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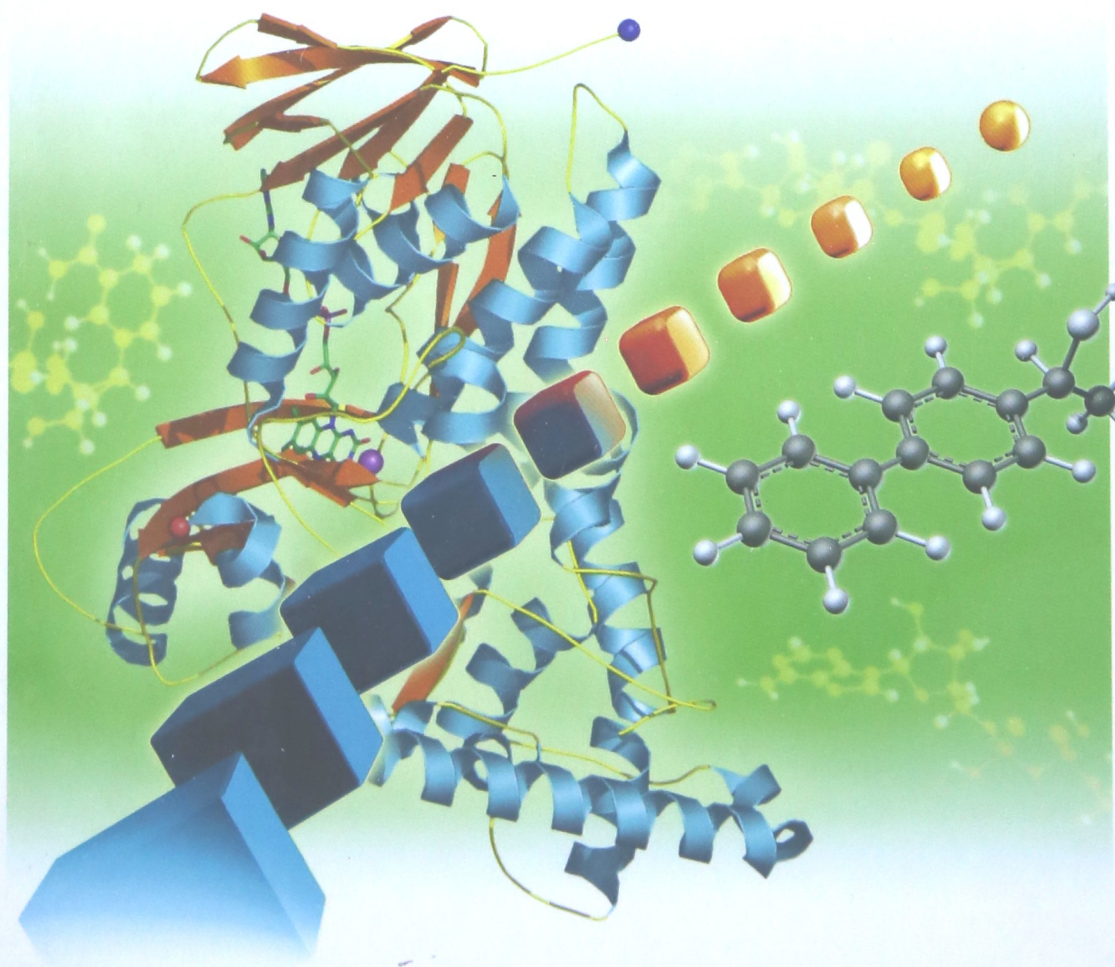
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Enzyme Catalysis in Organic Synthesis

With a Foreword by Herbert Waldmann

Third, Completely Revised
and Enlarged Edition

Volume 2



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Harald Gröger, and Oliver May*

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**WILEY-
VCH**

WILEY-VCH Verlag GmbH & Co. KGaA

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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>.

