

WILEY-VCH

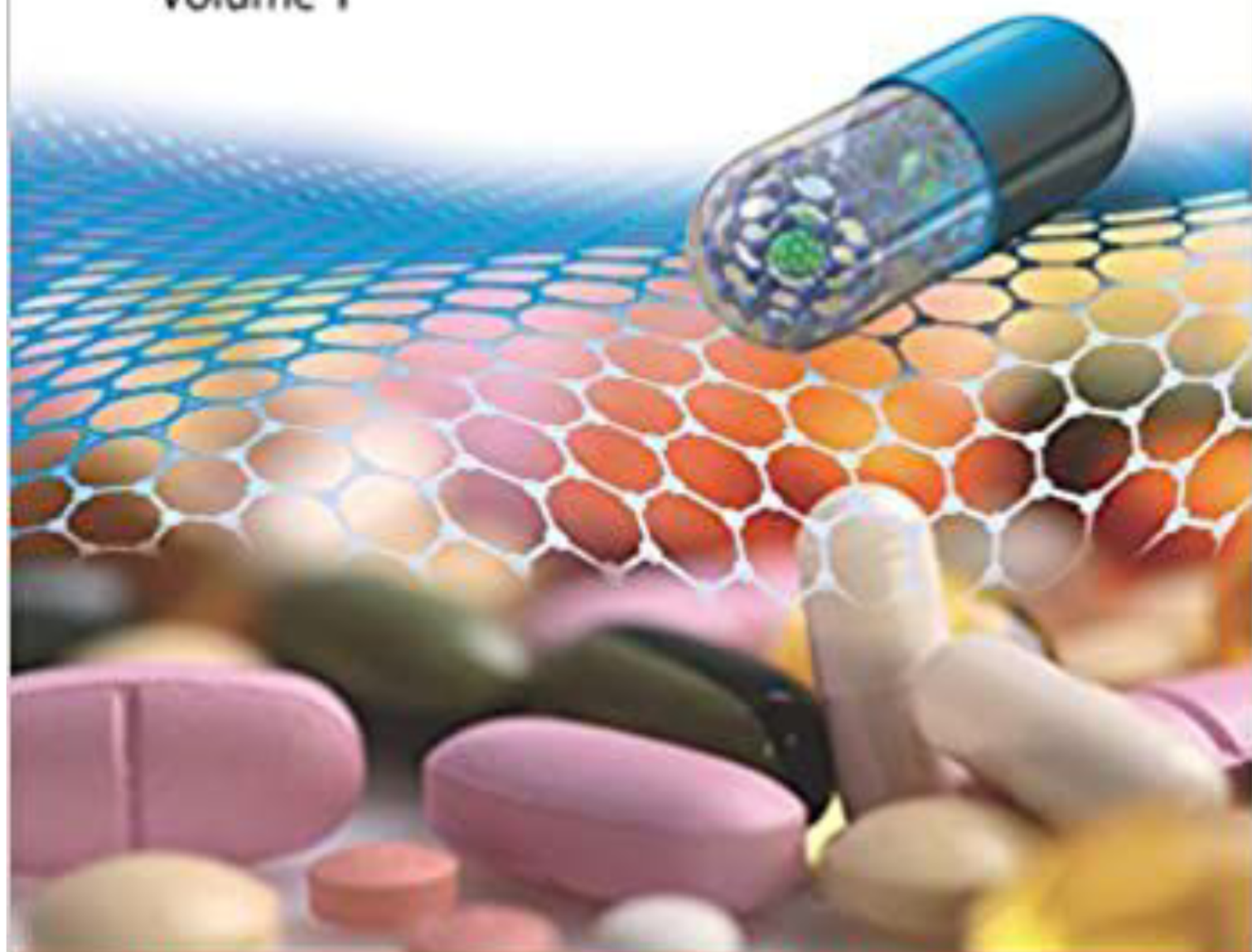
Edited by Jean Cornier, Andrew Owen, Arno Kwade,
and Marcel Van de Voorde

Pharmaceutical Nanotechnology

Innovation and Production

Volume 1

Series Editor:
Marcel Van de Voorde



Nanotechnology Innovation & Applications

*Edited by Jean Cornier,
Andrew Owen, Arno Kwade,
and Marcel Van de Voorde*

Pharmaceutical Nanotechnology

Further Volumes of the Series "Nanotechnology Innovation & Applications"

Axelos, M. A. V. and Van de Voorde, M. (eds.)

