

HANSER

Polyolefins

James L. White, Choi

Processing, Structure Development, and Properties

ISBN 3-446-22962-0

Inhaltsverzeichnis

Weitere Informationen oder Bestellungen unter
<http://www.hanser.de/3-446-22962-0> sowie im Buchhandel

Contents

Preface	V
1 Origins of Polyolefins	1
1.1 Introduction and Prehistory	1
1.2 Polyethylene	2
1.2.1 Low Density Polyethylene	2
1.2.2 Karl Ziegler and High Density Polyethylene	3
1.2.3 Standard Oil of Indiana	5
1.2.4 Phillips Petroleum and High Density Polyethylene	5
1.2.5 Linear Low Density Polyethylene	6
1.3 Isotactic Polypropylene	7
1.3.1 Giulio Natta, Milan Politecnico and Montecatini	7
1.3.2 Standard Oil of Indiana and Phillips Petroleum	8
1.4 Isotactic Polybutene-1	9
1.5 Isotactic Polymers of Higher Olefins and Poly(4-Methyl Pentene-1) ..	10
1.6 Ethylene-Propylene Rubber	11
1.7 Metallocene Polymerization	12
1.8 Stereoregular Polystyrenes	13
1.8.1 Isotactic Polystyrene	13
1.8.2 Syndiotactic Polystyrene	13
1.9 Syndiotactic Polypropylene	14
1.10 Cyclopolyolefins	14
1.11 New Metallocene Polyolefin Copolymers	16
1.12 Current Production Levels	16
1.13 Bulk Polymer Properties and Chemical Stability	17
References	19
2 Characterization Methods	23
2.1 Introduction	23
2.2 Asymmetric Carbon Atoms and Tacticity	23
2.2.1 Low Molecular Weight Compounds	23
2.2.2 Polyolefins [5]	24
2.2.3 Tacticity Levels	26

2.3	Crystallinity	27
2.4	Crystal Structure [16, 17]	28
2.5	Chain Conformations in Crystals	32
2.6	Molecular Weight Distribution [7, 34, 35]	33
2.7	Orientation	37
2.7.1	Uniaxial Orientation	37
2.7.2	Biaxial Orientation	40
2.8	Superstructure	43
	<i>References</i>	44
3	Crystallography of Polyolefins	49
3.1	Introduction	49
3.2	Early Investigations of Low Molecular Weight Paraffinic Compounds	49
3.3	Polyethylene	55
3.4	Isotactic Polypropylene	58
3.5	Syndiotactic Polypropylene	60
3.6	Isotactic Polybutene-1	62
3.7	Syndiotactic Polybutene-1	63
3.8	Isotactic Poly(4-Methyl Pentene-1)	63
3.9	Isotactic Polymers of Other α -Olefins	65
3.10	Isotactic Polystyrene	66
3.11	Syndiotactic Polystyrene	67
3.12	Summary and Trends	68
	<i>References</i>	68
4	Single Crystals: Structural Hierarchy and Morphology	75
4.1	Introduction	75
4.2	Polyethylene	75
4.2.1	Single Crystals	75
4.2.2	Flow-Induced Structures from Solution	77
4.2.3	Bulk Structure	78
4.3	Isotactic Polypropylene	80
4.3.1	Single Crystals	80
4.3.2	Flow-Induced Structures from Solution	80
4.3.3	Bulk Structure	81
4.4	Syndiotactic Polypropylene	82
4.5	Isotactic Polybutene-1	83
4.5.1	Single Crystals	83
4.5.2	Bulk Structure	83