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Boschstr. 12, 69469 Weinheim, Germany

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Cover Design Formgeber, Eppelheim
Typesetting Thomson Digital, Noida, India
Printing and Binding betz-druck GmbH, Darmstadt

Printed in the Federal Republic of Germany
Printed on acid-free paper

Print ISBN: 978-3-527-32547-4

eBook ISBN: 978-3-527-63986-1

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Synthesis**

Volume 2

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Foreword

When the first edition of *Enzyme Catalysis in Organic Synthesis: A Comprehensive Handbook* was planned and then published biocatalysts had made their first major impact on research in organic synthesis both in academia and in industry. Significant advances in the expression and isolation of enzymes as well as techniques for their immobilization and stabilization had prompted a flurry of research activities and publications from the organic chemistry community and the industrial sector. This was adequately reflected in the “handbook” with its dominant central part summarizing applications of enzymes in academic and industrial synthesis, arranged according to reaction type.

In the following years, the number of applications – less so the kind of novel transformations – steadily grew, but gradually the main emphasis in the community shifted from the application to the biocatalysts themselves. Directed evolution, molecular biology techniques, and biocatalyst design began to have a major impact and to define new challenges and the frontier of research in the field.

Since the publication of the second edition the use of “enzymes in organic synthesis” has again undergone a major shift in emphasis. “Green chemistry,” the focus of the chemical industry towards increasingly environmentally friendlier processes, is now a major driver in the establishment of novel techniques and transformations, and clearly the advantages of biocatalytic transformations shape the field to a major extent. Along with the scientific and economic pull arising from this industrial demand, the scientific push provided by the rise of “synthetic biology” offers completely novel opportunities for research and application.

This shift in emphasis since the publication of the first edition is mirrored by an appropriate change in the editors (and of course the authors) of the “handbook.” Karlheinz Drauz has a knowledge of the whole field and experience in research in biocatalysis in more fundamental research as well as in industrial application that is second to none. He guarantees the continuity and the “reality check” that the practicing reader of a “handbook” expects. Harald Gröger and Oliver May together guarantee that the face-changing recent developments in academia and industry are very well reflected in the scientific and technological expertise of the editorial team.

The third edition of *Enzyme Catalysis in Organic Synthesis* accordingly has kept the originally chosen classification of biocatalytic transformations by reaction type but it also covers new developments that have changed and will change the face of the field.

It is not only an invaluable source of knowledge and references, it also embodies a treasure that consists of a multitude of findings not yet exploited by the scientific community. I have no doubt that – like the first and the second editions – it will fuel numerous research projects and industrial applications.

Dortmund, November 2011
Herbert Waldmann

About the Editors



Karlheinz Drauz Karlheinz Drauz was Vice President International Scientific Relations of Evonik Degussa. He evaluated interesting topics in research and development and networks globally with academic and industrial institutions. He did his Ph.D. at the Technical University Stuttgart, Germany, and started his career at Degussa 1980 and run through various positions in research and development and innovation management. Amongst his research interests are amino acids, peptides, biological active compounds, asymmetric synthesis, metal and biocatalysis as well as material science and process

chemistry. He holds more 160 patents and 100 scientific publications. Since 1992 he is honorary professor for organic chemistry at the University Würzburg, Germany. Since 2010 he functions as Senior Advisor.



Harald Gröger Harald Gröger studied Chemistry at the Universities of Erlangen-Nürnberg and Oldenburg and received his diploma degree in Chemistry from the University of Oldenburg in 1994. His doctoral thesis he completed at the University of Oldenburg in 1997 under the supervision of Prof. Dr. Martens. After staying as a postdoctoral fellow at the University of Tokyo in the group of Prof. Dr. Shibasaki, he joined the research department Chemische Forschung of SKW Trostberg AG in 1998. After the merger with Degussa-Hüls AG to Degussa AG in 2001, he became Project Manager in the Project

