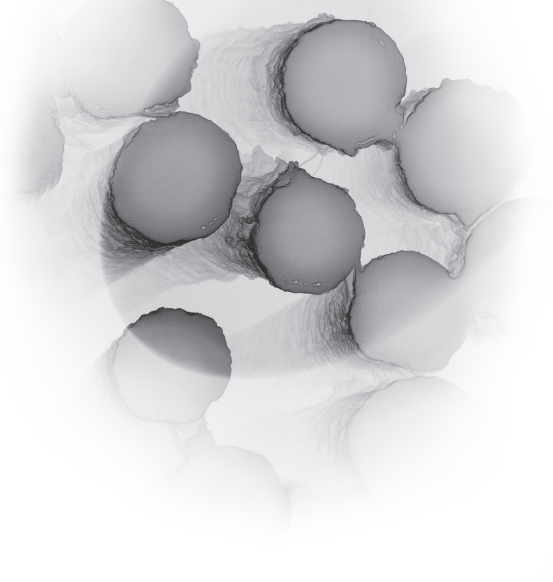
The background of the cover is a scanning electron micrograph (SEM) showing several large, spherical, and somewhat irregular nanoporous structures. These structures have a bright, glowing orange-yellow center and a darker, textured outer shell, giving them a three-dimensional appearance. They are set against a dark, almost black background.

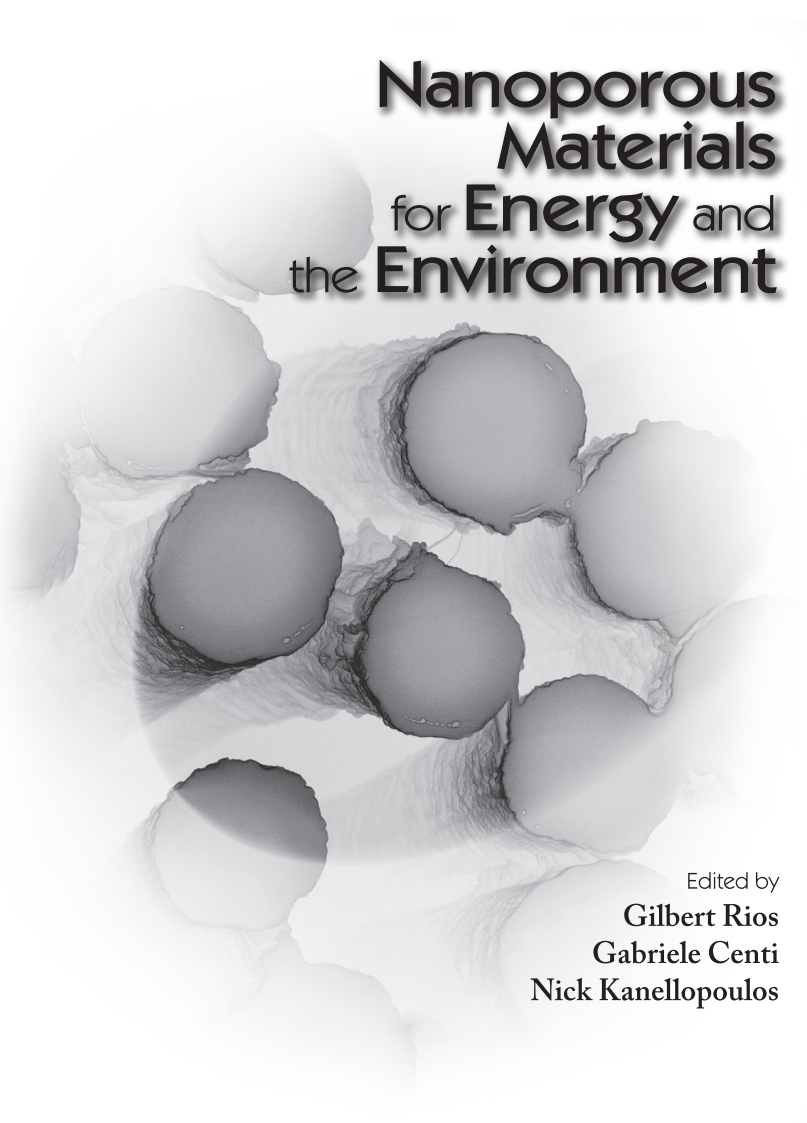
Nanoporous Materials for Energy and the Environment

