

Contents

<i>Preface</i>	(v)
<i>Acknowledgement</i>	(vii)
<i>List of Contributors</i>	(ix)
<i>About the Editors</i>	(xi)

Chapter 1 Controlled Release and Gastroretentive Drug Delivery Systems

Rajendra Awasthi, Vivek K. Pawar and Giriraj T. Kulkarni

1.1 Diffusion	2
1.1.1 Fick's First Law of Diffusion.....	2
1.1.2 Fick's Second Law of Diffusion	3
1.2 Designing of Diffusion Controlled Matrix	3
1.2.1 Classification of Diffusion Controlled Drug Delivery Systems	6
1.2.2 Reservoir Diffusion Systems	6
1.2.3 Matrix Diffusion Systems	9
1.2.4 Factors Affecting Drug Release Rate from Monolithic Matrix Systems.....	10
1.3 Designing of Dissolution Controlled Matrix	11
1.4 Kinetic Modeling on Drug Release from Diffusion and Dissolution Controlled Drug Delivery Systems	13
1.4.1 Zero Order Model	13
1.4.2 First Order Model	14
1.4.3 Higuchi Model	15
1.4.4 Peppas' Model	16
1.4.5 Krosmayer Peppas Model.....	16
1.4.6 Hixson Crowell's Model.....	17
1.4.7 Selection of the Best Fit Model for Release Data.....	17

1.5 Design and Fabrication of Gastroretentive Dosage Forms	18
1.5.1 Gastrointestinal Motility	19
1.5.2 Factors Affecting Gastric Retention	20
1.5.3 Formulation Approaches.....	21
1.5.4 High Density Systems.....	21
1.5.5 Swelling and Expandable Systems	21
1.5.6 Mucoadhesive or Bioadhesive Systems	22
1.5.7 Superporous Hydrogel based Systems	22
1.5.8 Magnetic Systems	23
1.5.9 Floating Drug Delivery Systems.....	24
1.5.9. 1 Classification of Floating Drug Delivery Systems.....	24
1.5.9.2 Effervescent Systems.....	24
1.5.9.3 Non-Effervescent Systems	25
1.5.9.4 Hydrodynamically Balanced Systems.....	25
1.5.9.5 Low-Density Systems.....	25
1.5.9.6 Raft Forming Systems	25
1.5.10 Advanced Technologies used to Develop Gastroretentive Systems	27
1.5.10.1 Intragastric Floating Gastrointestinal Drug Delivery Systems.....	27
1.5.10.2 Inflatable Gastrointestinal Drug Delivery Devices	28
1.5.10.3 Intragastric Osmotically Controlled Floating Drug Delivery Devices	28
1.5.11 Evaluation of Gastroretentive Drug Delivery Systems	30
1.5.11.1 <i>In vitro</i> Evaluation	31
1.5.11.2 <i>In vivo</i> Evaluation.....	32
1.5.12 Future Recommendations	33
References	33

Chapter 2 Self-Emulsifying Drug Delivery Systems:
A Novel Drug Delivery Model

*Jaya Gopal Meher, M. Chaurasia, S. K. Paliwal and
Manish K. Chourasia*

2.1	Introduction.....	38
2.2	Excipients.....	41
2.2.1	Oils	41
2.2.2	Surfactants.....	42
2.2.3	Co-solvents/Co-surfactants	45
2.2.4	Pharmaceutical Additives	46
2.3	Formulation and Development	46
2.4	Factors Affecting Formulation and Performance of SEDDS	53
2.4.1	Excipients.....	53
2.4.2	Physicochemical State of SEDDS and Intended Dosage Form	55
2.5	Characterization	57
2.5.1	Self-emulsification Efficiency	57
2.5.2	Zeta Potential	57
2.5.3	Size and Size Distribution.....	58
2.5.4	Morphology.....	58
2.5.5	Drug Content.....	59
2.5.6	<i>In vitro</i> Drug Dissolution and <i>Ex Vivo</i> Drug Permeation.....	59
2.5.7	<i>In vivo</i> Bio-Distribution	60
2.5.8	Stability	60
2.6	Fate of SEDDS <i>In vivo</i>	61
2.7	Safety and Toxicological Issues.....	63
2.8	Applications of SEDDS	64
2.9	Commercial SEDDS	69
2.10	Future Prospects and Challenges	70
	References	73

