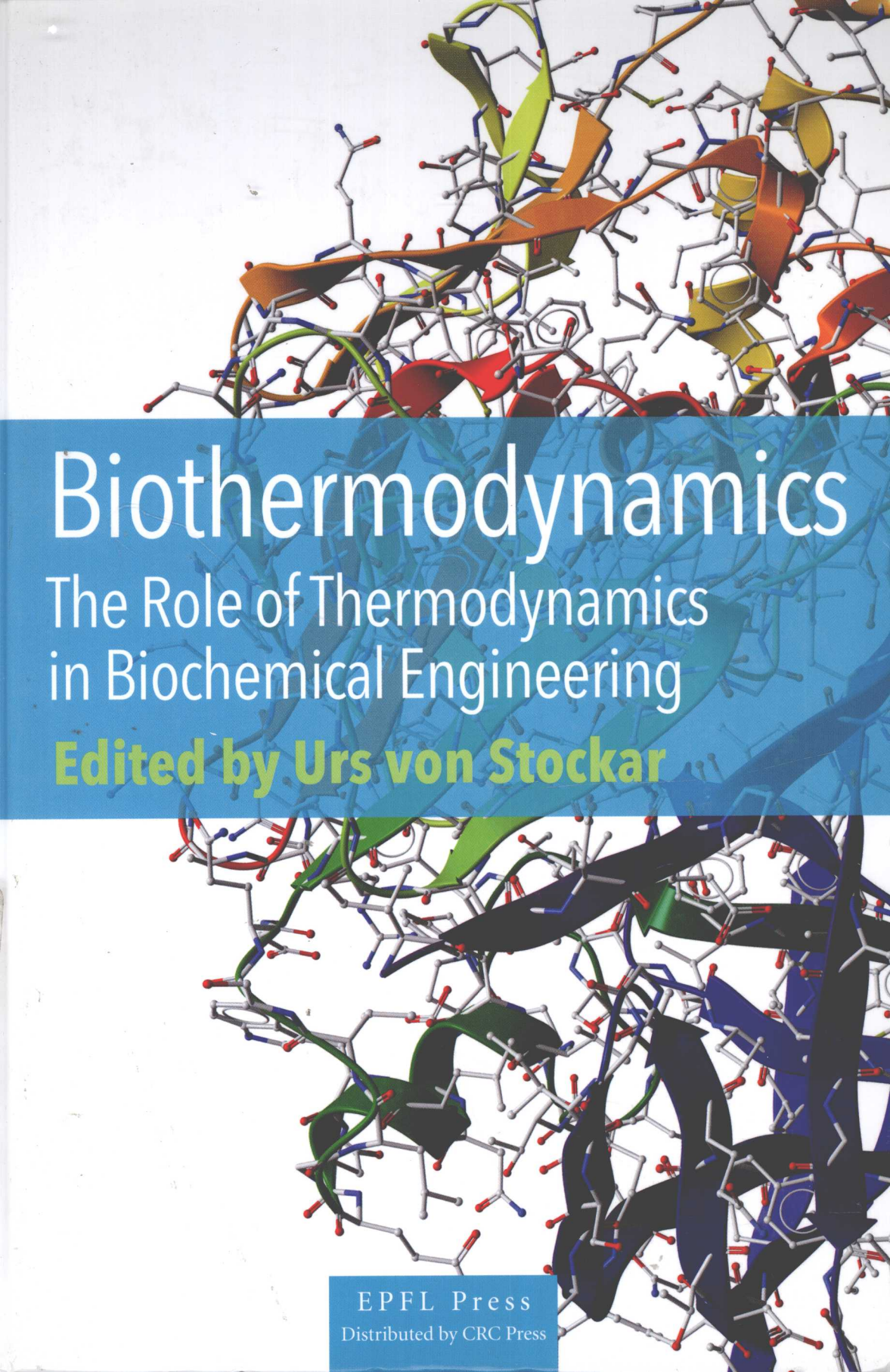

Biothermodynamics

The Role of Thermodynamics in Biochemical Engineering

Edited by Urs von Stockar

EPFL Press
Distributed by CRC Press

Biothermodynamics

The Role of Thermodynamics in Biochemical Engineering

Edited by Urs von Stockar

常州大学山书馆
藏书章

WITH CONTRIBUTIONS BY: John F. Carpenter, Eva Y. Chi, A. Espah Borujeni, M.T. Gude, W.M. van Gulik, Charles Haynes, Sef J. J. Heijnen, Curtis B. Hughesman, Gisela Karlström, Jürgen U. Keller, E. Jamalzadeh, Marcel L. Jansen, Hans-Olof Johansson, Karel Ch. A. M. Luyben, Thomas Maskow, Willem Norde, John M. Prausnitz, Theodore W. Randolph, E. S. J. Rudolph, Urs von Stockar, Adrie Straathof, H. Taymaz-Nikerel, Folke Tjerneld, Robin F. B. Turner, Patricia Vázquez Villegas, Voja Vojinic, P. J. T. Verheijen, and Luuk van der Wielen.