House Biotechnology of Degussa AG. From 2004 to 2006 he worked as a Senior Project Manager at the research unit Service Center Biocatalysis of Degussa AG. From 2006 to 2011 he was W2-Professor (Associate Professor) for Organic Chemistry

at the University of Erlangen-Nürnberg, and since April 2011 he is W3-Professor (Full Professor) for Organic Chemistry at Bielefeld University. Harald Gröger has authored more than 90 scientific publications and more than 30 patent applications. He and his teams were awarded the Degussa Innovation Award 2003 (category: new products) and the Degussa Innovation Award 2005 (category: new or improved processes). In addition, he was awarded the Carl-Duisberg-Memorial-Prize 2008 of the German Chemical Society (GDCh). His main current research areas center on the use of biocatalysts in organic synthesis.



Oliver May Oliver May is R&D Director of DSM Bio-based Products & Services and was responsible for the Biocatalysis competence field within DSM as Corporate Scientist. Before joining DSM in April 2006, he was with Degussa (now Evonik) in various functions; latest as General Manager of Degussa's Service Center Biocatalysis. He was educated in Germany, receiving a PhD degree in Technical Biology from the University of Stuttgart where he worked at the Institute of Biochemical Engineering for Prof. C. Syldatk and at the German Center for Biotechnology in Braunschweig with Prof. D. Schomburg. He joined Caltech as a postdoc in 1998 where he worked

until 2000 in the group of Prof. F.H. Arnold on directed evolution of enzymes. Oliver May has authored more than 40 scientific contributions in Journals and Books and more than 15 patent applications. He and his team was awarded several research & innovation awards on hydantoinase technology, whole-cell processes, recombinant pig liver esterase in its application for production of a pharma intermediate and the latest on advanced yeasts for production of bioethanol from cellulosic feedstocks.

Preface

While biocatalysis experts refer to the previous two editions of this handbook as “The Drauz–Waldmann” handbook its official title is of course *Enzyme Catalysis in Organic Synthesis* and it is recognized as a reference work in the field of biocatalysis. We hope this third edition will provide the same value as the previous two editions and so become known as “The Drauz–Gröger–May” handbook. The fact that you are holding this book in your hands shows your trust in our selection of the world renowned experts who have authored this book. All the authors have put a lot of effort into their individual chapters to secure high level contributions and to create a reference work on biocatalysis.

We felt that a third edition is necessary as ten years have elapsed since the last edition, which is a long time in such a dynamic field. Progress is reflected by the fact that many of the chapters had to be completely rewritten and new chapters have been added. To show the relevance of biocatalysis one fact was very important for us: highlighting proven industrial applications by adding new coherently structured application sections to the various chapters dealing with the different chemical reaction types. We hope this will convince non-professionals in biocatalysis that this technology is an established tool that should not be omitted from the repertoire of any chemist working on the development of highly efficient syntheses in academia as well as industry.

There are also elements that we did not want to change. Again we have chosen to keep the overall arrangement of three different volumes, of which the first provides a comprehensive introduction to the field and important enabling tools. The other two volumes focus on specific reaction types and emerging fields in biocatalysis. Many evolutions, or even revolutions, have taken place over the last decade, especially in the field of enabling tools. While directed evolution was just emerging when we issued the second edition, in the first volume of this new edition genome sequencing, gene synthesis, metagenomics, and bioinformatics are now much more prominently featured as standard tools that have an enormous positive impact on development speed and diversity of enzymes that can thus be created. The reader will also observe many new developments in specific reaction types, for example, the conversion of ketones into amines and alcohols triggered by the improved accessibility of transaminases and dehydrogenases.

We hope this book will motivate a generation of open-minded chemists to capture the full potential of biocatalysis and to collaborate closely with biologists to enable urgently needed innovations for today in an alliance that enables the most successful mastery of chemistry in the future.

Hanau, Bielefeld, and Aachen
November 2011

*Karlheinz Drauz, Harald Gröger,
and Oliver May*

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