

CONTENTS

Preface	xiii
-------------------	------

Part I Introduction to Polymers

1. Basic Principles	3
1.1. Introduction and Historical Development	3
1.2. Definitions	7
1.3. Polymerization Processes	11
1.4. Step-Growth Polymerization	13
1.5. Chain-Growth Polymerization	17
1.6. Step-Growth Addition and Chain-Growth Condensation	21
1.7. Nomenclature	21
 2. Molecular Weight	 31
2.1. Introduction	31
2.2. Measurement of Number Average Molecular Weight	32
2.3. Measurement of Weight Average Molecular Weight	38
2.4. Viscometry	41
2.5. Molecular Weight Distribution	43
 3. Chemical Structure and Polymer Properties	 49
3.1. Introduction	49
3.2. Molecular Weight and Intermolecular Forces	49
3.3. Stereochemistry	51
3.4. Crystallinity	59
3.5. Effect of Restricting Rotation in Polymer Chains	63
3.6. Crosslinking	66

3.7.	Glass Transition Temperature	66
3.8.	Flame Resistance	68
3.9.	Thermal Stability	71
3.10.	Chemical Resistance	72
4.	Evaluation, Characterization, and Analysis of Polymers	77
4.1.	Evaluation of Mechanical and Chemical Properties	77
4.2.	Thermal Analysis	83
4.3.	Spectroscopic Methods of Analysis	91
4.4.	Chemical Methods of Analysis	97
 Part II Vinyl Polymers		
5.	Free Radical Vinyl Polymerization	103
5.1.	Introduction.	103
5.2.	Free Radical Initiators	104
5.3.	Mechanism of Polymerization	109
5.4.	Stereochemistry of Polymerization	113
5.5.	Polymerization of Dienes	116
5.6.	Monomer Reactivity	120
5.7.	Copolymerization	123
5.8.	Polymerization Techniques	129
 6.	 Ionic Vinyl Polymerization.	 133
6.1.	Introduction.	133
A.	Cationic Polymerization	133
6.2.	Cationic Initiators	133
6.3.	Mechanism and Reactivity in Cationic Polymerization	135
6.4.	Stereochemistry of Cationic Polymerization	139
6.5.	Cationic Copolymerization	143
6.6.	Isomerization in Cationic Polymerization	144
6.7.	Cationic Polymerization of Diazoalkanes	146
B.	Anionic Polymerization	147
6.8.	Anionic Initiators	147
6.9.	Mechanism and Reactivity in Anionic Polymerization	149
6.10.	Stereochemistry of Anionic Polymerization	152
6.11.	Stereochemistry of Anionic Polymerization of Dienes	155
6.12.	Anionic Copolymerization	157
 7.	 Vinyl Polymerization with Complex Coordination Catalysts	 163
7.1.	Introduction.	163
7.2.	Ziegler-Natta Catalysts	163
7.3.	Mechanism of Ziegler-Natta Polymerization	167
7.4.	Stereochemistry of Ziegler-Natta Polymerization.	170

7.5.	Polymerization of Dienes with Ziegler-Natta Catalysts	171
7.6.	Ring-Opening (Metathesis) Polymerization with Ziegler-Natta Catalysts	174
7.7.	Ziegler-Natta Copolymerization	176
7.8.	Supported Metal Oxide Catalysts	177
7.9.	Alfin Catalysts	178

8. Reactions of Vinyl Polymers 183

8.1.	Introduction.	183
8.2.	Simple Reactions	183
8.3.	Ring-Forming Reactions	187
8.4.	Crosslinking	189
8.5.	Block and Graft Copolymer Formation	196
8.6.	Polymer Degradation	203

