Smart Materials for Advanced Environmental Applications

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# Contents

## Chapter 1  Introduction

_Lianbin Zhang and Peng Wang_

References 15

## Chapter 2  Smart Materials as Forward Osmosis Draw Solutes

_Shucheng Chen and Xianmao Lu_

2.1 Introduction 19

2.2 Hydrophilic Magnetic Nanoparticles 24

2.3 Stimuli-Responsive Magnetic Nanoparticles 29

2.3.1 Introduction 29

2.3.2 Thermo-Responsive Magnetic Nanoparticles 30

2.3.3 Other Stimuli-Responsive Magnetic Nanoparticles as Potential FO Draw Solutes 31

2.4 Smart Polyelectrolytes and Solvents 35

2.4.1 Introduction 35

2.4.2 Thermo-Responsive Polyelectrolytes 35

2.4.3 CO₂ Switchable Dual Responsive Polymers 37

2.4.4 Switchable Polarity Solvents 39

2.5 Smart Hydrogels 40

2.5.1 Introduction 40

2.5.2 Synthetic Methods and FO Performance 42

2.5.3 Dewatering Method and Performance 44

2.6 Conclusions and Future Perspectives 45

References 46
Chapter 3  Superwetting Nanomaterials for Advanced Oil/Water Separation: From Absorbing Nanomaterials to Separation Membranes  
Shoujian Gao and Jian Jin

3.1 Introduction  51
3.2 How to Construct Nanomaterials with Superwetting Surfaces  53
  3.2.1 Theoretical Basis of Wettability of Solid Materials  53
  3.2.2 Theoretical Principle to Construct Superwetting Nanomaterials  56
  3.2.3 Natural and Artificial Examples of Superwetting Nanomaterials  57
3.3 Superwetting Absorbing Nanomaterials for Separation of Free Oil/Water Mixtures  61
  3.3.1 Sponge- and Foam-Based Superwetting Absorbing Nanomaterials  62
  3.3.2 Textile-Based Superwetting Absorbing Nanomaterials  69
3.4 Superwetting Separation Membranes for Oil/Water Separation  70
  3.4.1 Mesh- and Textile-Based Superwetting Films for Separation of Oil/Water-Free Mixtures and Emulsions  70
  3.4.2 Polymer-Dominated Superwetting Filtration Membranes for Separation of Oil/Water Emulsions  75
  3.4.3 Nanomaterial-Based Ultrathin Superwetting Films for Separation of Oil/Water Emulsions  81
3.5 Summary and Perspective  84
References  85

Chapter 4  Responsive Particle-Stabilized Emulsions: Formation and Applications  91
Man-hin Kwok and To Ngai