Chapter 3 Colon Specific Drug Delivery Systems

*Arvind Gulbake, Pramod Kumar, Prashant Khare and
Nitin K. Jain*

3.1	Introduction.....	78
3.2	Anatomy and Physiology of Gastro Intesitinal Tract	79
3.2.1	The Stomach	79
3.2.2	The Small Intestine	79
3.2.3	The Large Intestine	80
3.3	Important Factors Considered for Colonic Drug Delivery.....	81
3.3.1	Gastric Emptying	82
3.3.2	Small Intestinal Transit.....	82
3.3.3	Colonic Transit.....	82
3.3.4	Gastrointestinal pH	83
3.3.5	Colonic Microflora.....	83
3.3.6	Disease state of Large Intestine	84
3.4	Drug Candidates for Colon Specific Drug Delivery	85
3.5	Formulation Approaches for Colon Specific Drug Delivery	85
3.5.1	Timed Release/Delayed Release Dosage Forms	86
3.5.2	Osmotic Controlled Drug Delivery	87
3.5.3	pH Dependent Systems: Enteric Coating ..	89
3.5.3.1	CODES TM	92
3.5.4	Prodrug Based Systems.....	93
3.5.5	Pressure Based Drug Delivery Systems....	94
3.5.6	Microbial Triggered Approach	94
3.5.7	Commensal Bacteria	95
3.5.8	Hydrogel	96
3.5.9	Redox-Sensitive Polymers	98
3.6	Colon Specific Polymeric Carrier Systems.....	98
3.6.1	Biodegradable Polysaccharide Carriers	99

3.6.2 Microspheres based Systems	100
3.6.3 Nanoparticle based Systems.....	101
3.6.4 Ligand Anchored Polymeric Nanoparticles	102
3.7 Consluson	103
<i>References</i>	104

Chapter 4 Targeting of Bioactives to Peyer's Patches

*Piush Khare, Mohini Chaurasia, Prashant Khare,
S. K. Paliwal, Nitin K. Jain and Manish K. Chourasia*

4.1 Introduction.....	108
4.1.1 Small Intestine	109
4.1.2 Peyer's Patches	110
4.1.3 M-Cells	112
4.2 Targeting of Therapeutics to Peyer's Patches.....	113
4.2.1 Uptake of Particles through Peyer's Patch.....	116
4.2.1.1 Size of the Micro/ Nanoparticles	118
4.2.1.2 Species Difference and Number of Peyer's Patches.....	119
4.2.1.3 Hydrophillic/Hydrophobic Nature of the Microparticles....	120
4.2.1.4 Type of Polymer	120
4.2.1.5 Influence of Co-administered Agents.....	120
4.2.1.6 Fluid Volume and Osmotic Parameters	121
4.3 Role of Peyer's Patches in Design and Development of Oral Vaccines.....	121
4.4 Targeting Strategies	124
4.4.1 Lectin Mediated Targeting.....	124
4.4.2 Antibody Mediated Targeting.....	126
4.4.3 Other Targeting Ligands	126

4.5 Evaluation of the Uptake of Particles	127
4.5.1 Microscopic Methods.....	128
4.5.2 Electron Microscopy	128
4.5.3 Fluorescent Activated Cell Sorter	129
4.5.4 Radioactivity and Fluorometry	129
4.6 Models for Assessment of Uptake	129
4.7 Conclusion and Future Prospects.....	130
References	131