Edited by
Gilbert Rios
Gabriele Centi
Nick Kanellopoulos



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Contents

<i>Preface</i>	xi
<i>Acknowledgments</i>	xv
1 Self-Organized Hybrid Membranes: Toward a Supramolecular Proton Conduction Function	1
1.1 Self-Organized Hybrid Membranes	2
1.2 Supramolecular Proton-Conduction Function	5
1.3 A Selected Application: PEMs	6
1.4 Conclusions	9
2 Design and Applications of Multifunctional Catalysts Based on Inorganic Oxides	13
2.1 Heterogeneous Multifunctional Catalyst: One System for Several Transformations	13
2.2 Design and Preparation of Multifunctional Catalysts	15
2.3 Multifunctional Catalysts in Chemical Synthesis	21
2.4 Relevant Examples	22
2.4.1 <i>Concerted Catalysis</i>	22
2.4.1.1 Catalytic reactions occurring on acid–base bifunctional heterogeneous catalysts	22
2.4.1.2 Bifunctional catalysts for Heck reactions	29
2.4.1.3 Other examples of concerted catalysis	30
2.4.2 <i>Tandem Catalysis</i>	31
2.5 Concluding Remarks	43

3	Use of Chemometric Analysis in the Characterization of the Adsorption Properties of Nanoporous Solids	55
3.1	Overview	55
3.2	Introduction	56
3.3	Experimental	59
3.4	Results and Discussion	59
4	Molecular Modeling and Polymer Behavior	71
4.1	Introduction	71
4.2	Force Fields	72
4.3	Realization of Amorphous Packing Models	77
4.4	Characterization of Polymer Structure and Behavior from Atomistic Simulations	80
4.4.1	<i>Characterization of Free Volume and Its Distribution in Glassy Polymers</i>	81
4.4.2	<i>Mobility of Polymer Matrix and Diffusion of Small Molecules</i>	85
4.5	Summary	88
5	Modeling of Gas Transport Properties and its use for Structural Characterization of Mesoporous Solids	91
5.1	Introduction	91
5.2	Dilute Nonadsorbed Gas Flow (Knudsen Regime)	92
5.2.1	<i>Capillary Bundle Models</i>	93
5.2.2	<i>Heteroporous Network Model</i>	94
5.2.2.1	Relative gas permeability	95
5.2.3	<i>Macroscopic Modeling</i>	96
5.2.3.1	Systematic permeation time-lag analysis	97
5.2.3.2	Interpretation of helium permeation data	99
5.3	Dilute Adsorbable Gas Flow (Henry Law Adsorption Region)	102
5.3.1	<i>Heteroporous Network Model with Conventional Physics of Flow</i>	102
5.3.2	<i>Advanced Modeling of the Physics of Flow</i>	104
5.4	Vapor Transport in the Multilayer Adsorption Region	107

6	Membrane Modeling and Simulation Across Scales	113
6.1	Introduction to Multiscale Modeling	113
6.2	Mechanisms of Transport in Membranes	116
6.3	Atomistic Reconstruction of Inorganic Membrane Materials	117
6.4	Simulation of Sorption	118
6.5	Simulation of Diffusion: Molecular Dynamics	119
6.6	Coarse Graining: “Reduced Representations”	120
6.7	Mesosopic Scale Modeling of Membrane Structure	121
6.8	Simulation of Diffusion at the Mesoscopic Scale	124
6.9	Lattice-Boltzmann Method	127
6.10	Direct Simulation Monte Carlo Method	128
6.11	Concluding Remarks	129
7	Hybrid Modeling of Membrane Processes	133
7.1	Overview	133
7.2	Introduction	134
7.3	Why Hybrid Modeling	134
7.4	Hybrid Modeling Applied to Membrane Science and Engineering	140
7.5	Selected Case Studies	141
7.5.1	<i>Solvent-Resistant NF</i>	141
7.5.2	<i>Membrane Bioreactors</i>	148
7.6	Future Trends and Challenges	153
8	Membranes for Energy	157
8.1	Clean Refineries	160
8.2	Zero Emission Coal Plants	162
8.3	Fuel Cells	164
8.4	Electrolysis and Water Splitting	166
8.5	Batteries	167
8.6	Osmotic Power	167
9	Carbon Nanotubes for Energy Applications	173
9.1	CNTs for LIB Application	174
9.1.1	<i>Lithium-Ion Storage in CNTs</i>	175
9.1.2	<i>CNTs as Active Materials for Electrode</i>	177