EPFL Press
A Swiss academic publisher distributed by CRC Press

CRC Press
Taylor & Francis Group

Taylor and Francis Group, LLC
6000 Broken Sound Parkway, NW, Suite 300,
Boca Raton, FL 33487

Distribution and Customer Service
orders@crcpress.com

www.crcpress.com

Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress.

This book is published under the editorial direction of
Professor Hubert Girault (EPFL).

The publisher thanks James DeRose for his careful copyediting of the original manuscript.

The editor would like to acknowledge the role of DECHEMA-Forschungsinstitut, which helped organize the course around which this book is structured.

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

The publisher and author express their thanks to the Ecole Polytechnique Fédérale de Lausanne (EPFL) for its generous support towards the publication of this book.

EPFL Press

The EPFL Press is the English-language imprint of the Foundation of the Presses polytechniques et universitaires romandes (PPUR). The PPUR publishes mainly works of teaching and research of the Ecole polytechnique fédérale de Lausanne (EPFL), of universities and other institutions of higher education.

Presses polytechniques et universitaires romandes, EPFL – Rolex Learning Center,
Post office box 119, CH-1015 Lausanne, Switzerland
E-mail: ppur@epfl.ch
Phone: 021/693 21 30
Fax: 021/693 40 27

www.epflpress.org

© 2013, First edition, EPFL Press
ISBN 978-2-940222-61-2 (EPFL Press)
ISBN 978-1-4665-8216-3 (CRC Press)

Printed in Italy

All right reserved (including those of translation into other languages). No part of this book may be reproduced in any form – by photoprint, microfilm, or any other means – nor transmitted or translated into a machine language without written permission from the publisher.

Biothermodynamics

Cover Illustration: © Leonid Andronov - Fotolia.com

此为试读,需要完整PDF请访问: www.ertongbook.com

PREFACE

Biotechnology is a fascinating yet complex area with enormous potential for enhancing the well-being of mankind and of the environment. For those applications under development that aim to bring this potential to fruition, biotechnologists and biochemical engineers seek those fundamental principles that provide insight into the immensely complicated behaviour of the biological and biochemical world and that can be used for planning experimental research and interpreting results.

In the early 90s, the Steering Committee of the European Science Foundation (ESF) program on Process Integration in Biochemical Engineering (PIBE) recognized that thermodynamics represents one set of such fundamental principles, but which had hitherto only rarely been applied in biotechnology, although quite a substantial body of knowledge and results had already been published. It therefore decided to develop a course for advanced graduate students and researchers in order to make the field of themodynamics as applied to biotechnology better known, and in order to stimulate its use.

Since then, this graduate course on *Thermodynamics in Biochemical Engineering* has taken place six times: 1994 in Toulouse (F), 1996 in Braga (P), 1998 in Nijmegen (NL), 2000 on Monte Verità above Ascona (CH), 2005 in Mürren (CH) and 2008 in Biedenkopf (D). Table 1 lists the lecturers who taught these courses. They were organized and coordinated by L.A.M. van der Wielen and / or U. von Stockar.

In all these years, a considerable amount of course material has accumulated. The aim of this book is to make this available to a larger audience in an up-dated and edited format. The book will also serve as a formal basis for future advanced courses on thermodynamics in biochemical engineering.

The very nature of such an endeavour makes the perfect matching of writing and presentation styles for the individual chapters impossible. The fact that thermodynamics has not yet been very widely applied in biotechnology, and that consequently many biotechnologists are unfamiliar with thermodynamics, made it necessary to include quite a number of chapters intended as introductions to particular topics and written in a pedagogical manner. At the same time, a growing number of research projects on the application of thermodynamics to biochemical engineering are carried out and published. In an attempt to inform the reader on the state of art in this field, other chapters represent reviews of cutting edge research and results.

For the courses, a large number of problems and assignments for the participants have been developed as well. Some of these are included in certain chapters as

Table 1 List of speakers who have lectured in one or several advanced courses on Thermodynamics in Biochemical Engineering.