4.1 Introduction  91
4.2 Particulate Emulsion Stabilizer  92
  4.2.1 The Stabilization of an Emulsion  92
  4.2.2 Special Features About Particulate Emulsion Stabilizers  94
4.3 Categories of Particles  102
  4.3.1 Inorganic Particles  102
  4.3.2 Biological Particles  104
## Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.3 Polymeric Particles (Synthetic) and Microgel Dispersions</td>
<td>106</td>
</tr>
<tr>
<td>4.3.4 Janus Particles</td>
<td>110</td>
</tr>
<tr>
<td>4.4 Responsiveness of Emulsions</td>
<td>112</td>
</tr>
<tr>
<td>4.4.1 Thermal Stimulation</td>
<td>112</td>
</tr>
<tr>
<td>4.4.2 pH Stimulation</td>
<td>115</td>
</tr>
<tr>
<td>4.4.3 Magnetic Stimulation</td>
<td>121</td>
</tr>
<tr>
<td>4.4.4 Other Stimulations</td>
<td>124</td>
</tr>
<tr>
<td>4.5 Applications</td>
<td>127</td>
</tr>
<tr>
<td>4.5.1 Pharmaceutical Applications</td>
<td>127</td>
</tr>
<tr>
<td>4.5.2 Petroleum Industry</td>
<td>128</td>
</tr>
<tr>
<td>4.5.3 Extraction</td>
<td>129</td>
</tr>
<tr>
<td>4.5.4 Catalysis</td>
<td>130</td>
</tr>
<tr>
<td>4.5.5 Pickering Emulsion Polymerization</td>
<td>132</td>
</tr>
<tr>
<td>4.6 Concluding Remarks</td>
<td>133</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>134</td>
</tr>
<tr>
<td>References</td>
<td>134</td>
</tr>
<tr>
<td>Chapter 5 Intrinsic Self-Healing Polymeric Materials for Engineering and Environmental Applications Lin Li, Jingsi Chen, Bin Yan, and Hongbo Zeng</td>
<td></td>
</tr>
<tr>
<td>5.1 Introduction</td>
<td>139</td>
</tr>
<tr>
<td>5.2 Self-Healing Polymeric Materials via Reversible Bond Formation</td>
<td>140</td>
</tr>
<tr>
<td>5.2.1 Self-Healing Polymeric Materials via Dynamic Covalent Bonding</td>
<td>140</td>
</tr>
<tr>
<td>5.2.2 Self-Healing Polymeric Materials via Supramolecular Chemistry</td>
<td>143</td>
</tr>
<tr>
<td>5.3 Mussel-Inspired Self-Healing Polymeric Materials</td>
<td>150</td>
</tr>
<tr>
<td>5.3.1 Catechol-Mediated Interactions</td>
<td>151</td>
</tr>
<tr>
<td>5.3.2 Histidine-Metal Coordination</td>
<td>156</td>
</tr>
<tr>
<td>5.4 Case Studies of Self-Healing Polymeric Materials for Environmental Applications</td>
<td>157</td>
</tr>
<tr>
<td>5.5 Conclusions and Outlook</td>
<td>159</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>159</td>
</tr>
<tr>
<td>References</td>
<td>159</td>
</tr>
<tr>
<td>Chapter 6 Biomimetic Materials for Efficient Atmospheric Water Collection Lianbin Zhang and Peng Wang</td>
<td></td>
</tr>
<tr>
<td>6.1 Introduction</td>
<td>165</td>
</tr>
<tr>
<td>6.2 Desert Beetle-Inspired Surface with Patterned Wettability for Fog Collection</td>
<td>167</td>
</tr>
</tbody>
</table>
6.2.1 Introduction 167
6.2.2 Traditional Lithographic Methods for the Fabrication of Biomimetic Patterned Surfaces for Fog Collection 168
6.2.3 Direct Methods for Creating Patterned Wettability for Fog Harvesting 171
6.3 Spider Silk-Inspired Fibers for Atmospheric Water Collection 174
6.4 Desert Plants-Inspired Water Collection 176
6.5 Summary and Outlook 180
References 181

Chapter 7 “Slippery” Liquid-Infused Surfaces Inspired by Nature 185
Nicole S. Zacharia

7.1 Introduction and Background 185
7.1.1 Introduction 185
7.1.2 Background and Biomimetic Inspiration 186
7.1.3 Introduction of the SLIPS Concept 189
7.2 Self-Cleaning SLIPS Surfaces 191
7.3 More Than Omniphobicity: Extra Functionality 194
7.3.1 SLIPS for Anti-Icing Surfaces 194
7.3.2 SLIPS for Anti-Fouling Surfaces 196
7.3.3 Beyond Slippery Surfaces 198
7.4 Thermodynamics and Stability 200
7.4.1 Thermodynamic Description of SLIPS Surfaces 200
7.4.2 Stability of SLIPS Surfaces 203
7.5 Conclusions and Outlook 205
References 206

Chapter 8 Challenges and Opportunities of Superhydrophobic/ Superamphiphobic Coatings in Real Applications 209
Maxime Paven, Lena Mammen, and Doris Vollmer

8.1 Wetting 209
8.1.1 Rough Surface: Wenzel’s and Cassie’s Models 210
8.1.2 Laser Scanning Confocal Microscopy (LSCM) 212
8.1.3 Superhydrophobicity 214
8.1.4 Superamphiphobicity 217
8.1.5 Fabrication of Superamphiphobic Surfaces 218
8.1.6 Stability of the Cassie State 220
Contents

