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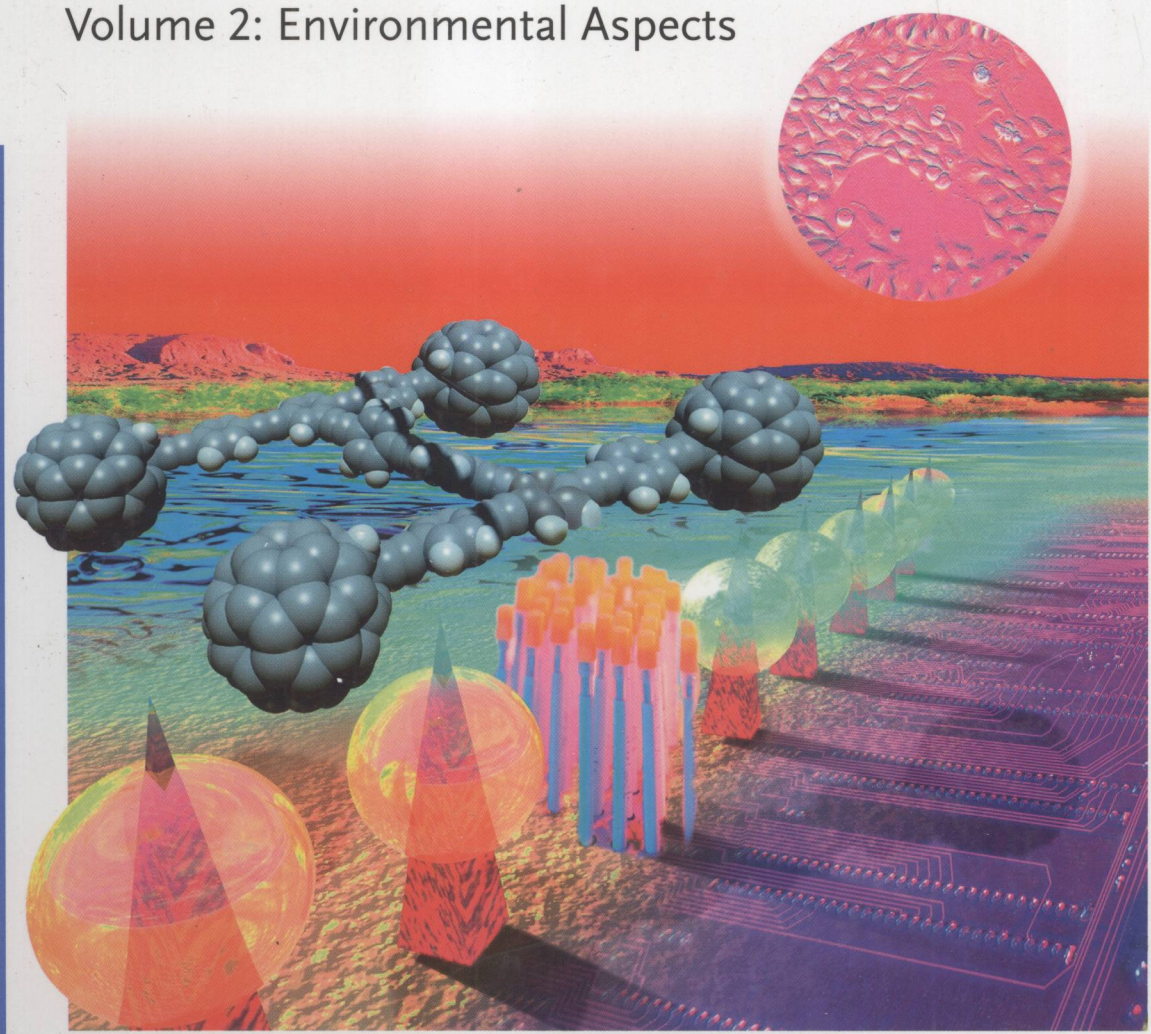
Nanotechnology

Volume 2: Environmental Aspects



G. Schmid, H. Krug, R. Waser, V. Vogel, H. Fuchs,
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The Editor

Prof. Dr. Harald F. Krug
EMPA - Materials Science & Technology
Lerchenfeldstr. 5
9014 St. Gallen
Switzerland

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Preface

"Nowhere the Nature of things is greater than in the smallest things," stated Pliny the Elder almost 2000 years ago. With these few words, he combined the special properties of small things with the "environment".

