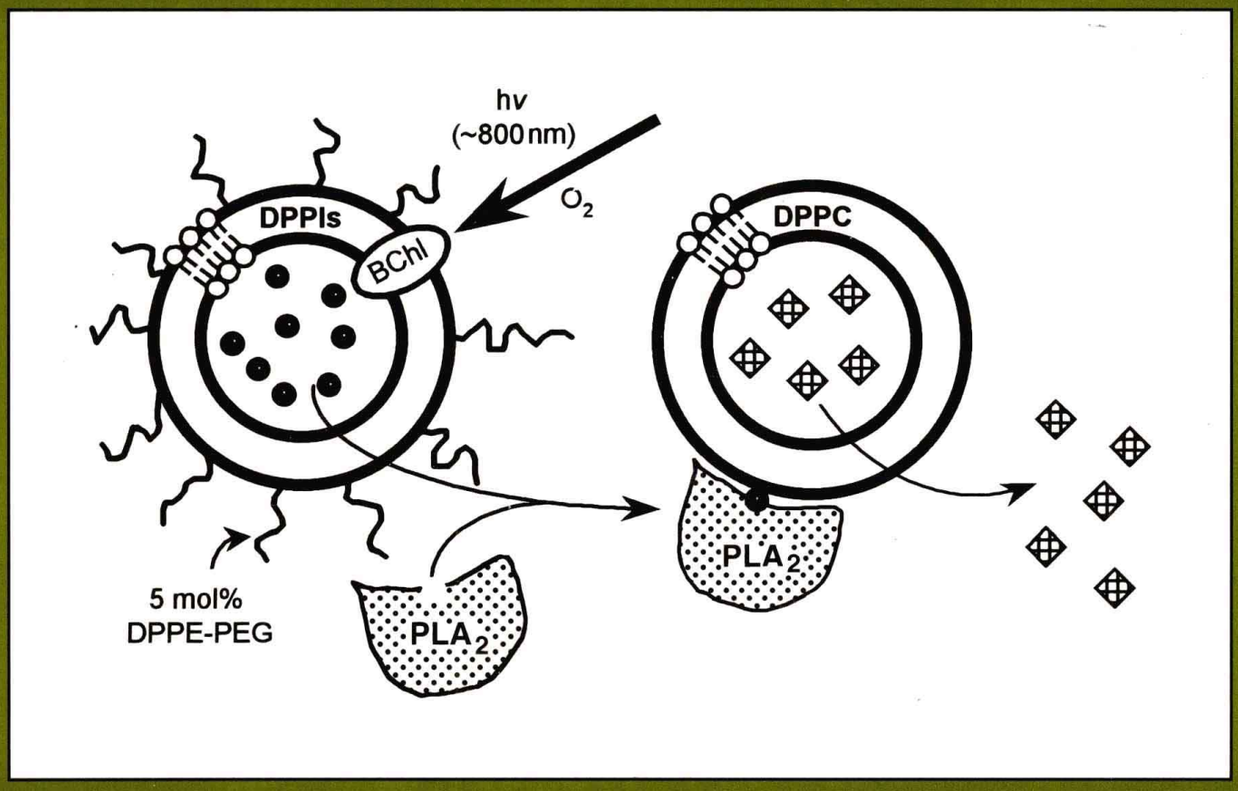
surfactant science series
volume 100

REACTIONS AND SYNTHESIS IN SURFACTANT SYSTEMS



edited by
John Texter

REACTIONS AND SYNTHESIS IN SURFACTANT SYSTEMS

REACTIONS AND SYNTHESIS IN SURFACTANT SYSTEMS

edited by

John Texter

Strider Research Corporation
Rochester, New York

MARCEL DEKKER, INC.

NEW YORK • BASEL

SURFACTANT SCIENCE SERIES

Library of Congress Cataloging-in-Publication Data

Reactions and synthesis in surfactant systems/edited by John Texter.
p. cm.—(Surfactant science series ; 100)
Includes index.
ISBN 0-8247-0255-7 (acid-free paper)
1. Surface active agents. 2. Surface chemistry. I. Texter, J. (John) II. Surfactant science series ; v. 100.

TP994 .R42 2001
668′.1—dc21

2001028628

This book is printed on acid-free paper.

