Contents

Author Biography xiii	
Preface xv	
Acknowledgment and Dedications	xvii

1	Introduction 1
1.1	Overview of Polymer Foams 1
1.2	Polymer Foaming Methods 2
1.2.1	Mechanical Foaming 2
1.2.2	Physical Foaming 2
1.2.3	Chemical Foaming 4
1.3	Fundamentals of SCF Foaming 5
1.3.1	Preparation of Homogeneous Solution 5
1.3.2	Cell Nucleation 7
1.3.2.1	Homogeneous Foam Nucleation 7
1.3.2.2	Heterogeneous Foam Nucleation 9
1.3.2.3	Mixed Nucleation Theory 10
1.3.3	Cell Growth 11
1.3.4	Cell Coalescence and Rupture 13
1.3.4.1	The Mechanism of Cell Rupture 14
1.3.4.2	Mechanism of Cell Opening 14
1.3.5	Solidification and Curing 17
1.4	Influencing Factors of Cell Structure in the Foaming Process 18
1.4.1	Effects of Polymer Properties 19
1.4.1.1	Rheological Properties of Polymers 19
1.4.1.2	Solubility and Diffusion of Blowing Agent 19
1.4.1.3	Interaction Between Foaming Agent and Polymer Matrix 20
1.4.1.4	Nucleating Agent and Nanoparticles 21
1.4.2	Effects of Foaming Process Parameters 21
1.4.2.1	Foaming Temperature 21
1.4.2.2	Saturation Pressure or Foaming Pressure 22
1.4.2.3	Depressurization Rate 22
1.4.2.4	Multistage Saturation and Depressurization 23



vi	Contents
•••	

1.5	Previlant Foaming Methods for Microcellular Foams 23
1.5.1	Batch Foaming 24
1.5.2	Continuous Extrusion Foaming 25
1.5.3	Injection Foaming Technique 26
1.6	Advanced Applications of Functionalized Polymer Foams 27
1.6.1	Energy Absorbing Buffer Foam 28
1.6.2	Thermal Insulation Polymer Foams 28
1.6.3	Acoustic Absorption Polymer Foams 28
1.6.4	Superhydrophobic Polymer Foams 29
1.6.5	Electromagnetic Shielding Conductive Polymer Foam 29
1.6.6	Medical Tissue Engineering Repair 29
1.6.7	Flexible Sensors Based on Porous Polymer Foams 30
1.6.8	Triboelectric Nanogenerator Based on Polymer Foams 30
1.6.9	Porous Polymers for Solar Steam Generation 30
	References 30
2	Energy-Absorbing Polymer Foams 37
2.1	Overview of Energy-Absorbing Foam 37
2.1.1	Classification of Energy-Absorbing Polymer Foams 37
2.1.2	Factors Affecting Mechanical Properties of Polymer Foams 38
2.1.2.1	Relative Density 38
2.1.2.2	Morphological Features of the Cells 39
2.1.2.3	Cell Size Influence on Mechanical Properties 40
2.1.2.4	Matrix Influence on Mechanical Properties 41
2.1.2.5	Effect of Open-Cells on Mechanical Properties 42
2.2	Energy Absorption Mechanism of Polymer Foams 43
2.2.1	Open-Cell Structure Model 43
2.2.2	Closed-Cell Foam 46
2.2.3	Other Special Structural Models 48
2.2.4	Energy Dissipation Mechanism of Polymer Foams 51
2.2.5	Effect of the Matrix Material 53
2.3	Testing and Characterization of Energy-Absorbing Foams 55
2.3.1	Morphology Characterization 55
2.3.2	Quasistatic Compression Test 56
2.3.3	Dynamic Compression Test 57
2.3.4	Rebound Performance and Hysteresis Testing 59
2.4	Preparation Methods of Energy-Absorbing Polymer Foam 61
2.4.1	Open-Cell Foams 61
2.4.2	Closed-Cell Foams 63
2.4.3	Composite Foams 64
2.4.4	Special-Structured Foams 66
2.5	Applications of Energy-Absorbing Polymer Foams 68
2.5.1	Energy-Absorbing Foams in Sports 69
2.5.2	Energy-Absorbing Foams for House and Home 69
2.5.3	Energy-Absorbing Foams for Transportation and Vehicles 70