This combination – which forms the central aspect of this book – demonstrates the multifaceted correlation between *Nanotechnology* and environmental problems. The many promises made during the past two decades on the one hand, and the demand for higher safety and the regulation of new technologies on the other hand, highlight the fact that today the use of nanomaterials within the environment is a very sensitive issue. The first chemical revolution bestowed on us some critical environmental problems which still have not been satisfactorily resolved today. An example is the relationship between the distribution of pollutants and their control, with many organizations and societal groups demanding a better control of chemicals and their associated technological difficulties. The questions that arise from these considerations are addressed in the second volume of this series on *Nanotechnology*. In this respect, *Environmental Aspects* covers both sides of the coin, from the use of nanomaterials as catalysts to reduce or prevent pollution or identify the situation both early and accurately, to solving energy-related problems by applying nanotechnology or addressing environmental difficulties arising during the production and use of nanoparticles. The aging of nanoparticles in the atmosphere, and the related problems of their presence in the environment, have also been addressed in this book.

The initial planning of this book proved difficult when some of the selected authors were forced to cancel their collaboration for reasons of ill health, and I extend my sympathy to these colleagues. However, I was extremely pleased to find in all cases not only substitutes but true experts in these fields who proved capable of presenting an outstanding summary on all topics relating to *Nanotechnology* and the *Environment*.

Clearly, I would like to express my sincere thanks to all authors of the chapters, for their dedication and patience during the preparation of this book. My special thanks go to Günther Schmid, the editor of the series *Nanotechnology*, who invited and motivated me to edit this volume on *Environmental Aspects*, and of course to the staff

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of Wiley-VCH – and in particular Gudrun Walter, Steffen Pauly and Axel Eberhard – who supported me in every possible way. My thanks also go to Waltraud Wüst, without whom even this preface would not have been written. Last, but not least, I thank my wife for her great patience, as she spent many hours alone while I was working at my desk.

St. Gallen, March 2008 *Harald F. Krug*

List of Contributors

Billie L. Abrams
Danish Technical University
Department of Physics
Nano DTU
Center for Integrated Nanoparticle Functionality (CINF)
2800 Kongens Lyngby
Denmark

Norman S. Allen
Manchester Metropolitan University
Biology, Chemistry and Health Sciences
Chester Street
Manchester M1 5GD
United Kingdom

Christof Asbach
Institute of Energy and Environmental Technology (IUTA) e.V.
Air Quality & Sustainable Nanotechnology
Bliersheimer Strasse 60
47229 Duisburg
Germany

Irene Brüske-Hohlfeld
Helmholtz Zentrum München
Institut für Epidemiologie
Ingolstädter Landstrasse 1
85764 Neuherberg
Germany

Claire Bygott
Millennium Chemicals (Lyondell Group)
P.O. Box 26
Grimsby
Lincolnshire DN41 8DP
United Kingdom

Joydeep Dutta
Asian Institute of Technology
School of Engineering and Technology
P.O. Box 4, Klong Luang
Pathumthani 12 120
Thailand

Michele Edge
Manchester Metropolitan University
Biology, Chemistry and Health Sciences
Chester Street
Manchester M1 5GD
United Kingdom

Heinz Fissan
Institute of Energy and Environmental Technology (IUTA) e.V.
Air Quality & Sustainable Nanotechnology
Bliersheimer Strasse 60
47229 Duisburg
Germany

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Petra Klug
Forschungszentrum Karlsruhe GmbH
Molecular & Environmental Toxicology Laboratory
Hermann-von-Helmholtz-Platz 1
76344 Egg.-Leopoldshafen
Germany