Headquarters
Marcel Dekker, Inc.
270 Madison Avenue, New York, NY 10016
tel: 212-696-9000; fax: 212-685-4540

Eastern Hemisphere Distribution
Marcel Dekker AG
Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland
tel: 41-61-261-8482; fax: 41-61-261-8896

World Wide Web
http://www.dekker.com

The publisher offers discounts on this book when ordered in bulk quantities. For more information, write to Special Sales/ Professional Marketing at the headquarters address above.

Current printing (last digit):
10 9 8 7 6 5 4 3 2 1

PRINTED IN THE UNITED STATES OF AMERICA

1. Nonionic Surfactants, *edited by Martin J. Schick* (see also Volumes 19, 23, and 60)
2. Solvent Properties of Surfactant Solutions, *edited by Kozo Shinoda* (see Volume 55)
3. Surfactant Biodegradation, *R. D. Swisher* (see Volume 18)
4. Cationic Surfactants, *edited by Eric Jungermann* (see also Volumes 34, 37, and 53)
5. Detergency: Theory and Test Methods (in three parts), *edited by W. G. Cutler and R. C. Davis* (see also Volume 20)
6. Emulsions and Emulsion Technology (in three parts), *edited by Kenneth J. Lissant*
7. Anionic Surfactants (in two parts), *edited by Warner M. Linfield* (see Volume 56)
8. Anionic Surfactants: Chemical Analysis, *edited by John Cross*
9. Stabilization of Colloidal Dispersions by Polymer Adsorption, *Tatsuo Sato and Richard Ruch*
10. Anionic Surfactants: Biochemistry, Toxicology, Dermatology, *edited by Christian Gloxhuber* (see Volume 43)
11. Anionic Surfactants: Physical Chemistry of Surfactant Action, *edited by E. H. Lucassen-Reynders*
12. Amphoteric Surfactants, *edited by B. R. Bluestein and Clifford L. Hilton* (see Volume 59)
13. Demulsification: Industrial Applications, *Kenneth J. Lissant*
14. Surfactants in Textile Processing, *Arved Datyner*
15. Electrical Phenomena at Interfaces: Fundamentals, Measurements, and Applications, *edited by Ayao Kitahara and Akira Watanabe*
16. Surfactants in Cosmetics, *edited by Martin M. Rieger* (see Volume 68)
17. Interfacial Phenomena: Equilibrium and Dynamic Effects, *Clarence A. Miller and P. Neogi*
18. Surfactant Biodegradation: Second Edition, Revised and Expanded, *R. D. Swisher*
19. Nonionic Surfactants: Chemical Analysis, *edited by John Cross*
20. Detergency: Theory and Technology, *edited by W. Gale Cutler and Erik Kissa*
21. Interfacial Phenomena in Apolar Media, *edited by Hans-Friedrich Eicke and Geoffrey D. Parfitt*
22. Surfactant Solutions: New Methods of Investigation, *edited by Raoul Zana*
23. Nonionic Surfactants: Physical Chemistry, *edited by Martin J. Schick*
24. Microemulsion Systems, *edited by Henri L. Rosano and Marc Clausse*
25. Biosurfactants and Biotechnology, *edited by Naim Kosaric, W. L. Cairns, and Neil C. C. Gray*
26. Surfactants in Emerging Technologies, *edited by Milton J. Rosen*
27. Reagents in Mineral Technology, *edited by P. Somasundaran and Brij M. Moudgil*
28. Surfactants in Chemical/Process Engineering, *edited by Darsh T. Wasan, Martin E. Ginn, and Dinesh O. Shah*
29. Thin Liquid Films, *edited by I. B. Ivanov*
30. Microemulsions and Related Systems: Formulation, Solvency, and Physical Properties, *edited by Maurice Bourrel and Robert S. Schechter*
31. Crystallization and Polymorphism of Fats and Fatty Acids, *edited by Nissim Garti and Kiyotaka Sato*
32. Interfacial Phenomena in Coal Technology, *edited by Gregory D. Botsaris and Yuli M. Glazman*
33. Surfactant-Based Separation Processes, *edited by John F. Scamehorn and Jeffrey H. Harwell*
34. Cationic Surfactants: Organic Chemistry, *edited by James M. Richmond*
35. Alkylene Oxides and Their Polymers, *F. E. Bailey, Jr., and Joseph V. Koleske*
36. Interfacial Phenomena in Petroleum Recovery, *edited by Norman R. Morrow*
37. Cationic Surfactants: Physical Chemistry, *edited by Donn N. Rubingh and Paul M. Holland*
38. Kinetics and Catalysis in Microheterogeneous Systems, *edited by M. Grätzel and K. Kalyanasundaram*
39. Interfacial Phenomena in Biological Systems, *edited by Max Bender*
40. Analysis of Surfactants, *Thomas M. Schmitt* (see Volume 96)