Part III Nonvinyl Polymers

9. Polyethers, Polysulfides, and Related Polymers 213

9.1.	Introduction.	213
A.	Preparation of Polyethers by Chain-Growth Processes	214
9.2.	Polymerization of Aldehydes	214
9.3.	Stereochemistry of Aldehyde Polymerization	220
9.4.	Polymerization of Cyclic Ethers	221
9.5.	Stereochemistry of Epoxide Polymerization	228
B.	Preparation of Polyethers by Step-Growth Processes	229
9.6.	Synthesis of Polyethers from Glycols and Bisphenols	229
9.7.	Polacetals and Polyketals	231
9.8.	Poly(phenylene Oxides)	234
9.9.	Epoxy Resins	237
C.	Polysulfides, Poly(alkylene Polysulfides), and Polysulfones	242
9.10.	Polysulfides	242
9.11.	Poly(alkylene Polysulfides)	246
9.12.	Polysulfones	248

10. Polyesters 251

10.1.	Introduction.	251
A.	Linear Polyesters	253
10.2.	Preparation of Polyesters by Polycondensation Reactions	253
10.3.	Polycarbonates	260
10.4.	Polymerization of Lactones	263
10.5.	Miscellaneous Methods of Preparing Linear Polyesters	266
B.	Crosslinked Polyesters	268
10.6.	Saturated Polyester Resins	268
10.7.	Unsaturated Polyesters	271

11. Polyamides and Related Polymers	277
11.1. Introduction.	277
A. Polyamides	278
11.2. Preparation of Polyamides by Polycondensation Reactions	278
11.3. Polymerization of Lactams	281
11.4. Other Methods of Preparing Polyamides	286
11.5. Properties of Polyamides	289
11.6. Polyureas	293
B. Polymers Related to Polyamides	295
11.7. Polyurethanes	295
11.8. Polyurethane Foams	299
11.9. Polyhydrazides and Related Polymers	301
11.10. Polyimides	302
11.11. Heterocyclic Polymers Prepared from Polyamides and Related Polymers	309
12. Phenol-, Urea-, and Melamine-Formaldehyde Resins	319
12.1. Introduction.	319
12.2. Phenol-Formaldehyde Polymers: Resoles	320
12.3. Phenol-Formaldehyde Polymers: Novolacs	324
12.4. Chemical Modifications of Phenolic Resins	327
12.5. Urea-Formaldehyde Polymers	328
12.6. Melamine-Formaldehyde Polymers	330
13. Inorganic-Organic Polymers	333
13.1. Introduction.	333
13.2. Polysiloxanes	334
13.3. Phosphonitrilic Polymers.	338
13.4. Carborane Polymers	340
13.5. Organometallic Polymers.	342
13.6. Coordination Polymers	346
13.7. Ionic Polymers	350
14. Miscellaneous Organic Polymers	355
14.1. Introduction.	355
14.2. Miscellaneous Unsaturated Polymers	355
14.3. Miscellaneous Heterocyclic Polymers.	361
14.4. Poly(<i>p</i> -phenylene) and Poly(<i>p</i> -xylylene)	365
14.5. Friedel-Crafts Polymers	367
14.6. Cycloaddition Polymers	368
14.7. Ring-Opening Polymerization of Strained Cycloalkanes.	375
14.8. Polyanhydrides	376
14.9. Polyamines	377
14.10. Charge-Transfer Polymers	380

15. Natural Polymers	385
15.1. Introduction.	385
A. Polysaccharides	388
15.2. Cellulose	388
15.3. Regenerated Cellulose	391
15.4. Derivatives of Cellulose	392
15.5. Starch	396
15.6. Derivatives of Starch	398
15.7. Other Polysaccharides	398
B. Proteins	400
15.8. Amino Acids, Polypeptides, and Proteins	400
15.9. Determination of Protein Structure	406
15.10. Synthesis of Polypeptides and Proteins	412
15.11. Wool, Silk, Collagen, and Regenerated Protein	416
C. Nucleic Acids	418
15.12. Nucleic Acid Structure	418
15.13. The Genetic Code	425
15.14. Conclusion	428
 Appendix: Sources of Laboratory Experiments in Polymer Chemistry	 431
Author Index	435
Subject Index	443