EMULSIONS AND EMULSION STABILITY

Second Edition

SURFACTANT SCIENCE SERIES

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 Dobiás*
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 Dobiás, 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 Malgorzata 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*
102. Chemical Properties of Material Surfaces, *Marek Kosmulski*

103. Oxide Surfaces, *edited by James A. Wingrave*
104. Polymers in Particulate Systems: Properties and Applications, *edited by Vincent A. Hackley, P. Somasundaran, and Jennifer A. Lewis*
105. Colloid and Surface Properties of Clays and Related Minerals, *Rossman F. Giese and Carel J. van Oss*
106. Interfacial Electrokinetics and Electrophoresis, *edited by Ángel V. Delgado*
107. Adsorption: Theory, Modeling, and Analysis, *edited by József Tóth*
108. Interfacial Applications in Environmental Engineering, *edited by Mark A. Keane*
109. Adsorption and Aggregation of Surfactants in Solution, *edited by K. L. Mittal and Dinesh O. Shah*
110. Biopolymers at Interfaces: Second Edition, Revised and Expanded, *edited by Martin Malmsten*
111. Biomolecular Films: Design, Function, and Applications, *edited by James F. Rusling*
112. Structure–Performance Relationships in Surfactants: Second Edition, Revised and Expanded, *edited by Kunio Esumi and Minoru Ueno*
113. Liquid Interfacial Systems: Oscillations and Instability, *Rudolph V. Birikh, Vladimir A. Briskman, Manuel G. Velarde, and Jean-Claude Legros*
114. Novel Surfactants: Preparation, Applications, and Biodegradability: Second Edition, Revised and Expanded, *edited by Krister Holmberg*
115. Colloidal Polymers: Synthesis and Characterization, *edited by Abdelhamid Elaissari*
116. Colloidal Biomolecules, Biomaterials, and Biomedical Applications, *edited by Abdelhamid Elaissari*
117. Gemini Surfactants: Synthesis, Interfacial and Solution-Phase Behavior, and Applications, *edited by Raoul Zana and Jiding Xia*
118. Colloidal Science of Flotation, *Anh V. Nguyen and Hans Joachim Schulze*
119. Surface and Interfacial Tension: Measurement, Theory, and Applications, *edited by Stanley Hartland*
120. Microporous Media: Synthesis, Properties, and Modeling, *Freddy Romm*
121. Handbook of Detergents, *editor in chief: Uri Zoller* Part B: Environmental Impact, *edited by Uri Zoller*
122. Luminous Chemical Vapor Deposition and Interface Engineering, *HirotsuguYasuda*
123. Handbook of Detergents, editor in chief: Uri Zoller Part C: Analysis, *edited by Heinrich Waldhoff and Rüdiger Spilker*
124. Mixed Surfactant Systems: Second Edition, Revised and Expanded, *edited by Masahiko Abe and John F. Scamehorn*
125. Dynamics of Surfactant Self-Assemblies: Micelles, Microemulsions, Vesicles and Lyotropic Phases, *edited by Raoul Zana*
126. Coagulation and Flocculation: Second Edition, *edited by Hansjoachim Stechemesser and Bohulav Dobiás*
127. Bicontinuous Liquid Crystals, *edited by Matthew L. Lynch and Patrick T. Spicer*
128. Handbook of Detergents, editor in chief: Uri Zoller Part D: Formulation, *edited by Michael S. Showell*
129. Liquid Detergents: Second Edition, *edited by Kuo-Yann Lai*
130. Finely Dispersed Particles: Micro-, Nano-, and Atto-Engineering, *edited by Aleksandar M. Spasic and Jyh-Ping Hsu*
131. Colloidal Silica: Fundamentals and Applications, *edited by Horacio E. Bergna and William O. Roberts*
132. Emulsions and Emulsion Stability, Second Edition, *edited by Johan Sjöblom*

EMULSIONS AND EMULSION STABILITY

Second Edition

Edited by

Johann Sjöblom
Universitetet i Bergen
Bergen, Norway

Taylor & Francis
Taylor & Francis Group
Boca Raton London New York

A CRC title, part of the Taylor & Francis imprint, a member of the Taylor & Francis Group, the academic division of T&F Informa plc.

Published in 2006 by
CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number-10: 0-8247-2695-2 (Hardcover)
International Standard Book Number-13: 978-0-8247-2695-9 (Hardcover)

Library of Congress Cataloging-in-Publication Data

Catalog record is available from the Library of Congress

informa
Taylor & Francis Group
is the Academic Division of Informa plc.