41. Light Scattering by Liquid Surfaces and Complementary Techniques, *edited by Dominique Langevin*
42. Polymeric Surfactants, *Irja Piirma*
43. Anionic Surfactants: Biochemistry, Toxicology, Dermatology. Second Edition, Revised and Expanded, *edited by Christian Gloxhuber and Klaus Künstler*
44. Organized Solutions: Surfactants in Science and Technology, *edited by Stig E. Friberg and Björn Lindman*
45. Defoaming: Theory and Industrial Applications, *edited by P. R. Garrett*
46. Mixed Surfactant Systems, *edited by Keizo Ogino and Masahiko Abe*
47. Coagulation and Flocculation: Theory and Applications, *edited by Bohuslav Dobiáš*
48. Biosurfactants: Production • Properties • Applications, *edited by Naim Kosaric*
49. Wettability, *edited by John C. Berg*
50. Fluorinated Surfactants: Synthesis • Properties • Applications, *Erik Kissa*
51. Surface and Colloid Chemistry in Advanced Ceramics Processing, *edited by Robert J. Pugh and Lennart Bergström*
52. Technological Applications of Dispersions, *edited by Robert B. McKay*
53. Cationic Surfactants: Analytical and Biological Evaluation, *edited by John Cross and Edward J. Singer*
54. Surfactants in Agrochemicals, *Tharwat F. Tadros*
55. Solubilization in Surfactant Aggregates, *edited by Sherril D. Christian and John F. Scamehorn*
56. Anionic Surfactants: Organic Chemistry, *edited by Helmut W. Stache*
57. Foams: Theory, Measurements, and Applications, *edited by Robert K. Prud'homme and Saad A. Khan*
58. The Preparation of Dispersions in Liquids, *H. N. Stein*
59. Amphoteric Surfactants: Second Edition, *edited by Eric G. Lomax*
60. Nonionic Surfactants: Polyoxyalkylene Block Copolymers, *edited by Vaughn M. Nace*
61. Emulsions and Emulsion Stability, *edited by Johan Sjöblom*
62. Vesicles, *edited by Morton Rosoff*
63. Applied Surface Thermodynamics, *edited by A. W. Neumann and Jan K. Spelt*
64. Surfactants in Solution, *edited by Arun K. Chattopadhyay and K. L. Mittal*
65. Detergents in the Environment, *edited by Milan Johann Schwuger*
66. Industrial Applications of Microemulsions, *edited by Conxita Solans and Hironobu Kunieda*
67. Liquid Detergents, *edited by Kuo-Yann Lai*
68. Surfactants in Cosmetics: Second Edition, Revised and Expanded, *edited by Martin M. Rieger and Linda D. Rhein*
69. Enzymes in Detergency, *edited by Jan H. van Ee, Onno Misset, and Erik J. Baas*
70. Structure–Performance Relationships in Surfactants, *edited by Kunio Esumi and Minoru Ueno*
71. Powdered Detergents, *edited by Michael S. Showell*
72. Nonionic Surfactants: Organic Chemistry, *edited by Nico M. van Os*
73. Anionic Surfactants: Analytical Chemistry, Second Edition, Revised and Expanded, *edited by John Cross*
74. Novel Surfactants: Preparation, Applications, and Biodegradability, *edited by Krister Holmberg*
75. Biopolymers at Interfaces, *edited by Martin Malmsten*
76. Electrical Phenomena at Interfaces: Fundamentals, Measurements, and Applications, Second Edition, Revised and Expanded, *edited by Hiroyuki Ohshima and Kunio Furusawa*
77. Polymer-Surfactant Systems, *edited by Jan C. T. Kwak*
78. Surfaces of Nanoparticles and Porous Materials, *edited by James A. Schwarz and Cristian I. Contescu*
79. Surface Chemistry and Electrochemistry of Membranes, *edited by Torben Smith Sørensen*
80. Interfacial Phenomena in Chromatography, *edited by Emile Pefferkorn*