Chapter 5 Drug Delivery Systems based on Multiple Emulsions

Vinod K. Dhote, Kanika Dhote, Piush Khare and Sharad P. Pandey

5.1 Introduction.....	137
5.1.1 Multiple Emulsions	138
5.2 Formulation Considerations.....	139
5.2.1 Pharmaceutical Oils	139
5.2.2 Pharmaceutical Emulsifiers.....	140
5.2.3 Surface Active Agents	140
5.2.4 Preservatives	141
5.2.5 Antioxidants and Humectants	141
5.3 Formulation of Multiple Emulsions.....	142
5.3.1 Double Emulsification Technique (Two Step Technique).....	143
5.3.2 Phase Inversion Technique	144
5.3.3 Membrane Emulsification Technique	145
5.4 Instability in Multiple Emulsions.....	145
5.5 Multiple Emulsion Stability Testing.....	148
5.6 Drug Release Mechanism from Multiple Emulsions (Vaziri and Warburton, 1994).....	149
5.6.1 Diffusion Mechanism.....	150
5.6.2 Facilitated Diffusion (Carrier-Mediated Transport).....	150
5.6.3 Thinning of the Oil Membrane	150
5.6.4 Photo-Osmotic Transport.....	150

5.6.5 Rupture of Oil Phase	150
5.6.6 Solubilization of Internal Phase in the Oil Membrane	150
5.6.7 Micellar Transport	150
5.7 Application of Multiple Emulsions.....	151
References.....	154

Chapter 6 Site Specific Oral Drug Delivery Systems

Pankaj K. Singh and Priya Singh Kushwaha

6.1 Introduction.....	157
6.2 Designing of Oral Mucosal Drug Delivery System	160
6.3 Buccal Tablets.....	161
6.3.1 Mucoadhesion	162
6.3.1.1 The Electronic Theory	163
6.3.1.2 The Adsorption Theory	163
6.3.1.3 The Wetting Theory.....	163
6.3.1.4 The Diffusion Theory	163
6.3.1.5 The Fracture Theory	163
6.3.2 Basic Components of Mucoadhesive Buccal Tablets and Patches.....	164
6.3.2.1 Drug Substance.....	164
6.3.2.2 Mucoadhesive Polymers.....	164
6.3.2.3 Permeation Enhancers	166
6.3.2.4 Backing Membrane.....	167
6.3.3 Advantages of Buccal Tablets and Buccal Patches	167
6.3.4 Formulation of Mucoadhesive Buccal Tablet	168
6.3.5 Evaluation of Buccal Tablets	169
6.3.5.1 Weight Variation	169
6.3.5.2 Thickness	170
6.3.5.3 Hardness	170
6.3.5.4 Friability	170

6.3.5.5 Drug Content	170
6.3.5.6 Stability Studies.....	170
6.4 Buccal Patches	171
6.4.1 Method of Preparation	171
6.4.1.1 Solvent Casting.....	171
6.4.1.2 Direct Milling	171
6.4.2 Evaluation of Buccal Patches.....	172
6.4.2.1 Surface pH	172
6.4.2.2 Thickness.....	173
6.4.2.3 Swelling Index.....	173
6.4.2.4 Common Parameters for Evaluation of Buccal Tablets and Buccal Patches	173
6.5 Osmotic Tablet.....	176
6.5.1 Osmosis and its Principal.....	176
6.5.2 Historical Aspects of Osmotic Pumps....	177
6.5.3 Advantages of Osmotic Tablets	179
6.5.4 Disadvantages	180
6.5.5 Components of Osmotic Tablets.....	180
6.5.5.1 Drug.....	180
6.5.5.2 Osmotic Agent.....	180
6.5.5.3 Semipermeable Membrane	181
6.5.5.4 Plasticizers	182
6.5.5.5 Hydrophilic and Hydrophobic Polymers	182
6.5.5.6 Wicking Agents	183
6.5.5.7 Flux Regulators.....	183
6.5.6 Classification of Osmotic Tablets	184
6.5.6.1 Elementary Osmotic Pump.....	184
6.5.6.2 Controlled Porosity Osmotic Pump	184
6.5.6.3 Osmotic Bursting Osmotic Pump.....	185

