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*Volker Hessel, Albert Renken,*
*Jaap C. Schouten, and Jun-Ichi Yoshida*

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A Comprehensive Handbook

Volume 1: Fundamentals, Operations and Catalysts

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**The Editors**

***Prof. Dr. Volker Hessel***
Institut für Mikrotechnik
Mainz GmbH
Carl-Zeiss-Str. 18 -20
55129 Mainz
Germany

***Prof. Dr. Albert Renken***
École Polytechnique Fédérale
EPFL-ISISC-LGRC
Station 6
1015 Lausanne
Switzerland

***Prof. Dr. Jaap C. Schouten***
Eindhoven University of Technology
Chemical Reactor Engineering/Helix STW1
Den Dolech 2
5600 MB Eindhoven
The Netherlands

***Prof. Dr. Jun-Ichi Yoshida***
Department of Synthetic Chemistry
Kyoto University
Nishikyo-ku
Kyoto 606-8510
Japan



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# Contents



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# Preface

## Technology Scaled Out – Handbook Full of Facets

A handbook is a type of reference work that is intended to provide ready reference and is an established compendium format originating from the hour of birth of natural sciences, but being still modern today. In its original meaning, this refers to a pocket reference which is intended to be carried at all times - a vade mecum (lat. "go with me"). The emergence of micro reaction or micro process technology is so paramount that all relevant results and research directions cannot put anymore into such smart format. This applies analogously for the micro process plants, which have reached production stage and with increasing throughput and complexity have reached out-scaled formats, albeit being still compact and much smaller than conventional equipment. Accordingly, this handbook of micro process technology provides multiple facets of the new approach, spanning from microfluidics over applications to finally a system technology on respective plants. Actually, this led us giving the handbook a three-volume format, covering fundamental issues of flow within microchannels up to commercial implementation and cost analysis issues.

Volume 1 covers fluid dynamics, modelling, mixing of one-phase and dispersed two-phase systems, heat and mass transfer. One chapter is concerned about purification and separation focusing on extraction, membrane technology, and capillary electrochromatography. This is rounded off by a description on microstructured reactors and their engineering/design for various applications.

Volume 2 provides information on chemical applications, with those in fine chemistry having the largest share. These applications are grouped mechanistically, with the intention that the same or similar reactions ought to have similar process demands and process intensification potentials, thus facilitating comparison of performance. A complete chapter is given to polymerisations and another one to functional materials, reflecting an increasing trend in microfluidic research. Most prominent is particle making, split into pigment/organic, inorganic and polymer particles, and supramolecular assemblies (microencapsulates, vesicles). Emulsions are another class of functional materials frequently investigated using microstructured devices. Finally, fuel processing with its hydrogen making and gas purifying

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processes is described which has evolved as major microfluidic application in the past years.

Volume 3 is concerned with the transfer from single-plate device to system and scaled-out multi-plate devices. The system approach includes sensing and analytical functions and thus bridges to optics and microelectronics. Case studies in micro process plants are lively documents of the degree of implementation and mirror imaging the soft human factor in industry, having trust in the new technology or being more reluctant. Economic and eco-efficiency analysis is finally the financial and environmental measure of the concrete impact and provide hints for the decision makers within industry.

We hope this handbook will be a valuable source of information and reference both for the newcomer and practitioner of micro process technology. Each chapter is given by an expert in the field using updated information and providing a compact degree of origin and specific information. As the handbook bridges from small units and devices to large modules and complex systems, it should attract also a readership beyond the microreactor scientific community, being specialists in specific applications, i.e. the user of the novel approach. Finally, with all editors being university professors, we would be pleased if this handbook should be one knowledge piece to establish the new technology in the path of normal education and knowledge within chemical engineering.