Visit the Taylor & Francis Web site at
http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com

Preface

The revised and expanded edition of *Emulsions and Emulsion Stability* is a comprehensive treatise of different aspects of emulsions, both from a theoretical as well as a practical point of view. The book contains 19 chapters written by leading scientists in the field of emulsions. In more detail the chapters cover the following:

Dukhin's chapter covers fundamental processes, i.e. flocculation and coalescence in emulsified systems. A central aspect is to cover the time evolution of the droplet size distribution by means of the population balance equation (PBE) and based on subprocesses like droplet aggregation (both reversible and irreversible), aggregate fragmentation, droplet flocculation and droplet coalescence. In order to get an overall picture an attempt to couple these processes is undertaken.

Spontaneous emulsification is covered by Miller in his chapter. He relates the concept of self-emulsification to inversion processes and local supersaturation of oil, and a subsequent nucleation of oil droplets. The author also describes the role of a lamellar liquid crystalline phase in coating the small oil droplets and hence protecting them from coalescence. Also the formation of "nanoemulsions" is brought forward by the author.

The importance of thin liquid films in colloidal systems is presented by Platikanov and Exerowa from the famous Bulgarian school. The chapter provides a valuable insight into theory of thin films, essential properties and experimental techniques to characterize them.

Salager's chapter deals with the central question of inversion in emulsion systems. The phenomenon is presented as depending of different system variables, like formulation variables related to the equilibrium of the system, composition variables related to the quantity in proportions of the compounds (generally surfactant/cosurfactant, oil and water) and protocol variables describing the preparation of the emulsion.

Johansson and Voets elaborate further the phase inversion concept as a tool for optimization of surfactant mixtures in water/oil systems. The chapter by Johansson and Voets also deals with several technical applications of the optimized surfactant mixtures. It is by now well-known that unconcentrated emulsions have a polyheder structure instead of the spherical structure for low internal phase volume fractions.

The chapter of Esquena and Solans takes up the topic of highly concentrated emulsions as templates for solid foams. The idea is to prepare low density foams (< 0.1 g/ml) by polymerizing the continuous phase. These macroporous foams can be based on either organic or inorganic components in the continuous phase.

Colloidal structures like emulsions and microemulsions can serve as templates for chemical reactions. One of the leading scientists in this area, Krister Holmberg gives a comprehensive survey of different organic reactions in dispersed systems. The advantage in using emulsions/microemulsions is in enhanced solubility of reactants and in huge interfacial areas.

The first chapter in the characterization session of the emulsions deals with NMR. Peña and Hirasaki give an excellent review and update of different NMR applications in this field. The chapter covers basic NMR principles, relaxation measurements based on CPMG experiments and diffusion measurements via PGSE and PGSTE experiments. The applications for emulsified systems cover a determination of droplet sizes and stability against coalescence. The chapter also gives a comprehensive analysis of the pros and cons of the technique.

The emulsion characterization continues with Andrei Dukhin's chapter about ultrasound characterization of emulsions and microemulsions. The author gives a brilliant introduction to the topic. After this he gives numerous examples on practical applications on the determination of droplet sizes on a variety of systems, in addressing dairy systems like milk and butter. The author also gives a detailed comparison of the ultrasound technique and other techniques, like scattering measurements.

The book continues with some technical emulsions. The first chapter by Moldestad et al. deals with environmental emulsions, where the authors present in detail problems with oil spills. In an oil spill there is a natural uptake of water, and the wave energy contributes to the emulsification. As a result a stable w/o emulsion will emerge. A contributing factor is also the continuous evaporation of volatile components from the crude oil. Sintef in Trondheim has significantly contributed to a better understanding of the characterization and stability of such emulsions.

Per Redelius from Nynäs gives a comprehensive introduction to the topic of bitumen emulsions. These emulsions are in wide use in what we know as asphalt on our roads. In these formulations the road surface is a result of mixing the bitumen formulation to crushed rock, combined with a binding agent giving the final colour. Alternatively, for grey surfaces, a Portland concrete is used.

In the chapter by Sjöblom et al. the focus is on experimental techniques for characterization of crude oils. There seems to be a need for better and systematic needs to characterize crude oils and predict flow assurance related problems on a sound basis. Problems in relation to production and processing are water-in-oil and oil-in-water emulsions, foams and deposits. These problems (often resulting in shut-in periods) can be related to the properties of the crude oils and hence a detailed characterization is needed. In addition there is also a need to extend the characterization to elevated pressures and temperatures to cover subsea and downhole conditions.