9.1.3	<i>CNTs as Additive Materials for Electrodes</i>	179
9.1.4	<i>CNTs-Based Composites Materials for Electrodes</i>	180
9.2	CNTs for Supercapacitor Application	182
9.2.1	<i>CNTs as Active Materials for Supercapacitors</i>	183
9.2.2	<i>CNT-Based Composite Materials for Supercapacitors</i>	185
9.2.3	<i>Pseudocapacitance of CNTs and CNT-Based Materials</i>	186
9.3	CNTs in Polymer Electrolyte Membrane Fuel Cells	186
9.3.1	<i>Role of Defects and Surface Characteristics in CNTs</i>	190
9.3.2	<i>Role of Three-Phase Boundary</i>	193
9.4	Conclusions and Outlooks	194
10	Ceramic Membranes for Gas Treatment and Separation	203
10.1	Materials and Architectures	205
10.2	Applications	209
10.2.1	<i>Membranes for Gas Separation</i>	209
10.2.1.1	Microporous membranes	209
10.2.1.2	Dense membranes for transport of O_2 and H_2	212
10.2.2	<i>Particle Filters</i>	215
10.3	Applications Involving Multifunctional Materials or Devices	218
10.3.1	<i>General Considerations on Membrane Reactors</i>	218
10.3.2	<i>Membrane Reactors with Catalytic Ceramic Membranes</i>	221
10.3.2.1	Catalyst dispersed in an inert porous membrane	222
10.3.2.2	Inherently catalytic membranes	223
10.3.2.3	Photocatalytic membranes	224
10.3.3	<i>Other Multifunctional Devices Involving Ceramic Membranes</i>	225
10.3.3.1	Catalytic particle filters for Diesel engine exhaust gas treatment	225

10.3.3.2 Ceramic membranes with adsorptive properties	227
10.4 Conclusion	228
11 Multifunctional Membranes Based on Photocatalytic Nanomaterials	231
11.1 Basic Principles on Photocatalysis and Membranes	232
11.2 TiO ₂ Anatase-Based Membranes	237
11.2.1 <i>Experimental Details</i>	237
11.2.2 <i>Results and Discussion</i>	239
11.2.2.1 Mesoporous anatase membranes: Configuration 1	243
11.2.2.2 Photoactive supports: Configuration 2	245
11.3 ZnO-Based Membranes	246
11.3.1 <i>Experimental Details</i>	247
11.3.2 <i>Results and Discussion</i>	248
11.3.2.1 Membrane properties	249
11.3.2.2 Photoactivity	250
11.4 Membrane Shaping and Integration	251
11.5 Conclusion	252
12 Nanostructured Titania Thin Films for Solar Use in Energy Applications	257
12.1 Requirements of Titania Photoanode for PEC Solar Cells	258
12.2 Preparation and Photoresponse of Titania Nanotube Ordered Arrays	261
12.2.1 <i>Role of the Nanostructure</i>	263
12.2.2 <i>Visible Light Absorption</i>	267
12.3 Titania Nanomembrane	272
12.4 Titania Nanostructured Films for DSC Applications	274
12.5 Conclusions and Outlooks	276
13 Inorganic Membrane Reactors for Energy Applications	283
13.1 Pd Membrane Reactors for Hydrogen Production	284
13.2 Oxygen Selective Membrane Reactors	287

13.3 Other Developments	288
13.4 Recent Developments at the University of Zaragoza	289
13.4.1 <i>Glycerol Upgrading</i>	289
13.4.2 <i>Methanol Formation</i>	290
13.4.3 <i>Methane Aromatization</i>	291
13.5 Conclusions	294
<i>Index</i>	299

Preface

Energy and environment are two closely related challenges for a sustainable future. We need an increasing availability of energy that is estimated to grow worldwide from the current 16TW to approximately 25TW by 2050, while at the same time it is necessary to address the issue of decreasing the impact on the environment associated with the increase of the energy production. To this end, a step enhancement in the introduction of breakthrough technologies is needed in the field of energy production, transport, and saving; of clean production; and of environment protection. At the core of these technologies and processes is the development of novel materials, such as catalysts, membranes, adsorbents, and advanced coatings. Most of the aforementioned materials are nanoporous because the presence of pores and interfaces induces unique properties in these materials, which are not present in the corresponding bulk materials.