81. Solid–Liquid Dispersions, *Bohuslav Dobiáš, Xueping Qiu, and Wolfgang von Rybinski*
82. Handbook of Detergents, *editor in chief: Uri Zoller*
    Part A: Properties, *edited by Guy Broze*
83. Modern Characterization Methods of Surfactant Systems, *edited by Bernard P. Binks*
84. Dispersions: Characterization, Testing, and Measurement, *Erik Kissa*
85. Interfacial Forces and Fields: Theory and Applications, *edited by Jyh-Ping Hsu*
86. Silicone Surfactants, *edited by Randal M. Hill*
87. Surface Characterization Methods: Principles, Techniques, and Applications, *edited by Andrew J. Milling*
88. Interfacial Dynamics, *edited by Nikola Kallay*
89. Computational Methods in Surface and Colloid Science, *edited by Małgorzata Borówko*
90. Adsorption on Silica Surfaces, *edited by Eugène Papirer*
91. Nonionic Surfactants: Alkyl Polyglucosides, *edited by Dieter Balzer and Harald Lüders*
92. Fine Particles: Synthesis, Characterization, and Mechanisms of Growth, *edited by Tadao Sugimoto*
93. Thermal Behavior of Dispersed Systems, *edited by Nissim Garti*
94. Surface Characteristics of Fibers and Textiles, *edited by Christopher M. Pastore and Paul Kiekens*
95. Liquid Interfaces in Chemical, Biological, and Pharmaceutical Applications, *edited by Alexander G. Volkov*
96. Analysis of Surfactants: Second Edition, Revised and Expanded, *Thomas M. Schmitt*
97. Fluorinated Surfactants and Repellents: Second Edition, Revised and Expanded, *Erik Kissa*
98. Detergency of Specialty Surfactants, *edited by Floyd E. Friedli*
99. Physical Chemistry of Polyelectrolytes, *edited by Tsetska Radeva*
100. Reactions and Synthesis in Surfactant Systems, *edited by John Texter*
101. Protein-Based Surfactants: Synthesis, Physicochemical Properties, and Applications, *edited by Ifendu A. Nnanna and Jiding Xia*

ADDITIONAL VOLUMES IN PREPARATION

Chemical Properties of Material Surfaces, *Marek Kosmulski*

Oxide Surfaces, *edited by James A. Wingrave*

Interfacial Electrokinetics and Electrophoresis, *edited by Ángel V. Delgado*

Preface

This book presents a review of extant applications of surfactant technology in chemical synthesis as well as chemical reactions and catalysis. The applications and utilization of surfactants in diverse chemistries, including many areas of organic, inorganic, colloidal, surface, and materials chemistry, cover a very wide gamut. With the possible exception of the journal *Langmuir*, no single journal or professional publication ties together all these areas. It is therefore hoped that this volume will help practitioners and students increase the breadth of their appreciation of surfactant systems in various synthetic and practical applications. The burgeoning arena of template synthesis and nanotechnology indicates that major advances in nanoelectronics will not be forthcoming from further miniaturization programs, but must rely on dramatic improvements in the sophistication with which we wield molecular design and synthesis of surfactants and amphiphiles. Self-assembly principles have been clearly delineated, and the time has come to put this technology to work in chemical synthesis and processing technologies. The success of such endeavors will require closer collaboration among synthetic and physical scientists and engineers, and greater appreciation among practitioners in one discipline for the opportunities and limitations of key related disciplines.

The present volume is extremely wide in scope, covering a broad swath of organic, inorganic, surface, and colloidal chemistry and materials science united by the universal use of surfactant and amphiphile technology in each application. While the volume may seem too synthetic for some readers and too physical for others, it is intended to bring together many related areas and to facilitate closer collaboration between synthetic and physical practitioners in developing new applications and materials. The genesis of this broad arena is found in micellar catalysis, monolayer studies at the water–air interface, and inorganic particle precipitation. Although the general principles of monolayer formation at air–water interfaces and in self-assembled monolayers appear well defined, the controlled multilayer formation of composites, using surfactant templating and molecular recognition principles, is at an early stage in the development of practical applications and processes. Compartmentalization of reactants, as effected by self-organization in surfactant systems, is providing size and morphology control in synthesizing nanoparticulate inorganics and organics. These nanoparticulates are being incorporated into controlled arrays on mesoscales in furthering practical device development. While it was the editor's intention to cover all major application areas, some areas will regrettably have been overlooked, and for these omissions the reader is extended an apology. It is hoped that this book will stimulate readers to invent new applications areas, as naturally occurs in the bridging of disciplines.