8.2 Potential Applications
  8.2.1 PolymericParticles in the mm to μm Range 228
  8.2.2 Particle Synthesis via Tuning Temperature 228
  8.2.3 Particle Synthesis via Radical Polymerization 231
  8.2.4 Protein and Cell Adhesion on Superamphiphobic Layers 232
  8.2.5 Superamphiphobic Membranes 235
  8.2.6 Fog Harvesting 237

8.3 Challenges 238
Acknowledgements 239
References 239

Subject Index 244
Preface

Water pollution and water scarcity are among the most severe grand environmental challenges facing mankind nowadays. With rapid population growth, steadily improving living standards, fast industrialization and modernization of the developing countries, these challenges will persist, if not worsen, in the years to come. Conventional water treatment technologies, including adsorption, chemical treatment, membrane-based filtration, biological treatment, etc., with no doubt have made critical contributions in sustaining human society in the past century. However, the ever-increasing demand for safe and clean water by the ever-growing human population has gradually pushed these conventional technologies to their limits over the past 100 years or so. Therefore, it is now a popular perception that the solutions to existing and future environmental problems highly hinge on further developments in materials science.

The concept of smart materials, since its inception in 1990s, has extended its presence in a variety of applications and has led to development of many new technologies. Smart materials are conventionally defined as materials that are designed to have one or more properties which can be significantly changed in a controlled fashion in response to external stimuli, such as stress, temperature, moisture, pH, electric fields or magnetic fields. Piezoelectric materials and shape-memory materials were the early types of smart materials. However, in essence, the response mechanism of all smart materials lies in the change in molecular movement in response to external stimuli, which then brings about the macroscopic property change of the materials. Following this line of thought, the origin of all smart materials is biomimicry as nature is the ultimate builder of machines. Thus, smart materials can also be generically defined as materials which are astute or “operating as if by intelligence”, and the term “smart materials” can thus be used broadly...
Preface

to refer to materials that are designed and fabricated from bioinspirations, mimicking nature’s procedures, structures or strategies.

The concept of smartness in materials design involves thinking outside the box and integrates multiple synergistic and advanced functions into one single material or device, which helps create new applications, broaden existing applications, enhance performances, and elongate the lifetime of the materials. Therefore, the development of smart materials represents the future of materials design and fabrication. It is not a surprise that smart materials have also set foot in the environmental field, and have shown great promise in coming up with novel and next-generation solutions to the large environmental challenges. In return, the interaction between environmental science and materials science has also promoted the development of new smart materials, and a series of novel smart materials and their application in environmental areas have been put forward and explored.

However, this book is not intended to be exhaustive about all areas of smart material applications to advanced environmental problem solving. Rather, it focuses on some selected topics, especially bioinspired smart interfacial materials, which I believe are novel and inspirational to conventional thinking. As you will see, the topics of the book chapters are truly multidisciplinary. They span from an introduction to smart materials and their applications (Chapter 1, Zhang and Professor Wang), smart draw solutions in forward osmosis (Chapter 2, Chen and Professor Lu), superwetting materials for oil–water separation (Chapter 3, Gao and Professor Jin), responsive particle-stabilized emulsions (Chapter 4, Kwok and Professor Ngai), self-healing materials (Chapter 5, Professor Zeng et al.), bioinspired fog collection (Chapter 6, Zhang and Professor Wang), nature-inspired “slippery” liquid-infused surfaces (Chapter 7, Professor Zacharia) to challenges and opportunities of superhydrophobic/superamphiphobic coatings in real applications (Chapter 8, Paven, Mammen and Professor Vollmer). The contributors are all established researchers who are in their early or mid career. In my opinion, they are the ones to watch in the years to come in this emerging field of smart materials and their applications to environmental problem solving.

I hope this book will provide an inspiration for readers who are interested in smart materials and who are passionate at further exploring smart materials to make contributions to the solutions to our grand environmental challenges.

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