2.5.4	Energy-Absorbing Foams for Security and Military 70 References 71
3	Thermal Insulation Polymer Foams 75
3.1	Overview of Thermal Insulation Foams 75
3.2	Fundamentals of Thermal Insulation 76
3.2.1	The Convection of Heat Transfer 78
3.2.2	Thermal Conduction of Gases and Solids 78
3.2.3	Thermal Radiation 81
3.3	Performance and Characterization 85
3.3.1	Property Characterization Methods 85
3.3.1.1	Thermal Conductivity Measurements 85
3.3.1.2	Porosity (p)Measurement for a Polymer Foam 86
3.3.1.3	Thermal Deformation Measurement 86
3.3.2	Factors Affecting Thermal Conductivity 86
3.3.2.1	Pore Size and Porosity 86
3.3.2.2	Temperature 89
3.3.2.3	Material Refractive Index 89
3.4	Fabrication of Thermal Insulation Polymer Foams 90
3.4.1	Composite Polymer Matrices 90
3.4.2	Fabrication of Bimodal Foams 93
3.4.3	Fabrication of Closed-Cell Foams 97
3.4.4	Fabrication of Polymer Foams with Honeycomb Structures 98
3.4.5	Fabrication of Nanocellular Polymer Foams 98
3.5	Other Thermal Insulation Polymer Foams 101
3.5.1	Microcellular Polyimide (PI) Foams 101
3.5.2	Phenolic Foams Chilled Water Piping 103
3.5.3	Spray Polyurethane Foam 103
3.5.4	Thermal Insulation Aerogels 104
	References 107
4	Acoustic Absorption Polymer Foams 111
4.1	Overview of Sound Absorption and Noise Reduction Foams 111
4.2	Fundamentals of Acoustic Absorption of Polymer Foams 112
4.2.1	Propagation and Absorption of Sound Waves 112
4.2.2	Sound Absorption Principle and Models 113
4.3	Characterization and Influencing Factors for Sound 118
4.3.1	Characterization of Sound Absorption Properties 118
4.3.1.1	Sound Absorption Coefficient (α) Measurement 118
4.3.1.2	Porosity Measurement 119
4.3.1.3	Cell Diameter, Cell Density, and Open-Cell Content 119
4.3.1.4	Tortuosity α_{∞} Measurement 119
4.3.1.5	Airflow Resistance Measurement 120
4.3.2	Factors Affecting Sound Absorption Performance 120
4.3.2.1	Effect of Cellular Morphology 120

	•	
Ē		í

4.3.2.2	Macro Shape and Geometry of Polymer Foam 122
4.3.2.3	Resistance of Airflow 125
4.3.2.4	Tortuosity Factor 125
4.4	Types of Acoustic Absorption Foams 125
4.4.1	Sound Absorption Ceramic 125
4.4.2	Sound Absorption Metallic Foam 127
4.4.3	Sound Absorption Polymer Foam 128
4.4.4	Sound Absorption Polymer Composite Foam 129
4.5	Fabrication of Acoustic Absorption Polymer Foams 132
4.5.1	Chemical Foaming 132
4.5.2	Supercritical CO ₂ Foaming 133
4.5.3	Coating of Foam Skeletons 137
4.5.4	Phase Separation and Particulate Leaching 137
	References 141
5	Superhydrophobic Polymer Foams 145
5.1	Overview of Superhydrophobic Polymer Foams 145
5.1.1	Superhydrophobicity in Nature 146
5.1.2	Influencing Factors for Superhydrophobicity 146
5.1.2.1	Surface Energy 147
5.1.2.2	Surface Structure 147
5.1.3	Methods to Engineer Hierarchical Structured Surface 147
5.1.3.1	Surface Treatment Method 147
5.1.3.2	Etching Method 148
5.1.3.3	Phase Separation Method 148
5.1.3.4	Template Replicating 150
5.1.3.5	Electrostatic Spinning 151
5.2	Theoretical Basis of Superhydrophobicity 153
5.2.1	Wetting on a Solid Surface 153
5.2.2	Wetting on Rough Surfaces 153
5.2.3	Cassie-Baxter Model 154
5.2.4	Theoretical Basis for 3D Porous Foams 155
5.3	Characterizations of Superhydrophobic Foams 159
5.3.1	Morphological Characterization 159
5.3.1.1	Scanning Electron Microscope (SEM) 159
5.3.1.2	Atomic Force Microscope (AFM) 159
5.3.1.3	White-Light Interferometry (WLI) 160
5.3.2	Surface Chemistry and Wettability Characterization 160
5.3.2.1	Surface Chemistry Characterization 160
5.3.2.2	Surface Wettability Characterization 160
5.3.3	Selective Oil Adsorption Experiments 160
5.3.4	Absorption Capacity of Superhydrophobic Foams 161
5.4	Superhydrophobic Foam Preparation Technology 161
5.4.1	Nanoparticle/Porous Material Complexes 161
5.4.2	Superhydrophobic Foams Prepared by Phase Separation 162