December 2008

The Editors (*Volker Hessel, Albert Renken, Jaap Schouten, and Jun-ichi Yoshida*)

## About the Editors

**Volker Hessel** became part-time professor for the chair of "Micro Process Engineering" at Eindhoven University of Technology, TU/e, in the Chemical Reactor Engineering group of Professor Jaap Schouten in 2005. He has worked at Institut für Mikrotechnik Mainz GmbH since 1994, being appointed Head of the Microreaction Technology Department in 1999. In 2002, Prof. Hessel was appointed Vice Director of R&D and in 2007 as Director of R&D for Chemical Micro and Milli Process Technologies. He is author/co-author of 135 peer-reviewed publications, with 23 extended reviews, 11 book chapters, and 3 books. He received the AIChE award "Excellence in Process Development Research" in 2007 and was the AIChE chair (US) "Microprocess Engineering" (2005–2007). He is also an elected board member of the German industrial platform IPμVT, and chair of the program committees of the SynTOP and IMRET-10 Conferences.

**Albert Renken** was professor for Chemical Reaction Engineering at the Swiss Federal Institute of Technology in Lausanne until 2006. He is a Swiss delegate in the working party on Chemical Reaction Engineering (Chairman 1996–2003) of the European Federation of Chemical Engineering. He organized the 7th International Conference on Microreaction Technology (IMRET 7) in Lausanne, 2003 and the 19th International Symposium on Chemical Reaction Engineering (ISCRE 19) in Berlin/Potsdam, 2006. In 2007 he was awarded with the DECHEMA- Titanium Medal. He was a member of the research council of the Swiss National Science Foundation from 1992 until 2000 and a member of the Swiss Innovation Promotion Agency from 1999 to 2006. He is author/co-author of more than 450 scientific publications, 19 patents and two textbooks in Chemical Reaction Engineering.

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**Jaap Schouten** is professor of Chemical Reactor Engineering at Eindhoven University of Technology (TU/e). The Secretary of the Working Party on Chemical Reaction Engineering of the European Federation of Chemical Engineering (EFCE), Prof. Schouten is also a member of the Scientific Committees of the International Symposia on Chemical Reaction Engineering (ISCRE) and Microreaction Technology (IMRET), and of the European Process Intensification Conference (EPIC). He was granted the prestigious "Simon Stevin Mastership" award by the Dutch Technology Foundation STW in 2006, and became the recipient of the Chemistry Innovation KTN Award for Innovation in Applied Catalysis and Colloid Science from the British Institution of Chemical Engineers (IChemE) in the same year. In 2007 he was appointed Member of the Royal Holland Society of Sciences. In 2008 he was awarded a prestigious Advanced Grant by the European Research Council (ERC). Professor Schouten has authored/coauthored more than 170 scientific publications.

**Jun-ichi Yoshida** has been professor in the department of Synthetic Chemistry and Biological Chemistry at the Kyoto University in Japan since 1994. He is the recipient of many awards including the Progress Award of Synthetic Organic Chemistry, Japan (1987), the Chemical Society of Japan Award for Creative Work (2001), Nagoya Silver Medal (2006), and Humboldt Research Award (2007). After receiving his doctorate from the University of Kyoto, he became an associate professor at the Kyoto Institute of Technology. He was also a visiting professor at the University of Wisconsin before moving to Osaka City University in 1985. Professor Yoshida has authored/coauthored numerous scientific publications.

## List of Contributors

***David W. Agar***
Technische Universität Dortmund
Lehrstuhl für Technische Chemie B
Emil-Figge-Strasse 66
44227 Dortmund
Germany

***Panagiota Angeli***
University College London
Department of Chemical Engineering
Torrington Place
London WC1E 7JE
UK

***Nobuaki Aoki***
Kyoto University
Graduate School of Engineering
Department of Chemical Engineering
Kyoto-daigaku Katsura
Nishikyo-ku
Kyoto 615-8510
Japan

***Joëlle Aubin***
Université de Toulouse
INP, LGC-CNRS
Laboratoire de Génie Chimique
6 allée Emile Monso
BP 34038
31029 Toulouse
France

***Hans-Joerg Bart***
Technische Universität Kaiserlautern
Lehrstuhl für Thermische
Verfahrenstechnik
Postfach 3049
67653 Kaiserlautern
Germany