Contents **(xxi)**

6.5.6.4 Push Pull Osmotic Pump	185
6.5.6.5 Sandwich Osmotic Tablets	186
6.5.7 Marketed Osmotically Controlled Tablets.....	186
6.6 Pulsincap.....	187
6.6.1 Types of Pulsincaps	188
6.6.1.1 Osmosis Dependent Pulsincap...	189
6.6.1.2 Erodible or Rupturable Layer Dependent Pulsincap	189
6.6.1.3 Capsule Shell Dependent Pulsincap.....	190
6.6.1.4 pH Induced Pulsincap	190
6.6.1.5 Temperature Induced Pulsincap.....	190
6.6.1.6 Chemically Induced Pulsincap.....	190
6.6.1.7 Externally Induced Pulsincap ..	191
6.6.2 Evaluation of Pulsincap	191
6.6.2.1 Swelling Index.....	191
6.6.2.2 Lag Time and Drug Release	191
6.6.2.3 Water Uptake Study.....	191
6.6.2.4 Hardness	192
6.6.2.5 Thickness of Enteric Coated Layer.....	192
6.7 Lozenges	192
6.7.1 Classification of Lozenges	193
6.7.1.1 Medicated Lozenges	193
6.7.2 Commercially Available Lozenges	198
6.8 Medicated Chewing Gum	199
6.8.1 Advantages of MCG over Conventional Drug Delivery System	200
6.8.2 Disadvantages of MCG	200
6.8.3 Composition.....	201

6.8.4	Manufacturing and Evaluation.....	202
6.8.4.1	Conventional/Traditional Method (Melting)	202
6.8.4.2	Cooling, Grinding and Tableting Method	203
6.8.4.3	Use of Directly Compressible Chewing Gum Excipients.....	204
6.8.5	Factors affecting Release of Active Ingredient	205
6.8.5.1	Contact Time	205
6.8.5.2	Physicochemical Properties of Active Ingredient.....	205
6.8.5.3	Inter Individual Variability	206
6.8.5.4	Composition of Gum Base	206
6.8.6	Evaluation of MCG.....	206
6.8.6.1	Uniformity of Mass (Weight Variation Test).....	206
6.8.6.2	Uniformity of Content	206
6.8.6.3	<i>In-Vitro</i> Drug Release Study ...	207
6.8.7	Applications	208
6.8.8	Systemic Therapy.....	208
6.9	Egalet® Technology	209
6.9.1	Mechanism of Action.....	209
6.9.2	Manufacturing.....	210
6.9.2.1	Egalet® Prolonged Release Tablets	212
6.9.2.2	Egalet® Delayed Release	212
6.9.3	Factors Affecting Drug Release from Egalet® Tablets.....	213
6.9.3.1	Erosion of Matrix.....	213
6.9.3.2	Agitation	214
6.9.3.3	Surface Area of Tablet.....	214
6.9.3.4	Immediate Release Layer (Lag Compartment)	214

6.10 Enterion Capsule Technology	215
6.10.1 Description of Technology	215
6.10.2 Tracking the Enterion Capsule.....	217
6.10.3 Application of the Technology	218
6.11 Hydrophilic Sandwich	218
References	219

Chapter 7 Coarse Dispersion

*Sharad P. Pandey, Tripti Shukla, Vinod K. Dhote,
Kanika Dhote and Puneet Bhatnagar*