The first of the five general parts of this volume comprises surfactant syntheses and electrochemical transformations. Part Two is basically physical–organic chemistry in surfactant systems. Included are micellar catalysis, reaction chemistry in microemulsions, electrocatalysis and electrosynthesis in various surfactant systems, and diverse applications involving emulsions, microemulsions, and vesicles. Parts Three and Four are focused on particle formation, organic and inorganic. Part Three addresses the role of surfactants in organic polymerizations and also provides a thorough review of polymerizable surfactants. Part Four examines particle formation and the role of

surfactants in compartmentalizing precipitation chemistries, such as in reverse microemulsions and at surfactant interfaces. The precipitation of inorganic nanoparticles is not treated exhaustively, since an excellent recent volume edited by Tadao Sugimoto, *Fine Particles: Synthesis, Characterization, and Mechanisms of Growth* (Volume 92 of the Surfactant Science Series) treats this topic thoroughly. Part Five addresses syntheses and processing, via self-assembly, molecular recognition, and surfactant templating, on the supramolecular level. These categories cover a variety of themes, including:

Organic chemistry as influenced by surfactants and surfactant assemblies,
The production of organic particulates by chain polymerization in surfactant systems and by polymerizable surfactants,
The synthesis of inorganic nanoparticles using compartmentalized reaction chemistry,
The synthesis of supramolecular assemblies using surfactant assemblies as templates,
The formation of multilayer composites using surfactants and other growth-directing materials.

The interdisciplinary content presented bridges numerous areas of chemistry and materials science, including colloid and surface chemistry, organic synthesis and catalysis, inorganic synthesis and catalysis, electrochemical synthesis and electrocatalysis, inorganic–organic composites, and template-directed synthesis of mesoporous materials. This interconnected bridging makes this volume of interest to chemists and materials scientists of many persuasions. This volume is aimed at practicing industrial and academic scientists and engineers and at students involved in chemical and particle synthesis and processing.

Nearly 100 contributors collaborated in producing the 40 diverse chapters of this volume. I thank each of the authors for their contributions and patience as the volume progressed. I also thank my acquisitions editor, Anita Lekhwani, for her cheerful collaboration, and our production editor, Joseph Stubenrauch, for steadfastly coaxing and urging the volume forward and onward to completion.

John Texter

Contributors

Nicholas L. Abbott Department of Chemical Engineering, University of Wisconsin–Madison, Madison, Wisconsin

Joseph Akkara* U.S. Army Soldier Systems Center, Natick, Massachusetts

Nihal Aydogan Department of Chemical Engineering, University of Wisconsin–Madison, Madison, Wisconsin

Sukanta Banerjee Department of Chemical Engineering, Tulane University, New Orleans, Louisiana

Turgut Battal Department of Chemical Engineering, The Ohio State University, Columbus, Ohio

Ansgar Behler Cognis Deutschland GmbH, Düsseldorf, Germany

Manfred Biermann Cognis Corporation, Cincinnati, Ohio

Muriel Blanzat Laboratoire IMRCP, UMR CNRS 5623, Université Paul Sabatier, Toulouse, France

Janos B.Nagy Laboratoire de Résonance Magnétique Nucléaire, Universitaires Notre-Dame de la Paix, Namur, Belgium

Lucia Brinchi Department of Chemistry, University of Perugia, Perugia, Italy

Terri Carson† Department of Chemistry, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

Mario Castagnola Department of Chemistry, The Ohio State University, Columbus, Ohio

Carlos C. Co Department of Chemical Engineering, University of Delaware, Newark, Delaware

Nily Dan Department of Chemical Engineering, Drexel University, Philadelphia, Pennsylvania

Renko de Vries‡ Department of Chemical Engineering, University of Delaware, Newark, Delaware

F. Debuigne Laboratoire de Résonance Magnétique Nucléaire, Universitaires Notre-Dame de la Paix, Namur, Belgium

Current affiliation:
*National Science Foundation, Arlington, Virginia.
†Polyurethanes Research and Development, Dow Chemical Company, Freeport, Texas.
‡Laboratory of Physical Chemistry and Colloid Science, Wageningen University, Wageningen, The Netherlands.