***Jean-Marc Commenge***
LSGC-CNRS-INPL Groupe
ENSIC-Nancy
1 rue Grandville
BP 20451
54001 Nancy
France

***Laurent Falk***
LSGC-CNRS-INPL Groupe
ENSIC-Nancy
1 rue Grandville
BP 20451
54001 Nancy
France

***David F. Fletcher***
University of Sydney
School of Chemical and Biomolecular
Engineering,
NSW 2006
Australia

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***Asterios Gavriilidis***
University College London
Department of Chemical Engineering
Torrington Place
London WC1E 7JE
UK

***Roger Gorges***
Behr GmbH & Co. KG
Siemensstrasse 164
70469 Stuttgart
Germany

***Axel Günther***
University of Toronto
Department of Mechanical and Industrial Engineering and Institute of Biomaterials and Biomedical Engineering
5 King's College Road
Toronto
Ontario M5S 3G8
Canada

***Brian S. Haynes***
University of Sydney
School of Chemical and Biomolecular Engineering
NSW 2006
Australia

***Volker Hessel***
Institut für Mikrotechnik Mainz GmbH
Chemical Process Technology
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***Marko Hoffmann***
University of Bremen
Department of Production Engineering, Mechanical Engineering and Process Engineering
Institute of Environmental Process Engineering
28359 Bremen
Germany

***Niket S. Kaisare***
Indian Institute of Technology – Madras
Department of Chemical Engineering
Chennai 600-036
India

***Madhvanand N. Kashid***
Ecole Polytechnique Fédérale de Lausanne
EPFL-ISIC-GGRC
Station 6
1015 Lausanne
Switzerland

***Andreas Kirsch***
Friedrich Schiller University Jena
Institute of Technical Chemistry and Environmental Chemistry
Lessingstrasse 12
07743 Jena
Germany

***Lioubov Kiwi-Minsker***
Ecole Polytechnique Fédérale de Lausanne
EPFL-ISIC-GGRC
Station 6
1015 Lausanne
Switzerland

***Norbert Kockmann***
Lonza AG
Continuous Process Technology, Microreactors
R&D LES
3930 Visp
Switzerland

***Michiel T. Kreutzer***
Delft University of Technology
DelftChemTech
Faculty of Applied Sciences
Julianalaan 136
2628 BL Delft
The Netherlands

***François Lapicque***
LSGC-CNRS-INPL Groupe
ENSIC-Nancy
1 rue Grandville
BP 20451
54001 Nancy
France

***Patrick Löb***
Institut für Mikrotechnik Mainz GmbH
Chemical Process Technology
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***Kazuhiro Mae***
Kyoto University
Graduate School of Engineering
Department of Chemical Engineering
Kyoto-daigaku Katsura
Nishikyo-ku
Kyoto 615-8510
Japan

***Nam-Trung Nguyen***
Nanyang Technological University
School of Mechanical and Aerospace Engineering
Singapore 639798
Singapore

***Norbert Räbiger***
University of Bremen
Department of Production Engineering, Mechanical Engineering and Process Engineering
Institute of Environmental Process Engineering
28359 Bremen
Germany

***Albert Renken***
Ecole Polytechnique Fédérale de Lausanne
EPFL-ISIC-GGRC
Station 6
1015 Lausanne
Switzerland

***Gherhardt Ribatski***
University of São Paulo (USP)
Escola de Engenharia de São Carlos (EESC)
Department of Mechanical Engineering
13560-970 São Carlos, SP
Brazil

***Sabine Rode***
LSGC-CNRS-INPL Groupe ENSIC-Nancy
1 rue Grandville
BP 20451
54001 Nancy
France

***Michael Schlüter***
University of Bremen
Department of Production Engineering, Mechanical Engineering and Process Engineering
Institute of Environmental Process Engineering
28359 Bremen
Germany

***Georgios D. Stefanidis***
University of Delaware
Department of Chemical Engineering and Center for Catalytic Science and Technology
Newark, DE 19716-3110
USA

***John R. Thome***
École Polytechnique Fédérale de Lausanne (EPFL)
Faculty of Engineering Science
Laboratory of Heat and Mass Transfer (LTCM)
1015 Lausanne
Switzerland