4.6	Isotactic Poly(4-Methyl Pentene-1)	84
4.6.1	Single Crystals	84
4.6.2	Flow-Induced Structures from Solution	84
4.6.3	Bulk Structures	85
4.7	Isotactic Polystyrene	85
4.7.1	Single Crystals	85
4.7.2	Flow-Induced Structures from Solution	86
4.7.3	Bulk Structure	86
4.8	Syndiotactic Polystyrene	87
4.8.1	Single Crystals	87
4.8.2	Bulk Structures	87
4.9	Summary	87
	<i>References</i>	88
5	Spherulites and Quiescent Crystallization	91
5.1	Introduction	91
5.2	Spherulites	91
5.2.1	Quiescently Crystallized Polymers	91
5.2.2	Polyethylene	91
5.2.3	Isotactic Polypropylene	93
5.2.4	Syndiotactic Polypropylene	94
5.2.5	Isotactic Polybutene-1	94
5.2.6	Isotactic Poly(4-methyl pentene-1)	95
5.2.7	Isotactic Polystyrene	95
5.2.8	Syndiotactic Polystyrene	95
5.3	Quiescent Crystallization Kinetics	96
5.3.1	General	96
5.3.2	Polyethylene	98
5.3.3	Isotactic Polypropylene	99
5.3.4	Syndiotactic Polypropylene	100
5.3.5	Isotactic Polybutene-1	100
5.3.6	Isotactic Polystyrene	100
5.3.7	Syndiotactic Polystyrene	101
5.4	Time-Temperature Transformation and Continuous Cooling Transformation Plots	101
5.5	Summary and Perspectives	102
	<i>References</i>	103

6	Polyolefin Copolymers and Blends	107
6.1	Introduction	107
6.2	Stereoblock Copolymers [1, 2]	108
6.3	Copolymers of Polyethylene	109
6.3.1	General	109
6.3.2	Ethylene-Propylene Copolymers (EPM)	110
6.3.3	Ethylene-Butene-1/Hexene-1 Copolymers	111
6.3.4	Ethylene-Octene Copolymers	111
6.3.5	Ethylene-Styrene Copolymers	113
6.3.6	Ethylene-Cyclopentene/Norbornene Copolymers	113
6.4	Copolymers of Polypropylene	114
6.4.1	Isotactic Polypropylene with Ethylene [53]	114
6.4.2	Isotactic Polypropylene with Other Monomers	115
6.4.3	Syndiotactic Polypropylene with Butene-1	115
6.5	Blends	115
6.5.1	Inter-Polyolefin Homopolymer Miscibility	115
6.5.2	Polypropylene-Ethylene Copolymer Blends	116
6.5.3	Polypropylene Dynamic Vulcanizates [68]	116
6.6	Perspective	117
	References	117
7	Polymer Melt Processing, Rheological Properties, and Orientation in Flowing Polymer Melts	121
7.1	Introduction	121
7.2	Polymer Melt Processing Technology	121
7.2.1	Single Screw Extrusion [1, 2]	121
7.2.2	Twin Screw Extrusion and Polyolefin Modification/Grafting [2–4]	122
7.2.3	Die Extrusion [11]	124
7.3	Rheological Properties of Polymer Melts	126
7.4	Effects of Additives	131
7.5	Early Observations of Flow Birefringence	131
7.6	Flow Birefringence and Stress	132
7.7	Stress Optical Coefficients and Molecular Structure	134
7.8	Orientation Factors and Stress in Melts	135
7.9	Flow in Dies	136
7.9.1	Flow Patterns and Flow Birefringence	136
7.9.2	Unstable Flow	138
7.9.3	Flow Structuring of Polyolefins	138

7.10	Summary	139
	References	140
8	Melt Spinning	145
8.1	Introduction	145
8.2	Melt Spinning Process	145
8.2.1	General	145
8.2.2	Continuous Filaments	147
8.2.3	Bulked Continuous Filament Yarns	147
8.2.4	Staple Fibers [15]	147
8.2.5	Spunbonded Fabrics [14, 18–21]	148
8.2.6	Melt-Blown Fabrics [14]	149
8.3	Dynamics, Heat Transfer, and Modeling in Melt Spinning	149
8.3.1	Dynamics and Heat Balance	149
8.3.2	Modeling of Melt Spinning	151
8.4	Melt Flow Instabilities	152
8.4.1	Die Flow (see also Section 7.9.2)	152
8.4.2	Spinline Disturbances/Instabilities	153
8.5	Melt Spinning of Vitrifying Polyhydrocarbons	154
8.5.1	Atactic Polystyrene	154
8.5.2	Cyclopolyolefins	155
8.5.3	Other Vitrifying Thermoplastics	156
8.5.4	Modeling of Orientation-Birefringence Development	156
8.6	Polyethylene	157
8.6.1	High-Density Polyethylene	157
8.6.2	Ultrahigh Modulus Polyethylene Fibers	161
8.6.3	Polyethylene Copolymers	161
8.6.4	Polyethylene-Polystyrene Blends	162
8.7	Isotactic Polypropylene	163
8.7.1	High Tacticity Polymers	163
8.7.2	Lower Tacticity Polymers	168
8.7.3	Isotactic Polypropylene-Particulate Compounds	171
8.7.4	Isotactic Polypropylene Blends	171
8.7.5	Isotactic Polypropylene Thermoplastic Dynamic Vulcanizates	172
8.8	Syndiotactic Polypropylene	173
8.9	Isotactic Polybutene-1	175
8.10	Isotactic Poly(4-Methyl Pentene-1)	176
8.11	Syndiotactic Polystyrene	177