Acid crude oils are covered by C. Hurtevent et al. in their chapter. These crude oils cause production and maintenance problems due to both formation of water-in-oil emulsions and deposits in the form of calcium naphthenates. Obviously different naphthenic acids are responsible for emulsion formation and precipitation, respectively. This is the background to intense research in the field of isolation, separation and characterization of individual acids from the family occurring in crude oils worldwide.

Li et al. present the topic of chemical flooding and related to this the problem of w/o emulsions. Central themes in the chapter are the connection between characterization of Chinese crude oils and the prediction of emulsion stability.

Electrocoalescence as a unit process is presented in detail by Lundgaard et al. The treatment is very thorough and built on a fundamental understanding of droplet-droplet interactions in different electrical fields. Also some practical aspects of the installment of electrocoalescence are discussed by the authors.

Separation technology is also the topic of the next chapter by Ernst Hansen. He deals with numerical simulation of fluids in offshore gravity separations. The chapter deals with both batch and continuous separation, together with the effect of different inlet configurations. It is obvious that CFD (computational fluid dynamics) can provide valuable information about the flow conditions in a separator tank.

Friedemann continues with the same topic of fluid behavior in confined offshore separators. The author also extends the discussion to subsea solutions. This chapter also emphasizes the need for a detailed fluid characterization in order to gain a better understanding of the underlying mechanisms of the emulsion problems and how to treat these. The chapter presents a variety of models for the separation performance.

The problems with production water are emerging and there are huge quantities that are produced and need to be cleaned. In this context droplet sizes and droplet size distributions are essential in the treatment.

Hemmingsen et al. present video microscopy as a technique to monitor on-line the DSD in product lines from the separator. In this context one needs a technique that can be adopted to higher pressures. The DVM technique gives representable DSDs and seems to fulfill the essential requirements for on-line instrumentation.

A central question for processing offshore is to develop on-line instrumentation to follow for instance the demulsification process. The last chapter in the book deals with conductivity measurements as an alternative to such instrumentation. The chapter is written by van Dijk et al. The authors provide convincing data for the DEMCOM technique.

The revised and expanded edition of *Emulsions and Emulsion Stability* serves as a comprehensive treatise of the emulsion phenomenon. We have tried to cover fundamental and basic aspects, experimental characterization, technical systems and, finally, separation technology and examples on on-line instrumentation. I hope that the readers will enjoy this potpourri and that they gain new insight and knowledge that can be implemental both in academia and industry.

To my co-authors, I want to express my deepest gratitude for their contributions. I am very touched by the scientific level of all the chapters and also how the chapters are updated with modern references.

Finally, I do hope that the scientific community will appreciate our efforts to move the frontiers forward in the field of emulsion science.

Enjoy the reading!

Johan Sjöblom
Professor and
Head of Ugelstad Laboratory
NTNU, Trondheim
Norway

The Editor

Johan Sjöblom has been professor in surface and colloid chemistry, and head of the Ugelstad Laboratory at the Norwegian University of Technology and Sciences (NTNU), Trondheim, Norway, since January 2002. Previously, he was a professor at the University of Bergen between 1988 and 1999, and chief researcher at Statoil's R&D Center between 1998 and 2001. Dr Sjöblom has also served as adjunct professor of colloid chemistry and materials science at Clarkson University, Potsdam, New York, and at the Technical University of Helsinki from 1992 to 1999.

Dr Sjöblom is the editor of nine books and the author or co-author of more than 260 professional papers. He has also supervised 28 PhD students and 35 MSc students. He is editor-in-chief for *Journal of Dispersion Science and Technology* and a member of the advisory board of *Micro- and Macroporous Materials*, and was a board member of *Colloids and Surfaces* between 1993 and 2003.

Dr Sjöblom is a member of the American Chemical Society, the Norwegian Chemical Society, the Finnish Chemical Society, and an elected member of the Norwegian Academy of Technological Sciences and the Swedish Academy of Engineering Sciences in Finland. He received his PhD degree (1982) in physical chemistry from Åbo Akademi, Finland, and has been an industrial consultant in colloid chemistry since 1980.