***Franz Trachsel***
ETH Zurich
Institute for Process Engineering
Laboratory for Transport Processes and Reactions
Sonneggstrasse 3
8092 Zurich
Switzerland

***Dionisios G. Vlachos***
University of Delaware
Department of Chemical Engineering and Center for Catalytic Science and Technology
Newark, DE 19716-3110
USA

***Philipp Rudolf von Rohr***
ETH Zurich
Institute for Process Engineering
Laboratory for Transport Processes and Reactions
Sonneggstrasse 3
8092 Zurich
Switzerland

***Zhigang Wu***
Uppsala University
Department of Engineering Sciences
751 21 Uppsala
Sweden

***Catherine Xuereb***
Université de Toulouse
INP, LGC-CNRS
Laboratoire de Génie Chimique
6 allée Emile Monso
BP 34038
31029 Toulouse
France

## List of Contributors

***Freddy Aguilar***
Universität Karlsruhe
Institut für Bio- und
Lebensmitteltechnik
Bereich I:
Lebensmittelverfahrenstechnik
Kaiserstrasse 12
76128 Karlsruhe
Germany

***Ronald S. Besser***
Stevens Institute of Technology
Chemical, Biomedical and Materials
Engineering
Castle Point on Hudson
Hoboken, NJ 07030
USA

***Jürgen Brandner***
Forschungszentrum Karlsruhe
Institut für Mikroverfahrenstechnik
(IMVT)
P.O. Box 3640
76021 Karlsruhe
Germany

***Claude de Bellefon***
UMR CNRS 2214 – CPE Lyon
Bât. 308–43
boulevard du 11 novembre 1918
69622 Villeurbanne Cedex
France

***Thomas E. Enright***
Xerox Research Center of Canada
Mississauga
Ontario L0G 1W0
Canada

***Takahide Fukuyama***
Osaka Prefecture University Sakai
Graduate School of Science
Department of Chemistry
Osaka 599-8531
Japan

***J. G. E. (Han) Gardeniers***
University of Twente
MESA+ Institute for Nanotechnology
P.O. Box 217
7500 AE Enschede
The Netherlands

***Oliver Görke***
Forschungszentrum Karlsruhe
Institute for Micro Process Engineering
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
Germany

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***Katja Haas-Santo***
Forschungszentrum Karlsruhe
Institute for Micro Process Engineering
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
Germany

***Andreas Hensel***
Universität Karlsruhe
Institut für Bio- und
Lebensmitteltechnik
Bereich I:
Lebensmittelverfahrenstechnik
Kaiserstrasse 12
76128 Karlsruhe
Germany

***Volker Hessel***
Institut für Mikrotechnik Mainz GmbH
Chemical Process Technology
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***Takeshi Honda***
National Institute of Advanced
Industrial Science and Technology
(AIST)
Nanotechnology Research Institute
807-1
Shuku
Tosu 841-0052
Japan

***Hieng Kim***
Clariant International Ltd
Functional Chemicals Division
BU Performance Chemicals
Rothausstrasse 61
4132 Muttenz 1
Switzerland

***Karsten Köhler***
Universität Karlsruhe
Institut für Bio- und
Lebensmitteltechnik
Bereich I:
Lebensmittelverfahrenstechnik
Kaiserstrasse 12
76128 Karlsruhe
Germany

***Michael Köhler***
Technische Universität Ilmenau
Institut für Physik
Weimarer Strasse 32
PF 100565
98684 Ilmenau
Germany

***Gunther Kolb***
Institut für Mikrotechnik Mainz GmbH
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***Patrick Löb***
Institut für Mikrotechnik Mainz GmbH
Chemical Process Technology
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***Stefan Löbbecke***
Fraunhofer Institut für Chemische
Technologie
Joseph-von-Fraunhofer-Strasse 7
76327 Pfinztal (Berghausen)
Germany

***Hideaki Maeda***
National Institute of Advanced Industrial Science and Technology (AIST)
Nanotechnology Research Institute
807-1 Shuku
Tosu 841-0052
Japan

