polymers	18
1.4.15	Cellulose	18
1.4.16	Starch	19
1.4.17	Natural Rubber	20
1.4.18	Proteins	21
1.4.19	Poly(3-hydroxybutyrate)	22

Chapter 2	Polymerisation Reactions	23
2.1	Chain Polymerisation	24
2.1.1	Initiation	24
2.1.2	Propagation	25
2.1.3	Termination	25
2.1.4	Other Reactions	26
2.2	Arrangement of Monomer Units	27
2.3	Kinetics of Chain Polymerisation	27
2.4	Autoacceleration	30
2.5	Practical Methods of Chain Polymerisation	30
2.5.1	Bulk Polymerisation	30
2.5.2	Solution Polymerisation	31
2.5.3	Suspension Polymerisation	32
2.5.4	Emulsion Polymerisation	32
2.5.5	The Loop Process	33
2.6	Other Chain Polymerisation Mechanisms	33
2.7	Recent Developments in "Living" Polymerisation	35
2.7.1	RAFT Polymerisation	35
2.7.2	Atom Transfer Radical Polymerisation	37
2.8	Step Polymerisation	37
2.9	Step Polymerisation with Polyfunctional Monomers	38
2.10	Copolymerisation	39
Chapter 3	Polymer Structure	42
3.1	Polymer Stereochemistry	42
3.2	Polymer Crystallinity	43
3.2.1	Orientation and Crystallisation	46
3.2.2	The Crystalline Melting Point	46
3.2.3	Polyblends	47
3.3	Thermal and Mechanical Properties	47
3.3.1	The Glass Transition Temperature, T_g	48
3.3.2	The Effect of Plasticisers	50
3.3.3	Methods of Determining Glass Transition Temperature	51
3.3.4	The Effect of Polymer Stereochemistry on T_g	53
3.3.5	The Relationship between Crystalline Melting Point and T_g	54
3.3.6	Other Thermal Transitions	55
Chapter 4	Crosslinking	56
4.1	Introduction	56
4.2	Phenol-Formaldehyde Resins	58

4.3	Unsaturated Polyester Resins	61
4.4	Polyurethanes	63
4.5	Epoxy Resins	65
Chapter 5	Polymer Solutions	68
5.1	Introduction	68
5.2	Dissolution of Polymers	68
5.3	Solubility Parameters	69
5.4	Simple Liquid Mixtures and Raoult's Law	71
5.5	Entropy of Mixing	71
5.6	Real Molecules in Dilute Solution	74
5.7	Shapes of Polymer Molecules in Solution	75
5.8	Reptation Model of Molecular Motion	76
5.9	Water-Soluble Polymers	77
5.10	Uses of High-Viscosity Polymer Solutions	79
5.11	Polymer Melts	80
Chapter 6	Methods of Determining Relative Molar Mass	82
6.1	Introduction	82
6.2	Molar Masses from Colligative Properties	83
6.2.1	Vapour Phase Osmometry	85
6.3	Light Scattering	86
6.3.1	Experimental Determination	89
6.4	Viscosity Methods of Determining Relative Molar Mass	90
6.5	End Group Analysis	92
6.6	Gel Permeation Chromatography	93
Chapter 7	Mechanical Properties of Polymers	97
7.1	Introduction	97
7.2	Stress, Strain, and Young's Modulus	97
7.3	Brittle and Tough Fracture	98
7.4	Types of Strength	100
7.5	The Influence of Surfaces	102
7.6	Viscoelasticity	104
7.7	Creep and Stress Relaxation	106
7.8	Cold Drawing	108
7.9	Dynamic Tests	109
7.10	Time/Temperature Relationship	111
7.11	Rubberlike Elasticity	112
7.12	Reinforced Polymers	115

7.13	Practical Measurements of Mechanical Properties	117
7.14	Further Reading	118
Chapter 8	Polymer Degradation	119
8.1	Introduction	119
8.2	Behaviour of Polymers in Fires	119
8.2.1	The Behaviour of Individual Polymers	120
8.3	Assessment of Combustion Behaviour	121
8.4	Improvement of Stability of Polymers in Fires	122
8.5	Weathering of Polymers	123
8.6	Protection of Polymers from Photo-oxidation	125
8.7	Biological Degradation of Polymers	127
8.8	Exploitation of Polymer Degradation	128
8.9	Polymer Light Emitting Diodes	131
Chapter 9	Dendrimers	134
9.1	Introduction	134
9.2	Organic Dendrimers	137
9.3	Supramolecular Dendrimers	139
9.4	Shapes and Conformations of Dendrimers	140
9.5	Dendrimer Micelles	141
9.6	Characterization of Dendrimers	142
9.6.1	Mass Spectroscopy	142
9.6.2	Gel Permeation Chromatography	143
9.6.3	High-Performance Liquid Chromatography	143
9.6.4	NMR Spectroscopy	144
9.6.5	X-Ray Diffraction	144
9.6.6	Titration	144
9.6.7	Small Angle Neutron Scattering	145
9.6.8	Atomic Force Microscopy	146
9.7	Applications of Dendrimers	146
9.8	Megamers	148
	Further Reading	149
Chapter 10	Special Topics in Polymer Chemistry	150
10.1	Introduction	150
10.2	Polymers in Medicine	150
10.3	Ionomers	153
10.4	Electronically Conducting Polymers	154
10.5	Interpenetrating Polymer Networks	157

10.6 Inorganic Polymers	158
10.7 Polymer Liquid Crystals	160
10.8 Polymers for Food Packaging	162
10.9 Polymers for Controlled Drug Delivery	164
Further Reading	166
Chapter 11 Polymers and the Environment	167
11.1 Introduction	167
11.2 Pollution by Polymers	167
11.3 The Nature of the Problem	170
11.4 Polymers and Energy	171
11.5 Recycling of Polymers	172
11.6 Degradable Polymers	173
11.7 Green Polymerisation	175
11.8 The Future	175
Further Reading	176
Bibliography	177
Subject Index	179