7.1 Introduction.....	224
7.1.1 Molecular Dispersion.....	224
7.1.2 Colloidal Dispersion	225
7.1.3 Coarse Dispersion	225
7.2 Fundamentals of Suspension System.....	227
7.2.1 Advantages and Disadvantages of Suspension	227
7.2.2 Properties of an Ideal Suspension	228
7.2.3 Theoretical Consideration of Stable Formulation.....	228
7.2.4 Particle Size and its Distribution.....	229
7.2.5 Flocculated Suspensions	230
7.2.5.1 Inter-Particle Collision	231
7.2.5.2 Reduction of Electrical Charge..	232
7.2.5.3 Synthetic Bridging Flocculants.....	233
7.2.6 Deflocculated Suspension.....	234
7.2.7 Formulation of Stable Suspension	235
7.2.8 Stability of a Suspension.....	238
7.2.8.1 Chemical Stability	239
7.2.8.2 Physical Stability	239
7.2.8.3 Crystal Growth	239

7.2.9	Evaluation of Suspension	240
7.2.9.1	Appearance	240
7.2.9.2	Photomicroscopic Examination.....	240
7.2.9.3	Organoleptic Properties (color, taste, odor).....	240
7.2.9.4	Sedimentation Rate, Volume, Resuspendability	241
7.2.9.5	Viscosity	242
7.2.9.6	pH Value.....	242
7.2.9.7	Zeta Potential Measurement	242
7.2.9.8	Freeze Thaw Cycling.....	243
7.2.9.9	Drug Content Uniformity	244
7.2.9.10	Dissolution Testing.....	244
7.3	Pharmaceutical Emulsions	245
7.3.1	Advantages of Emulsions.....	246
7.3.2	Theory of Emulsification	246
7.3.2.1	Mono-Molecular Adsorption ...	247
7.3.2.2	Multi-Molecular Adsorption....	247
7.3.2.3	Solid Particle Adsorption Theory.....	248
7.3.3	Emulsion Type and Means of Detection ...	248
7.3.3.1	Dilution Test.....	248
7.3.3.2	Conductivity Test	249
7.3.3.3	Dye-Solubility Test.....	249
7.3.3.4	Fluorescence Test	250
7.3.3.5	CoCl ₂ /Filter Paper Test.....	250
7.3.4	Stability of Pharmaceutical Emulsions ...	250
7.3.4.1	Chemical Instability.....	250
7.3.4.2	Physical Instability	251
7.3.5	Formulation of Emulsion	253
7.3.5.1	Immiscible Phases	253
7.3.5.2	Emulsifiers.....	253

7.3.5.3 Auxiliary Agents (Emulsion Stabilizers)	255
7.3.5.4 Preservatives.....	256
7.3.5.5 Antioxidants.....	258
7.3.6 Method of Preparation of Emulsion.....	259
7.3.6.1 Dry Gum Method.....	259
7.3.6.2 Wet Gum Method	260
7.3.6.3 Bottle or Forbes Bottle Method.....	260
7.3.7 Preparation of Emulsion at Industrial Scale.....	260
7.3.7.1 Agitators/Mechanical Stirrers....	261
7.3.7.2 Colloid Mill	261
7.3.7.3 Homogenizers.....	261
7.3.7.4 Ultrasonic Devices.....	262
7.3.8 Evaluation of Emulsions	262
7.3.8.1 Globule Size and its Distribution.....	263
7.3.8.2 Electro-Kinetic Behavior	263
7.3.8.3 Drug Release Behavior	263
7.4 Sustained Release Suspensions.....	265
7.5 Conclusion	267
References	267

Chapter 8 Modified Release Drug Delivery Systems for
Oral Route

*Sharad P. Pandey, Vinod Dhote, Tripti Shukla and
M. S. Sudheesh*

8.1 Introduction.....	270
8.2 TIMERx Technology	274
8.2.1 Advantages of the System.....	276
8.2.2 Problems Associated with the Formulation.....	277
8.2.3 Advancement	277