***Shaun McGovern***
Stevens Institute of Technology
Chemical, Biomedical and Materials Engineering
Castle Point on Hudson
Hoboken, NJ 07030
USA

***Claude Mirodatos***
Institut de Recherches sur la Catalyse et l'Environnement de Lyon
IRCELYON
UMR 5256 CNRS/Université Lyon 1
2 avenue Albert Einstein
69626 Villeurbanne Cedex
France

***Aiichiro Nagaki***
Kyoto University
Graduate School of Engineering
Department of Synthetic Chemistry and Biological Chemistry
Sakyo-ku
Kyoto 606-8501
Japan

***Takasi Nisisako***
Tokyo Institute of Technology
Precision and Intelligence Laboratory
R2–6
4259 Nagatsuata-cho
Midori-ku
Yokohama
Kanagawa 226-8503
Japan

***Xun Ouyang***
IdaTech, LLC
63065 NE 18th Street
Bend, OR 97702
USA

***Peter Pfeifer***
Forschungszentrum Karlsruhe
Institute for Micro Process Engineering
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
Germany

***Md Taifur Rahman***
Osaka Prefecture University Sakai
Graduate School of Science
Department of Chemistry
Osaka 599-8531
Japan

***Ilhyong Ryu***
Osaka Prefecture University Sakai
Graduate School of Science
Department of Chemistry
Osaka 599-8531
Japan

***Heike P. Schuchmann***
Universität Karlsruhe
Institut für Bio- und Lebensmitteltechnik
Bereich I:
Lebensmittelverfahrenstechnik
Kaiserstrasse 12
76128 Karlsruhe
Germany

***Yves Schuurman***
Institut de Recherches sur la Catalyse et l'Environnement de Lyon
IRCELYON
UMR 5256 CNRS/Université Lyon 1
2 avenue Albert Einstein
69626 Villeurbanne Cedex
France

***Christophe Serra***
Université de Strasbourg
Ecole de Chimie Polymères et Matériaux
Dept. Polymères
25 rue Becquerel
67087 Strasbourg
France

***Alberto Simoncelli***
F&HC Engineering Process
Breakthrough
P&G Technical Centres Limited
Whitley Road, Longbenton
Newcastle upon Tyne, NE 12 9TS
United Kingdom

***Harshal Surangalikar***
Stevens Institute of Technology
Chemical, Biomedical and Materials
Engineering
Castle Point on Hudson
Hoboken, NJ 07030
USA

***Roald M. Tiggelaar***
University of Twente
MESA+ Institute for Nanotechnology
P.O. Box 217
7500 AE Enschede
The Netherlands

***John van der Schaaf***
Technische Universiteit Eindhoven
Faculteit Technologie Management
Postbus 513
5600 MB Eindhoven
The Netherlands

***Andre C. van Veen***
Institut de Recherches sur la Catalyse et
l'Environnement de Lyon
IRCELYON
UMR 5256 CNRS/Université Lyon 1
2 avenue Albert Einstein
69626 Villeurbanne Cedex
France

***Charlotte Wiles***
University of Hull
Department of Chemistry
Cottingham Road
Hull HU6 7RX
UK

***Paul Watts***
University of Hull
Department of Chemistry
Cottingham Road
Hull HU6 7RX
UK

***Jun-ichi Yoshida***
Kyoto University
Graduate School of Engineering
Department of Synthetic Chemistry and
Biological Chemistry
Sakyo-ku
Kyoto 606-8501
Japan

## List of Contributors

***Jacob Bart***
University of Twente
MESA + Institute for Nanotechnology
P.O. Box 217
7500 AE Enschede
The Netherlands

***Thomas Bayer***
Siemens AG
Industriepark Hoechst
Geb. HK 801
65926 Frankfurt
Germany

***S. Braune***
DSM Fine Chemicals
St.-Peter-Straße 25
4020 Linz
Austria

***Ray W. Chrisman***
University of Washington
Center for Process Analytical Chemistry
Box 351700
Seattle, WA 98195-1700
USA

***Jean-Marc Commenge***
Laboratoire des Sciences du Génie
Chimique
CNRS-Université de Nancy
1 rue Grandville
BP 20451
54001 Nancy Cedex
France