**Nanotechnology in
Agriculture and Food
Science**

2017

Print ISBN: 9783527339891

Müller, B. and Van de Voorde, M. (eds.)

**Nanoscience and
Nanotechnology for Human
Health**

2017

Print ISBN: 9783527338603

Fermon, C. and Van de Voorde, M. (eds.)

**Nanomagnetism
Applications and Perspectives**

2017

Print ISBN: 9783527339853

Puers, R., Baldi, L., van Nooten, S. E.,
Van de Voorde, M. (eds.)

**Nanoelectronics
Materials, Devices, Applications**

2017

Print ISBN: 9783527340538

Mansfield, E., Kaiser, D. L., Fujita, D.,
Van de Voorde, M. (eds.)

**Metrology and
Standardization for
Nanotechnology
Protocols and Industrial Innovations**

2017

Print ISBN: 9783527340392

Raj, B., Van de Voorde, M., Mahajan, Y.
(eds.)

**Nanotechnology for Energy
Sustainability**

2017

Print ISBN: 9783527340149

Meyrueis, P., Sakoda, K., Van de Voorde,
M. (eds.)

**Micro- and Nanophotonic
Technologies**

2017

Print ISBN: 9783527340378

Sels, B. and Van de Voorde, M. (eds.)

**Nanotechnology in Catalysis
Applications in the Chemical
Industry, Energy Development, and
Environment Protection**

2017

Print ISBN: 9783527339143

*Edited by Jean Cornier, Andrew Owen,
Arno Kwade, and Marcel Van de Voorde*

Pharmaceutical Nanotechnology

Innovation and Production

WILEY-VCH
Verlag GmbH & Co. KGaA

Volume Editors

Dr. Jean Cornier

vdiconsult
Seumestr. 7
81379 München
Germany

Prof. Andrew Owen

University of Liverpool
Department of Molecular & Clinical
Pharmacology
Ashton Street
Liverpool, L69 3GE
UK

Prof. Arno Kwade

TU Braunschweig
Partikeltechnik
Volkmaroder Str. 5
38104 Braunschweig
Germany

Prof. Dr. Dr. h.c. Marcel H. Van de Voorde

Member of the Science Council
of the French Senate and National
Assembly, Paris
Rue du Rhodania, 5
BRISTOL A, Appartement 31
3963 Crans-Montana
Switzerland

Series Editor

Prof. Dr. Dr. h.c. Marcel H. Van de Voorde

Member of the Science Council
of the French Senate and National
Assembly, Paris
Rue du Rhodania, 5
BRISTOL A, Appartement 31
3963 Crans-Montana
Switzerland

Cover credits: Pills bottom and background:

fotolia © Sven Bähren

3D pill top right with nanostructure inside:

© mauritius-images

■ All books published by **Wiley-VCH** are carefully produced. Nevertheless, authors, editors, and publisher do not warrant the information contained in these books, including this book, to be free of errors. Readers are advised to keep in mind that statements, data, illustrations, procedural details or other items may inadvertently be inaccurate.

Library of Congress Card No.: applied for

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at <http://dnb.d-nb.de>.

© 2017 Wiley-VCH Verlag GmbH & Co. KGaA,
Boschstr. 12, 69469 Weinheim, Germany

All rights reserved (including those of translation into other languages). No part of this book may be reproduced in any form – by photoprinting, microfilm, or any other means – nor transmitted or translated into a machine language without written permission from the publishers. Registered names, trademarks, etc. used in this book, even when not specifically marked as such, are not to be considered unprotected by law.