8.3 MASRx and COSRx: Modified Release Providing Systems	277
8.3.1 MASRx Technology	278
8.3.2 COSRx Technology	278
8.4 Smartrix® Technology	279
8.5 Geometrically Modified Core Containing Formulation: Procise Technology.....	281
8.5.1 Advantages of Procise Technology.....	282
8.6 Ring Cap Technology	283
8.6.1 Advantages.....	283
8.7 Pulsincap Technology.....	283
8.7.1 Polymeric Hydrogel Capsule	284
8.7.2 Gelatin Capsule having Impermeable Coating.....	285
8.7.3 Hydrophilic Polymer Sandwiched in between the Layers of two Capsules.....	285
8.8 Spheroidal Oral Drug Absorption System	286
8.9 Egalet Technology	288
8.10 Conclusion	289
References	289

Chapter 9 Designing of Modulated Release Drug Delivery Systems by Pelletization Techniques

*Vinod K. Dhote, Kanika Dhote, Sharad. P. Pandey,
Tripti Shukla and Vandana Soni*

9.1 Introduction.....	292
9.1.1 History of Pelletization	293
9.1.2 Advantages and Limitations.....	293
9.1.2.1 Technological Advantages	293
9.1.2.2 Therapeutic Advantages	294
9.1.2.3 Limitations of Pelletization	294
9.1.3 Rationale of using Pelletization	294

Contents **(xxvii)**

9.2 Pelletization Techniques	295
9.2.1 Extrusion/Spheronization.....	296
9.2.1.1 Advantages of Spheronization...	297
9.2.1.2 Dry Mixing	297
9.2.1.3 Wet Massing	298
9.2.1.4 Extrusion.....	298
9.2.2 Roto Granulation.....	299
9.2.3 Solution and Suspension Layering.....	299
9.2.4 Dry Powder Layering.....	300
9.2.5 Cryopelletization.....	300
9.2.6 Spray Drying and Spray Conealing	301
9.2.7 Freeze Pelletization	302
9.2.8 Melt-Induced Agglomeration.....	302
9.2.9 Melt Spheronization.....	302
9.2.10 Fluid-Bed Granulation	302
9.2.11 Bottom Spray Coating Process	303
9.2.12 Tangential Spray Fluid Bed Granulation ...	304
9.2.13 Suspension/Solution Layering Technique.....	304
9.2.14 Innovative Technologies	305
9.2.14.1 CPS™ Technology	305
9.2.14.2 MicroPx™ Technology	306
9.2.14.3 ProCell™ Technology	306
9.3 Factors Affecting Pelletization Process	307
9.3.1 Moisture Content	307
9.3.2 Rheological Characteristics.....	308
9.3.3 Solubility of Excipients and Drug in Granulating Fluid.....	308
9.3.4 Composition of Granulating Fluid	308
9.3.5 Physical Properties of Starting Material	308
9.3.6 Speed of the Spheronizer	308
9.3.7 Drying Technique and Drying Temperature	309
9.3.8 Extrusion Screen	309

9.4 Characterization of Pellets	309
9.4.1 Particle Size Distribution	310
9.4.2 Surface Area.....	310
9.4.3 Porosity	310
9.4.4 Density	311
9.4.5 Hardness and Friability	311
9.4.6 Tensile Strength	311
9.4.7 Disintegration Time	311
9.4.8 <i>In vitro</i> Dissolution Studies.....	311
9.5 Applications	312
9.5.1 Taste Masking.....	312
9.5.2 Immediate Release	312
9.5.3 Sustained Release.....	313
9.5.4 Chemically Incompatible Products	314
9.5.5 Varying Dosage without Reformulation....	314
9.6 Conclusion	314
References	315

Chapter 10 Colloidal Drug Delivery Systems

*Vinod K. Dhote, Kanika Dhote, Tripti Shukla,
Sharad P. Pandey and Piush Khare*

10.1 Colloidal Nanocarriers: General Considerations....	318
10.1.1 Colloidal Drug Delivery Systems	320
10.1.2 Properties of an Ideal CDDS.....	322
10.1.3 Applications of CDDS	323
10.2 Colloidal Drug Carriers	324
10.2.1 Liposomes	324
10.2.1.1 Advantages of Liposomes	325
10.2.1.2 Pharmaceutical Applications of Liposomes	326
10.2.2 Polymer Micelles and Polymersomes	327
10.2.3 Polymer Particles	328
10.2.4 Solid Lipid Nanoparticles	328
10.2.5 Microemulsion	329