Contributors

Pierre Atten
CNRS/LEMD
Grenoble, France

Inge H. Auflem
Statoil ASA
Stjørdal, Norway

Gunnar Berg
SINTEF Energy Research
Trondheim, Norway

Maurice Bourrel
Total Petrochemicals France
Lacq, France

Øystein Brandal
Norwegian University of
Science and Technology
Trondheim, Norway

Benjamin Brocart
Total Petrochemicals France
Lacq, France

Per S. Daling
Marine Environmental
Technology Department
SINTEF Materials and Chemistry
Trondheim, Norway

Jan van Dijk
Champion Technologies
Delden, Netherlands

Zhaoxia Dong
University of Petroleum
Beijing, China

A. S. Dukhin
Dispersion Technology Inc.
Bedford Hills,
New York, USA

Stanislav S. Dukhin
New Jersey Institute of Technology
Newark, New Jersey, USA

Marit-Helen Ese
Norwegian University of
Science and Technology
Trondheim, Norway

Jordi Esquena
IIQAB
Barcelona, Spain

Dotchi Exerowa
Institute of Physical Chemistry
Bulgarian Academy of Sciences
Sofia, Bulgaria

John D. Friedemann
Vetco Gray
Stavanger, Norway

Wilhelm R. Glomm
Department of Chemical Engineering
Norwegian University of
Science and Technology
Trondheim, Norway

P.J. Goetz
Dispersion Technology Inc.
Bedford Hills, New York, USA

Jixiang Guo
University of Petroleum
Beijing, China

Andreas Hannisdal
Department of Chemical Engineering
Norwegian University of
Science and Technology
Trondheim, Norway

Ernst W.M. Hansen
Complex Flow Design AS
Trondheim, Norway

Trond E. Havre
Champion Technologies
Delden, Netherlands

Pål V. Hemmingsen
Department of Chemical Engineering
Norwegian University of
Science and Technology
Trondheim, Norway

George J. Hirasaki
Department of Chemical Engineering
Rice University
Houston, Texas, USA

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

Christian Hurtevent
Total Exploration & Production
Pau, France

Stian Ingebrigtsen
SINTEF Energy Research
Trondheim, Norway

Øistein Johansen
Marine Environmental
Technology Department
SINTEF Materials and Chemistry
Trondheim, Norway

Ingegärd Johansson
Akzo Nobel Surface Chemistry
Stenungsund, Sweden

Harald Kallevik
Statoil R&D Center
Trondheim, Norway

Magne Knag
Norwegian University
of Science and Technology
Trondheim, Norway

Frode Leirvik
Marine Environmental
Technology Department
Chemistry
SINTEF Materials and Chemistry
Trondheim, Norway

Alun Lewis
Oil Spill Consultant
Staines, United Kingdom

Mingyuan Li
University of Petroleum
Beijing, China

Meiqin Lin
University of Petroleum
Beijing, China

Lars E. Lundgaard
SINTEF Energy Research
Trondheim, Norway

Clarence A. Miller
Department of Chemical
Engineering
Rice University
Houston, Texas, USA

Merete Ø. Moldestad
Marine Environmental
Technology Department
SINTEF Materials and
Chemistry
Trondheim, Norway

Hans-Jörg Oschmann
Champion Technologies
Delden, Netherlands

Gisle Øye
Department of Chemical Engineering
Norwegian University of
Science and Technology
Trondheim, Norway

Alejandro A. Peña
Department of Oilfield Chemical Products
Schlumberger Technology Corp.
Sugar Land, Texas, USA

Bo Peng
University of Petroleum
Beijing, China

Dimo Platikanov
Department of Physical Chemistry
University of Sofia, Bulgaria

Per Redelius
Nynas Bitumen
Nynäshamn, Sweden

Geir J. Rørtveit
Complex Flow Design AS
Trondheim, Norway

Guy Rousseau
Total Exploration & Production
Pau, France

Øystein Sæther
Det Norske Veritas
Section of Materials Technology
and Condition Management
Bergen, Norway

Jean-Louis Salager
FIRP
Universidad de Los Andes
Mérida, Venezuela

Johan Sjöblom
Department of Chemical
Engineering
Norwegian University of
Science and Technology
Trondheim, Norway

Conxita Solans
Consejo Superior de
Investigaciones Científicas
Barcelona, Spain

Ilja Voets
Laboratory of Physical
Chemistry and Colloid Science
Wageningen University
Wageningen, Netherlands

Jean Walter
Nynas Bitumen
South Wirral, UK

Arild Westvik
Statoil R&D Center
Trondheim, Norway

Zhaoliang Wu
University of Petroleum
Beijing, China

Table of Contents