5.4.3	Superhydrophobic Aerogels 163
5.4.4	Superhydrophobic Fibrous Sponge Prepared by Electrospinning 166
5.4.5	Superhydrophobic Foams Fabricated via Supercritical CO ₂
	Foaming 166
5.5	Advanced Application of Superhydrophobic Polymer Foams 170
5.5.1	Self-Cleaning and Antifouling 170
5.5.2	Oil–Water Separation and Oil Absorption 172
5.5.3	Integration with Other Functions 173
5.5.3.1	Superhydrophobic Foams for Electromagnetic Interference (EMI)
	Shielding 173
5.5.3.2	Superhydrophobic Foams for Piezoresistive Sensors 174
5.5.3.3	Superhydrophobic Foams for Radiative Cooling 174
5.5.3.4	Superhydrophobic Surfaces for Nanogenerators 177
	References 177
6	Electromagnetic Shielding Polymer Foams 183
6.1	Electromagnetic Pollution and Electromagnetic Interference
	Shielding 183
6.1.1	The Cause of Electromagnetic Radiation and Its Harm 183
6.1.2	Electromagnetic Interference Shielding Mechanism 183
6.1.3	EMI Shielding Mechanism for Porous Materials 185
6.2	Conventional EMI Shielding Materials and Conductive Polymer
	Foams 186
6.2.1	Conventional EMI Shielding Materials 186
6.2.2	Conductive Polymer Foams 187
6.3	Characterization of EMI Shielding Polymer Foams 188
6.3.1	EMI Shielding Effectiveness Measurement 188
6.3.2	EM Wave Absorption 189
6.3.3	Electrical Conductivity 189
6.3.4	Magnetic Property 190
6.4	Preparation of EMI Shielding Polymer Foams 190
6.4.1	Composition of EMI Shielding Polymer Foams 190
6.4.2	Factors Influence EMI Shielding Performance of Polymer Foams 191
6.4.2.1	Conductivity and Magnetic Properties 191
6.4.2.2	Material Thickness and Resonance Behavior 193
6.4.2.3	Cell Size, Cell Density, and Porosity 195
6.4.3	Foaming Methods for Conductive Polymer Foams 196
6.4.3.1	Chemical Foaming of EMI Shielding CPFs 197
6.4.3.2	Supercritical CO ₂ Foaming of EMI Shielding CPFs 198
6.4.4	EMI Shielding CPFs with Special Microstructures 199
6.4.4.1	Reentrant Cell Structure 199
6.4.4.2	Oriented Cell Structure 200
6.4.4.3	Segregated Cell Structure 201
6.4.4.4	Gradient Cell Structure 204
6445	Lavered Foam Structure 205