Harald F. Krug
Empa – Materials Science & Technology
Lerchenfeldstrasse 5
9014 St. Gallen
Switzerland

Thomas A. J. Kuhlbusch
Institute of Energy and Environmental Technology (IUTA) e.V.
Air Quality & Sustainable Nanotechnology
Bliersheimer Strasse 60
47229 Duisburg
Germany

Deanna N. Lekas
The Woodrow Wilson International Center for Scholars
Washington
DC
USA

Shannon M. Lloyd
Concurrent Technologies Corporation
100 CTC Drive
Johnstown
PA, 15904
USA

Julie Maltby
Millennium Chemicals (Lyondell Group)
P.O. Box 26
Grimsby
Lincolnshire DN41 8DP
United Kingdom

Bernd Nowack
Empa – Materials Science & Technology
Technology and Society Laboratory
Lerchenfeldstrasse 5
9014 St. Gallen
Switzerland

Annette Peters
Helmholtz Zenturm München
Institut für Epidemiologie
Ingolstädter Landstrasse 1
85764 Neuherberg
Germany

Ulrich Pöschl
Max Planck Institute for Chemistry
Biogeochemistry Department
Becherweg 27/29
55128 Mainz
Germany

Ketra A. Schmitt
Battelle Memorial Institute
505 King Avenue
Columbus
OH, 43201
USA

John Stratton
Millennium Chemicals (Lyondell Group)
P.O. Box 26
Grimsby
Lincolnshire DN41 8DP
United Kingdom

Abhilash Sugunan
Asian Institute of Technology
School of Engineering and Technology
P.O. Box 4, Klong Luang
Pathumthani 12 120
Thailand

Ian Ivar Suni
Clarkson University
Department of Chemical and
Biomolecular Engineering
Potsdam
NY 13699-5705
USA

Joanne Verran
Manchester Metropolitan University
Biology, Chemistry and Health Sciences
Chester Street
Manchester M1 5GD
United Kingdom

Jess P. Wilcoxon
University of Birmingham
Nanophysics Research Laboratory
Edgbaston Road
Birmingham B15 2TT
United Kingdom

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Pollution Prevention and Treatment Using Nanotechnology

Bernd Nowack

1.1
Introduction

Environmental nanotechnology is considered to play a key role in the shaping of current environmental engineering and science. Looking at the nanoscale has stimulated the development and use of novel and cost-effective technologies for remediation, pollution detection, catalysis and others [1]. However, there is also a wide debate about the safety of nanoparticles and their potential impact on environment and biota [2, 3], not only among scientists but also the public [4, 5]. Especially the new field of nanotoxicology has received a lot of attention in recent years [6, 7]. Nanotechnology and the environment – is it therefore a Janus-faced relationship? There is the huge hope that nanotechnological applications and products will lead to a cleaner and healthier environment [8]. Maintaining and re-improving the quality of water, air and soil, so that the Earth will be able to support human and other life sustainably, are one of the great challenges of our time. The scarcity of water, in terms of both quantity and quality, poses a significant threat to the well-being of people, especially in developing countries. Great hope is placed on the role that nanotechnology can play in providing clean water to these countries in an efficient and cheap way [9]. On the other hand, the discussion about the potential adverse effects of nanoparticles has increased steadily in recent years and is a top priority in agencies all over the world [10, 11]. Figure 1.1 shows the hits for a search for "risk" related to nanotechnology in the Web of Science. Publications that deal in one way or other with "risk" have skyrocketed in the last few years since 2002.

The same properties that can be deleterious for the environment can be advantageous for technical applications and are exploited for treatment and remediation. Figure 1.2 shows a few examples of this Janus face of nanotechnology: engineered particles with high mobility are needed for efficient groundwater remediation, but at the same time this property will render a particle more difficult to remove during water treatment. The toxicity of some nanoparticles can be used for water disinfection where killing of microorganisms is intended, whereas the same property is unwanted

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