Joseph M. DeSimone Department of Chemistry, University of North Carolina at Chapel Hill, Chapel Hill, and Department of Chemical Engineering, North Carolina State University, Raleigh, North Carolina

Prabir K. Dutta Department of Chemistry, The Ohio State University, Columbus, Ohio

Jan B. F. N. Engberts Physical Organic Chemistry Unit, Stratingh Institute, University of Groningen, Groningen, The Netherlands

Janos H. Fendler Department of Chemistry, Clarkson University, Potsdam, New York

Jürgen-Hinrich Fuhrhop Institut für Organische Chemie (WE 2), Freien Universität Berlin, Berlin, Germany

D. Neil Furlong RMIT University, Bundoora, Victoria, Australia

Jane R. Galsworthy Infineum UK Ltd., Abingdon, Oxfordshire, England

Raimondo Germani Department of Chemistry, University of Perugia, Perugia, Italy

Roger W. Glyde Infineum UK Ltd., Abingdon, Oxfordshire, England

Christine Göltner* Max-Planck-Institute of Colloids and Interfaces, Golm, Germany

Ferdinand Gonzaga Laboratoire IMRCP, UMR CNRS 5623, Université Paul Sabatier, Toulouse, France

Brian Grady School of Chemical Engineering and Materials Science, University of Oklahoma, Norman, Oklahoma

Franz Grieser School of Chemistry, University of Melbourne, Parkville, Victoria, Australia

Karen Grieve School of Chemistry, University of Melbourne, Parkville, Victoria, Australia

Alain Guyot Laboratory for Polymerization Chemistry and Processes, CNRS, Villeurbanne, France

Jeffrey H. Harwell Institute of Applied Surfactant Research, and School of Chemical Engineering and Materials Science, University of Oklahoma, Norman, Oklahoma

Hans-Peter Hentze Department of Colloid Chemistry, Max-Planck-Institute of Colloids and Interfaces, Golm, Germany

Karlheinz Hill Cognis Deutschland GmbH, Düsseldorf, Germany

Krister Holmberg Department of Applied Surface Chemistry, Chalmers University of Technology, Göteborg, Sweden

J. D. Holmes Department of Chemical Engineering, University College, Cork, Ireland

Duncan C. Hone School of Chemical Sciences, University of East Anglia, Norwich, Norfolk, England

Jutta Hotz Department of Physical Chemistry, University of Basel, Basel, Switzerland

Martin In Complex Fluids Laboratory, CNRS-Rhodia, Cranbury, New Jersey

Glen Irvin Chemical Engineering Department, Tulane University, New Orleans, Louisiana

G. B. Jacobson Los Alamos National Laboratory, Los Alamos, New Mexico

L. Jeunieau Laboratoire de Résonance Magnétique Nucléaire, Universitaires Notre-Dame de la Paix, Namur, Belgium

Vijay T. John Department of Chemical Engineering, Tulane University, New Orleans, Louisiana

Keith P. Johnston Department of Chemical Engineering, University of Texas, Austin, Texas

**Current affiliation*: School of Chemistry, University of Bristol, Bristol, England.

Lana I. Jong* Department of Chemical Engineering, University of Wisconsin–Madison, Madison, Wisconsin

Eric W. Kaler Department of Chemical Engineering, University of Delaware, Newark, Delaware

David Kaplan Department of Chemical Engineering, Tufts University, Medford, Massachusetts

Jason S. Keiper Department of Chemistry, Emory University, Atlanta, Georgia

Jong-Mok Kim Department of Chemistry, Purdue University, West Lafayette, Indiana

Katharina Landfester Department of Colloid Chemistry, Max-Planck-Institute of Colloids and Interfaces, Golm, Germany

Armand Lattes Laboratoire IMRCP, UMR CNRS 5623, Université Paul Sabatier, Toulouse, France

C. T. Lee Department of Chemical Engineering, University of Texas, Austin, Texas

Stephen J. Lee Chemical Sciences Division, U.S. Army Research Office, Research Triangle Park, North Carolina

Yoon Seob Lee Department of Chemical Engineering, The Ohio State University, Columbus, Ohio