Contents	
6.5	Advanced Research on EMI Shielding Porous Composites 207
6.5.1	EMI Shielding Aerogels 208
6.5.2	EMI Shielding Fibrous Networks 208
6.5.3	Metal-Based EMI Shielding Porous Materials 210
6.5.4	Surface Coated/Modified Foams for EMI Shielding 210
	References 212
-	
7	Polymer Foams for Tissue Engineering Scaffolds 217
7.1	Overview of Tissue Engineering 217
7.1.1	Basic Elements of Tissue Engineering 217
7.1.2	Tissue Engineering Scaffold Materials 218
7.2	Fundamentals of Tissue Engineering 219
7.2.1	Typical Process of Tissue Engineering 219
7.2.2	Ideal Scaffold Conditions 221
7.3	Characterization of Tissue Engineering Scaffolds 222
7.3.1	Surface Property Testing 222
7.3.1.1	Protein Absorption 222
7.3.2	Mechanical Performance Testing 223
7.3.3	Biological Performance Testing 223
7.4	Preparation of Tissue Engineering Scaffolds by Gas Foaming 224
7.4.1	Preparation of Tissue Engineering Scaffolds by Chemical Foaming 22
7.4.2	Preparation of Tissue Engineering Scaffolds by Physical Foaming 226
7.5	Application of Scaffolds in Tissues 230
7.5.1	Scaffolds for Bone Tissue Engineering 230
7.5.2	Scaffolds for Soft Tissue Repair 233
7.5.3	Scaffolds for Vascular Tissue Engineering 234
7.5.4	Scaffolds for Nervous Tissue Engineering 237
	References 240
8	Flexible Sensors Based on Porous Polymer and
	Polymer Foams 245
8.1	Overview of Flexible Strain Sensors 245
8.1.1	Substrate Materials for CPF Sensors 246
8.1.2	Active Conductive Materials 247
8.1.2.1	Carbon-Based Materials 248
8.1.2.2	Metallic Nanomaterials 249
8.1.2.3	Conducting Polymers 249
8.1.2.4	Hybrid Active Conductive Materials 250
8.2	Fundamentals of Piezoresistive Sensors 250
8.2.1	Sensing Mechanism of Flexible Piezoresistive Sensors 250
8.2.1.1	Percolation Theory Based on Conductive Polymer Composites 251
8.2.1.2	Tunneling Effect Based on Conductive Polymer Composites 252
8.2.1.3	Variation Based on Interface Contact Resistance 253
8.2.2	Sensing Mechanism of Conductive Foams 254
8.2.3	The Influencing Factors of Foam-Based Piezoresistive Sensors 255

8.2.3.1	Cell Size and Cell Wall Thickness of CPFs 255
8.2.3.2	Surface Microstructure of Materials 256
8.2.3.3	Interconnections of CPFs 257
8.3	Performance and Characterization of Piezoresistive Sensors 259
8.3.1	Sensitivity 259
8.3.2	Response Time and Recovery Time 259
8.3.3	Hysteresis 260
8.3.4	Linearity 262
8.3.5	Strain Response Range 262
8.3.6	Reliability and Stability 263
8.4	Preparation of Flexible Sensors Based on Porous Foams 263
8.4.1	Physical Foaming 263
8.4.2	Chemical Foaming 264
8.4.3	Freeze-Drying Method 266
8.4.4	Coating of Commercial Foams 267
8.4.5	Skeleton Etching Method 268
8.4.6	Template Sacrificial Method 269
8.5	Applications of Flexible Piezoresistive Sensors 270
8.5.1	Human Motion Monitoring 270
8.5.2	Tactile Perception 272
8.5.3	Temperature Monitoring 272
	References 275
9	Triboelectric Nanogenerators Based on Polymer Foams 281
9 9.1	Triboelectric Nanogenerators Based on Polymer Foams 281 Overview of TENG 281
-	· · · · · · · · · · · · · · · · · · ·
9.1	Overview of TENG 281
9.1 9.1.1	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281
9.1 9.1.1 9.1.2	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282
9.1 9.1.1 9.1.2 9.1.2.1	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2 9.2.2.3	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287 Single-Electrode Mode 288
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2 9.2.2.3 9.2.2.4	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287 Single-Electrode Mode 288 Independent Friction Layer Mode 289 Power Generation Mechanism of Porous Materials 290 Charge Accumulation in the Porous Structure 290
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2 9.2.2.3 9.2.2.4 9.2.3	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287 Single-Electrode Mode 288 Independent Friction Layer Mode 289 Power Generation Mechanism of Porous Materials 290 Charge Accumulation in the Porous Structure 290 Charge Separation in the Micro Cells 291
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2 9.2.2.3 9.2.2.4 9.2.3 9.2.3.1	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287 Single-Electrode Mode 288 Independent Friction Layer Mode 289 Power Generation Mechanism of Porous Materials 290 Charge Accumulation in the Porous Structure 290
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2 9.2.2.3 9.2.2.4 9.2.3 9.2.3.1 9.2.3.2	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGS Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287 Single-Electrode Mode 288 Independent Friction Layer Mode 289 Power Generation Mechanism of Porous Materials 290 Charge Accumulation in the Porous Structure 290 Charge Separation in the Micro Cells 291 Performance and Characterization of Polymer Foam-Based TENGS 292 Influencing Factors for Polymer Foam-Based TENGS 292
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2 9.2.2.3 9.2.2.4 9.2.3 9.2.3.1 9.2.3.2 9.3.1 9.3.1.1	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGs Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287 Single-Electrode Mode 288 Independent Friction Layer Mode 289 Power Generation Mechanism of Porous Materials 290 Charge Accumulation in the Porous Structure 290 Charge Separation in the Micro Cells 291 Performance and Characterization of Polymer Foam-Based TENGs 292 Influencing Factors for Polymer Foam-Based TENGs 292 Effect of Triboelectric Materials 292
9.1 9.1.1 9.1.2 9.1.2.1 9.1.2.2 9.1.3 9.2 9.2.1 9.2.2 9.2.2.1 9.2.2.2 9.2.2.3 9.2.2.4 9.2.3 9.2.3.1 9.2.3.2 9.3 9.3.1	Overview of TENG 281 The Development of Energy Harvesting Nanogenerators 281 TENG and Critical Factors 282 Triboelectric Materials 283 Macroscopic and Microscopic Structures 283 TENGS Based on Porous Materials 283 Fundamentals of TENG 284 Charge and Current Generation Mechanism 284 Working Mode and Principle of TENG 286 Vertical Contact-Separation Model 286 Horizontal Sliding Mode 287 Single-Electrode Mode 288 Independent Friction Layer Mode 289 Power Generation Mechanism of Porous Materials 290 Charge Accumulation in the Porous Structure 290 Charge Separation in the Micro Cells 291 Performance and Characterization of Polymer Foam-Based TENGS 292 Influencing Factors for Polymer Foam-Based TENGS 292