The applications of these materials are very important and they already represent a very huge market of several tenths billion euros, covering aspects such as the following:

- Environmental separations, e.g., CH_4 and H_2 storage, N_2/CH_4 separation from natural gas, and NO_x removal
- Clean energy production and storage, e.g., H_2 production with CO_2 sequestration and porous electrodes for fuel cells
- Catalysis and photocatalysis, e.g., catalysis in refinery and chemical processes, catalytic purification of auto exhaust emissions, TiO_2 for new water treatment systems or in indoor/outdoor air purification
- Sensors and actuators, e.g., for fast and reliable gas detection

- Biological applications, e.g., new ways of controlling proteins, cells, and tissue interaction by tailoring the material topography and the spatial distribution of functional groups, more efficient bioseparations, enzymatic transformation of raw substances into high value products, and drug delivery systems with considerably improved properties

Nanoporous materials are a subset of porous materials, with pore diameters ranging from 1 to 100 nm. Among the more relevant properties of these materials are the high surface to volume ratio and the large porosity with a very ordered uniform nanoporous structure. A large part of inorganic nanoporous materials are made from oxides. They are often nontoxic, inert, and chemically and thermally stable even in extreme conditions. What makes these materials so fascinating and so attractive is the possibility to get various functionalities and properties by tailoring their nanostructure and their internal surface properties.

Developing these materials properly and making possible their production at an industrial level need new engineering concepts and novel characterization methods. It is also worth keeping in mind that a strong commitment to fully develop the desired functionalities is to develop effective control of system/process working conditions by applying novel concepts in the fields of nanofluidics, transport and reaction phenomena, characterization, modeling, and simulation.

It is thus evident that in addition to the design, the behavior of the nanoporous materials and the nanostructure changes during their application as a sequel of their interaction with the reaction medium are also crucial. To this end, there is a need to combine expertise ranging from the chemistry and science of materials to the material and system engineering, passing through the experimentation of their performances.

The achievement of the performance criteria — high adsorption capacity, high selectivity, favorable adsorption kinetics, excellent mechanical properties, good stability and durability in use, etc. — requires effective monitoring and controlling of the evolution of their properties during their synthesis. In addition, accounting for the high performance of the material as soon as the manufacturing

process seems essential, this requires the application of novel methodologies that cap all of the length scales and even time scales.

From the aforementioned discussion it is clear that there is a need for strongly integrated and holistic approaches, involving many disciplines, skills, and know-how. Favoring the integration rather than the simple addition of competencies, as well as the loop schemes to the detriment of linear production processes, must also be a strong commitment in order to be able to realize a control system/process intensification by optimizing the whole chain from the molecular to the plant level. It is actually a strong paradigm of the think-tank on which our new economy of knowledge will be based.

Addressing the societal challenges for sustainable energy and environment protection by developing novel nanoporous materials is thus a very complex and multidisciplinary problem, which requires integration of a very broad range of knowledge and expertise in a novel vision and novel way of cooperation.

This is exactly the ambition and the aim of the three “complementary” Networks of Excellence (EC-FP6 – NMP’s priority) and their Durable Integrated Structure (DIS):

- NanoMemPro/European Membrane House (EMH/Membranes)
- IDECAT/European Research Institute on Catalysis (ERIC/Catalysis)
- Inside Pores/European Nanoporous Materials’ Institute of Excellence (ENMIX/Nanoporous materials)

The major objective of combining their complementary capabilities and competencies is the establishment of a world-class pole of excellence in the broad field of developing novel nanoporous materials and related processes for energy, environment, and other novel applications.

This book is a first result of this collaboration and it is based on a selection of contributions presented during 1st International Workshop on NanoPorous Material for Energy and Environment organized in Chania, Crete, 12–15 October 2008, which was organized by the three NoEs. The different chapters cover some of the key aspects of the broad topic of nanoporous materials for novel technologies, systems, and processes for clean and more efficient use of

energy and environment protection. They also provide an example of the necessary, different interdisciplinary competencies, ranging from modeling to materials development and testing. The chapters are written by well-known experts in these fields, with the objective to first introduce the topic for a broader audience and then provide the new trends and developments in the area. The book may be thus used both for teaching specialized courses and for providing a concise overview of the perspectives and opportunities in the field to scientists and managers involved in the fields relevant to nanoporous materials.

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