8.12 Trends and Conclusions	178
<i>References</i>	179
9 Film Processing and Profile Extrusion	185
9.1 Introduction	185
9.2 Film Extrusion Processes	185
9.2.1 Cast Film Extrusion	185
9.2.2 Tubular Blown Film Extrusion	186
9.2.3 Tentering Frame for Biaxially Oriented Film [12]	187
9.2.4 Double Bubble Process for Biaxially Oriented Film [13]	188
9.3 Dynamics, Heat Transfer, and Modeling	189
9.3.1 Cast Film Extrusion [16–18]	189
9.3.2 Tubular Blown Film Extrusion	190
9.4 Melt Flow and Solidification Instabilities	192
9.4.1 Haze and Surface Roughness	192
9.4.2 Die Flow Produced Extrudate Distortion	194
9.4.3 Cast Film Instabilities	194
9.4.4 Bubble Instabilities	195
9.5 Profile Extrusion	196
9.6 Atactic Polystyrene Film	197
9.6.1 Tubular Blown Film	197
9.6.2 Biaxially Stretched Film	198
9.7 Polyethylene Film	199
9.8 Isotactic Polypropylene Film	202
9.8.1 Cast Film	202
9.8.2 Tubular Blown Film	203
9.8.3 Biaxially Oriented Film	204
9.9 Syndiotactic Polypropylene Film	204
9.10 Isotactic Polybutene-1 Film	206
9.11 Isotactic Poly(4-Methyl Pentene-1) Film	206
9.12 Syndiotactic Polystyrene Film	206
9.13 Summary and Conclusions	207
<i>References</i>	208
10 Molding	213
10.1 Introduction	213
10.2 Molding Processes	213
10.2.1 Compression Molding	213
10.2.2 Injection Molding	214

10.2.3 Blow Molding	219
10.2.4 Thermoforming [31]	220
10.2.5 Scrapless Forming [32]	221
10.2.6 Rotational Molding [33]	221
10.3 Dynamics, Heat Transfer, and Modeling	222
10.3.1 Injection Molding	222
10.3.2 Blow Molding	225
10.4 Atactic Polystyrene and Vitrifying Polyolefins	226
10.4.1 Injection Molding	226
10.4.2 Blow Molding	227
10.4.3 Modeling of Orientation-Birefringence Development	227
10.5 Polyethylene	229
10.5.1 Injection Molding	229
10.5.2 Blow Molding	231
10.5.3 Rotational Molding	232
10.6 Isotactic Polypropylene	232
10.7 Syndiotactic Polypropylene	233
10.8 Isotactic Poly(4-Methyl Pentene-1)	234
10.9 Isotactic Polystyrene	235
10.10 Syndiotactic Polystyrene	235
10.11 Trends and Conclusions	235
<i>References</i>	236
11 Mechanical Properties of Polyolefins	241
11.1 Introduction	241
11.2 Stress and Small Strain Elasticity	241
11.3 Influence of Molecular Weight	243
11.4 Influence of Temperature	243
11.5 Influence of Crystallinity and Comparisons to Other Materials	244
11.6 Uniaxial Large Strain Behavior [3, 4]	245
11.7 Mechanical Properties of Melt-Spun/Drawn Fibers	245
11.8 High Modulus Polyolefin Fibers	248
11.9 Mechanical Properties of Films	248
11.10 Mechanical Property Modification by Copolymerization and Blending	249
<i>References</i>	250
Subject Index	251
Author Index	255