xii	Contents	
	9.3.2.1	Scanning Electronic Microscope (SEM) 294
	9.3.2.2	Fourier Transform Infrared Spectrometer (FT-IR) 294
	9.3.2.3	•
	9.3.2.4	Kelvin Probe Force Microscopy (KPFM) 295
	9.3.3	Performance Evaluation Criteria 296
	9.3.3.1	Figure of Merit (FOM) 296
	9.3.3.2	Output Current, Voltage, and Charge Measurement 297
	9.3.3.3	Measurement of Output Power Density 297
	9.4	Fabrication of Polymer Foams for TENGs 297
	9.4.1	Supercritical CO ₂ Foaming 297
	9.4.2	Chemical Foaming 300
	9.4.3	Phase Separation and Freeze Drying 301
	9.4.4	Other Methods to Fabricate Porous Films 303
	9.5	Advanced Application of TENG 304
	9.5.1	Micro and Nano Energy 304
	9.5.2	Blue Energy 307
	9.5.3	Self-Powered Sensors 307
	9.5.4	High Voltage Power Supply 308
		References 310
	10	Porous Polymers for Solar Steam Generation 315
	10.1	Overview of SSG 315
	10.1.1	Solar Evaporation-Based Desalination Methods 315
	10.1.2	Key Elements in an SSG System 317
	10.1.3	Porous Polymers for SSG 317
	10.2	Energy Conversion in SSG 318
	10.3	Characterization of Solar Steam Generator 320
	10.3.1	SSG Experiments 320
	10.3.2	Preparation of Simulated Wastewater and Artificial Seawater 321
	10.3.3	Water Evaporation Rate 321
	10.3.4	Light Absorption 322
	10.3.5	Surface Temperature 323
	10.3.6	Salt Resistance 323
	10.4	Structural Design for Enhancing SSG Performance 323
	10.4.1	Boosting the Light Absorption Characteristics 323
	10.4.2	Suppressing Heat Loss in Porous Polymers Systems 325
	10.4.3	Fast Water Transport of Porous Polymers 326
	10.4.4	Salt Resistance of Porous Polymers 328

Index 337