***Laurent Falk***
Laboratoire des Sciences du Génie
Chimique
CNRS-Université de Nancy
1 rue Grandville
BP 20451
54001 Nancy Cedex
France

***Wolfgang Ferstl***
BASF SE
GKA/S - E210
67056 Ludwigshafen
Germany

***Han Gardeniers***
University of Twente
MESA+ Institute for Nanotechnology
P.O. Box 217
7500 AE Enschede
The Netherlands

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***Volker Hessel***
Institut für Mikrotechnik Mainz GmbH
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***Dirk Kirschneck***
Microinnova Engineering GmbH
Reininghausstrasse 13a
8020 Graz
Austria

***Melvin V. Koch***
University of Washington
Center for Process Analytical Chemistry
Box 351700
Seattle, WA 98195-1700
USA

***M. Kotthaus***
DSM Fine Chemicals
St.-Peter-Straße 25
4020 Linz
Austria

***Dana Kralisch***
Friedrich-Schiller-Universität Jena
Institut für Technische Chemie und Umweltchemie
Lessingstrasse 12
07743 Jena
Germany

***Ulrich Krtschil***
Institut für Mikrotechnik Mainz GmbH
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***G. Kwant***
DSM Performance Materials Chemistry and Technology
P.O. Box 18
6160 MD Geleen
The Netherlands

***Patrick Löb***
Institut für Mikrotechnik Mainz GmbH
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***Holger Löwe***
Institut für Mikrotechnik Mainz GmbH
Carl-Zeiss-Strasse 18–20
55129 Mainz
Germany

***F. Mascarello***
DSM Nutritional Products
Hauptstraße 4
4334 Sisseln
Switzerland

***Michael Matlosz***
Laboratoire des Sciences du Génie Chimique
CNRS-Université de Nancy
1 rue Grandville
BP 20451
54001 Nancy Cedex
France

***Claude Mirodatos***
Institut de Recherche sur la Catalyse et l'Environement de Lyon
UMR 5256 CNRS
Université Lyon 1
2 avenue Albert Einstein
69626 Villeurbanne Cedex
France

***Olaf Stange***
Ehrfeld Mikrotechnik BTS GmbH
Mikrofurum Ring 1
55234 Wendelsheim
Germany

***P. Poechlauer***
DSM Fine Chemicals
St.-Peter-Straße 25
4020 Linz
Austria

***Krzysztof J. Ptasinski***
Eindhoven University of Technology
Department of Chemical Engineering
P.O. Box 513
5600 MB Eindhoven
The Netherlands

***R. Reintjens***
DSM Pharmaceutical Products
P.O. Box 18
6160 MD Geleen
The Netherlands

***Dominique M. Roberge***
Lonza Ltd
Valais Works
3930 Visp
Switzerland

***Dirk Schmalz***
Merck KGaA
Mainzerstraße 41
64579 Gernsheim
Germany

***Yves Schuurman***
Institut de Recherche sur la Catalyse et l'Environnement de Lyon
UMR 5256 CNRS
Université Lyon 1
2 avenue Albert Einstein
69626 Villeurbanne Cedex
France

***Günter Tekautz***
Microinnova Engineering GmbH
Reininghausstraße 13a
8020 Graz
Austria

***Shigenori Togashi***
Hitachi, Ltd
Mechanical Engineering Research Laboratory
832-2, Horiguchi
Hitachinaka Ibaraki
Japan

***André C. van Veen***
Institut de Recherche sur la Catalyse et l'Environnement de Lyon
UMR 5256 CNRS
Université Lyon 1
2 avenue Albert Einstein
69626 Villeurbanne Cedex
France

***M. Vorbach***
DSM Fine Chemicals
St.-Peter-Straße 25
4020 Linz
Austria

***Lukas E. Wiesegger***
Microinnova Engineering GmbH
Reininghausstraße 13a
8020 Graz
Austria

***Barbara Zechner***
Microinnova Engineering GmbH
Reininghausstraße 13a
8020 Graz
Austria