G. Li Department of Chemical Engineering, University of Texas, Austin, Texas

Sichu Li Department of Chemical Engineering, Tulane University, New Orleans, Louisiana

Raymond A. Mackay Department of Chemistry, Clarkson University, Potsdam, New York

Srinivas Manne Department of Physics, University of Arizona, Tucson, Arizona

Gary McPherson Department of Chemical Engineering, Tulane University, New Orleans, Louisiana

Wolfgang Meier Department of Physical Chemistry, University of Basel, Basel, Switzerland

Brian J. Melde Department of Chemistry, University of Minnesota, Minneapolis, Minnesota

Jean-Claude Micheau Laboratoire IMRCP, UMR CNRS 5623, Université Paul Sabatier, Toulouse, France

R. Nagarajan Department of Chemical Engineering, The Pennsylvania State University, University Park, Pennsylvania

John O'Haver Department of Chemical Engineering, University of Mississippi, University, Mississippi

Edgar A. O'Rear Institute of Applied Surfactant Research, and School of Chemical Engineering and Materials Science, University of Oklahoma, Norman, Oklahoma

Sijbren Otto† Physical Organic Chemistry Unit, Stratingh Institute, University of Groningen, Groningen, The Netherlands

Eric J. Paul Department of Chemical Engineering, Princeton University, Princeton, New Jersey

Emile Perez Laboratoire IMRCP, UMR CNRS 5623, Université Paul Sabatier, Toulouse, France

Ramannair Premachandran Department of Chemical Engineering, Tulane University, New Orleans, Louisiana

Robert K. Prud'homme Department of Chemical Engineering, Princeton University, Princeton, New Jersey

P. Psathas Department of Chemical Engineering, University of Texas, Austin, Texas

James F. Rathman Department of Chemical Engineering, The Ohio State University, Columbus, Ohio

Hans-Christian Raths Cognis Deutschland GmbH, Düsseldorf, Germany

Current affiliation:
*Department of Chemical Engineering, University of California, Davis, Davis, California.
†University Chemical Laboratory, University of Cambridge, Cambridge, England.

Isabelle Rico-Lattes Laboratoire IMRCP, UMR CNRS 5623, Université Paul Sabatier, Toulouse, France

Brian H. Robinson School of Chemical Sciences, University of East Anglia, Norwich, Norfolk, England

Laurence S. Romsted Department of Chemistry, Rutgers, The State University of New Jersey, New Brunswick, New Jersey

James F. Rusling Department of Chemistry, University of Connecticut, Storrs, Connecticut

Marie-Esther Saint Victor Cognis Corporation, Cincinnati, Ohio

Tetsuo Saji Department of Chemistry and Materials Science, Tokyo Institute of Technology, Tokyo, Japan

Gianfranco Savelli Department of Chemistry, University of Perugia, Perugia, Italy

Andreea Ruxandra Schmitzer Laboratoire IMRCP, UMR CNRS 5623, Université Paul Sabatier, Toulouse, France

Jason Y. Shin Department of Chemical Engineering, University of Wisconsin–Madison, Madison, Wisconsin

Blake A. Simmons *Department of Chemical Engineering, Tulane University, New Orleans, Louisiana*

Ramsharan Singh Department of Chemistry, The Ohio State University, Columbus, Ohio

Andreas Stein Department of Chemistry, University of Minnesota, Minneapolis, Minnesota

Sönke Svenson Corporate Research and Development–Chemical Sciences, The Dow Chemical Company, Midland, Michigan

Klaus Tauer Max-Planck-Institute of Colloids and Interfaces, Golm, Germany

John Texter Strider Research Corporation, Rochester, New York

Marc Thomalla Université Claude Bernard Lyon I, Villeurbanne, France

David H. Thompson Department of Chemistry, Purdue University, West Lafayette, Indiana

Günter Uphues Cognis Deutschland GmbH, Düsseldorf, Germany

Sharon L. Wells Department of Chemistry, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

J. L. Wolgemuth Department of Physics, University of Arizona, Tucson, Arizona

R. K. Workman Department of Materials Science and Engineering, University of Arizona, Tucson, Arizona

M. Z. Yates Los Alamos National Laboratory, Los Alamos, New Mexico

Weilie Zhou Advanced Materials Research Institute, University of New Orleans, New Orleans, Louisiana

Contents