Print ISBN: 978-3-527-34054-5

ePDF ISBN: 978-3-527-80067-4

ePub ISBN: 978-3-527-80069-8

Mobi ISBN: 978-3-527-80070-4

oBook ISBN: 978-3-527-80068-1

Cover Design Adam Design

Typesetting Thomson Digital, Noida, India

Printing and Binding

Printed on acid-free paper

*Thanks to my wife for her patience with me spending
many hours working on the book series through
the nights and over weekends.
The assistance of my son Marc Philip related to the complex
and large computer files with many sophisticated scientific
figures is also greatly appreciated.*

Marcel Van de Voorde

Series Editor Preface

Since years, nanoscience and nanotechnology have become particularly an important technology areas worldwide. As a result, there are many universities that offer courses as well as degrees in nanotechnology. Many governments including European institutions and research agencies have vast nanotechnology programmes and many companies file nanotechnology-related patents to protect their innovations. In short, nanoscience is a hot topic!

Nanoscience started in the physics field with electronics as a forerunner, quickly followed by the chemical and pharmacy industries. Today, nanotechnology finds interests in all branches of research and industry worldwide. In addition, governments and consumers are also keen to follow the developments, particularly from a safety and security point of view.

This books series fills the gap between books that are available on various specific topics and the encyclopedias on nanoscience. This well-selected series of books consists of volumes that are all edited by experts in the field from all over the world and assemble top-class contributions. The topical scope of the book is broad, ranging from nanoelectronics and nanocatalysis to nanometrology. Common to all the books in the series is that they represent top-notch research and are highly application-oriented, innovative, and relevant for industry. Finally they collect a valuable source of information on safety aspects for governments, consumer agencies and the society.

The titles of the volumes in the series are as follows:

Human-related nanoscience and nanotechnology

- *Nanoscience and Nanotechnology for Human Health*
- *Pharmaceutical Nanotechnology*
- *Nanotechnology in Agriculture and Food Science*

Nanoscience and nanotechnology in information and communication

- *Nanoelectronics*
- *Micro- and Nanophotonic Technologies*
- *Nanomagnetism: Perspectives and Applications*

Nanoscience and nanotechnology in industry

- Nanotechnology for Energy Sustainability
- Metrology and Standardization of Nanomaterials
- Nanotechnology in Catalysis: Applications in the Chemical Industry, Energy Development, and Environmental Protection

The book series appeals to a wide range of readers with backgrounds in physics, chemistry, biology, and medicine, from students at universities to scientists at institutes, in industrial companies and government agencies and ministries.

Ever since nanoscience was introduced many years ago, it has greatly changed our lives – and will continue to do so!

March 2016

Marcel Van de Voorde

About the Series Editor



Marcel Van de Voorde, Prof. Dr. ir. Ing. Dr. h.c., has 40 years' experience in European Research Organisations, including CERN-Geneva and the European Commission, with 10 years at the Max Planck Institute for Metals Research, Stuttgart. For many years, he was involved in research and research strategies, policy, and management, especially in European research institutions.

He has been a member of many Research Councils and Governing Boards of research institutions across Europe, the United States, and Japan. In addition to his Professorship at the University of Technology in Delft, the Netherlands, he holds multiple visiting professorships in Europe and worldwide. He holds a doctor honoris causa and various honorary professorships.

He is a senator of the European Academy for Sciences and Arts, Salzburg, and Fellow of the World Academy for Sciences. He is a member of the Science Council of the French Senate/National Assembly in Paris. He has also provided executive advisory services to presidents, ministers of science policy, rectors of Universities, and CEOs of technology institutions, for example, to the president and CEO of IMEC, Technology Centre in Leuven, Belgium. He is also a Fellow of various scientific societies. He has been honored by the Belgian King and European authorities, for example, he received an award for European merits in Luxemburg given by the former President of the European Commission. He is author of multiple scientific and technical publications and has coedited multiple books, especially in the field of nanoscience and nanotechnology.