10.3 <i>In-vivo</i> Fate of Colloidal Drug Carriers	330
10.4 Advantage and Successes	331
10.5 Conclusion	333
References	334

Chapter 11 *In-situ* Gel and Liquid Crystals as Potential Drug Delivery Systems

*Ashish Parashar, Ankit Jain, Kamlesh Bhaduriya,
Piush Khare and Punit Bhatnagar*

11.1 Introduction.....	339
11.2 <i>In-Situ</i> Gelling System.....	340
11.2.1 Physiological Stimuli Approach	341
11.2.1.1 Temperature Induced	341
11.2.1.2 pH Induced	342
11.2.2 Physical Reaction Approach	342
11.2.3 Chemical Changes in Biomaterial.....	343
11.2.3.1 Ionic Crosslinking.....	343
11.2.3.2 Photo-Polymerization	343
11.2.3.3 Enzymatic Cross Linking	343
11.3 Methods of Preparation of <i>In-Situ</i> Gel Systems...	344
11.3.1 Solution Polymerization/Crosslinking	344
11.3.2 Suspension Polymerization	344
11.3.3 Polymerization by Irradiation	345
11.3.4 Chemically Crosslinked Hydrogels	345
11.3.5 Physically Crosslinked Hydrogels	345
11.4 In-Situ Gelling Polymers	345
11.4.1 Pectin.....	346
11.4.2 Gellan Gum.....	346
11.4.3 Xyloglucan.....	346
11.4.4 Guar Gum.....	347
11.4.5 Xanthum Gum.....	347
11.4.6 Carbopol.....	347
11.4.7 Synthetic Polymers	348

11.5	Evaluation and Characterizations of <i>In-Situ</i> Gel System	348
11.5.1	Clarity	348
11.5.2	Texture Analysis	348
11.5.3	pH of Gel.....	348
11.5.4	Sol-Gel Transition Temperature and Gelling Time	348
11.5.5	Gel-Strength.....	349
11.5.6	Viscosity and Rheology	349
11.5.7	Fourier Transform Infrared Spectroscopy and Thermal Analysis.....	349
11.5.8	<i>In-vitro</i> Drug Release Studies	349
11.6	Applications of <i>In-Situ</i> Polymeric Drug Delivery System	350
11.6.1	<i>In-Situ</i> Gel based Oral Drug Delivery....	350
11.6.2	Ocular Delivery.....	351
11.6.3	Nasal Delivery	351
11.6.4	Rectal and Vaginal Drug Delivery Systems	352
11.6.5	Injectable Drug Delivery Systems	352
11.7	Liquid Crystals as Drug Delivery Systems.....	353
11.7.1	Classification of Liquid Crystals.....	355
11.7.1.1	Lyotropic Liquid Crystals.....	355
11.7.1.2	Thermotropic Liquid Crystals....	356
11.7.2	Characterization of Liquid Crystals	356
11.7.2.1	Polarized Light Microscopy	357
11.7.2.2	Transmission Electron Microscopy	357
11.7.2.3	X-Ray Scattering Pattern	357
11.7.2.4	Differential Scanning Calorimetry.....	357
11.7.2.5	Rheology.....	357
11.7.2.6	Determination of Vesicle Size ..	357

Contents **(xxxii)**

11.7.3 Applications of Liquid Crystals	358
11.7.3.1 Liquid Crystalline Drug Substances	358
11.7.3.2 Liquid Crystalline Formulations for Dermal Application	358
11.7.3.3 Liquid Crystalline Formulations for Sustained Drug Delivery	358
11.7.3.4 Liquid Crystals in Cosmetics...	358
11.8 Conclusion	359
References	359
<i>Index</i>	363