Lecturers	Affiliation	Country
J. de Swaan Arons	Delft University of Technology (TUD)	The Netherlands
F. Franks	Pafra Ltd, Cambridge	United Kingdom
E. Gnaiger	University Hospital	Austria
P. J. Halling	University of Strathclyde, Glasgow	United Kingdom
C. A. Haynes	University of British Columbia, Vancouver	Canada
J. J. Heijnen	Delft University of Technology (TUD)	The Netherlands
J. Keller	Universität Siegen	Germany
T. Maskow	Umwelt Forschungszentrum (UFZ) Leipzig	Germany
W. NOrde	Wageningen University (WUR)	The Netherlands
J. M. Prausnitz	University of California, Berkeley	USA
T. Randolph	University of Colorado, Boulder	USA
S. Rudolph	Delft University of Technology (TUD)	The Netherlands
A. J. J. Straathof	Delft University of Technology (TUD)	The Netherlands
L. A. M. van der Wielen	Delft University of Technology (TUD)	The Netherlands
U. von Stockar	Swiss Federal Institute of Technology Lausanne	Switzerland
H. Wennerström	University of Lund	Sweden

sample calculations or examples, and we are convinced that the reader will appreciate these as highly valuable help in understanding difficult topics. A larger number of assignments and worked results, however, remain in our files. Space restrictions for this current volume do not allow us to publish the exercises together in a single volume, so in order to help the interested reader a selection of these will be made available as Mathcad files in the summer of 2013 (information concerning the availability of this supplementary material can be found at the publisher's website: http://www.epflpress.org, on the page dedicated to this book). These very same exercises will be elaborated and edited in book form at some later date.

Many people have contributed toward the present work. The authors are indebted to a large number of graduate students, postdocs and secretaries who have helped us to organize, prepare and teach the various international courses. We acknowledge DECHEMA in Frankfurt for having organized the last course in Biedenkopf. The authors would like to thank those colleagues who have taken the time to read and review the manuscripts. We are grateful to Lars Regestein, RWTH Aachen, for having advised us on the assignment problems after having conducted a critical evaluation of the full set.

Luuk van der Wielen
Course coordinator

Urs von Stockar
Editor, Course coordinator

ABOUT THE AUTHORS

John F. Carpenter joined the faculty at the University of Colorado School of Pharmacy in 1993 where he is currently Professor of Pharmaceutical Sciences and Co-Director of the University of Colorado Center for Pharmaceutical Sciences. His research interests include stabilization and degradation of therapeutic protein during processing, formulation and delivery, and development of new analytical methods for protein aggregation and particle formation.

Eva Y. Chi received a Ph.D. degree in Chemical Engineering from the University of Colorado, during which she worked with Prof. Theodore Randolph on the thermodynamics of protein aggregation. She is now an Assistant Professor of Chemical Engineering at the University of New Mexico. Her current research interests include physical properties and self-assembly behaviors of proteins, polymers, and biomembranes, where biomolecular thermodynamics plays a central role.

Charles Haynes is Professor at the Michael Smith Laboratories of the University of British Columbia, Canada. His laboratory runs the Centre for Biological Calorimetry, a federally funded centre which provides Canada with state-of-the-art methods for measuring the delicate energetics of biological interactions in solution or at interfaces.

Sef J. J. Heijnen is professor and group leader for Bioprocess Technology, Department of Biotechnology, Faculty of Applied Sciences, Delft University of Technology, The Netherlands. He has worked in the fermentation industry (1973-1988) and at TU-Delft (1988) in bioprocess technology. His interest is in design based on thermodynamic/kinetic/transport modelling of industrial processes and for micro-organisms (cell systems engineering).

Jürgen U. Keller is professor at the Institute for Fluid Dynamics and Thermodynamics, University of Siegen, Germany.

Marcel L. Jansen is Manager of the department Process Support and Development at Sanquin Blood Supply Foundation, Division of Plasma Products in Amsterdam, The Netherlands. After doctoral studies at the Delft University of Technology, he started R&D career in downstream processing in the biopharmaceutical industry in 1996. He

joined the plasma fractionation industry in 2004, where he is currently responsible for production support, process development, process engineering and validation.

Hans-Olof Johansson is in the Department of Biochemistry and Structural Biology, Lund University, Sweden. His main interest is modeling the thermodynamic driving forces of protein-polymer interactions. His two main areas of research are aqueous two-phase systems for bioseparation and surface-tethered polymers and proteins.

Gunnar Karlström is professor in the Department of Theoretical Chemistry, Lund University, Sweden. His main areas of activity are macroscopic properties of dipolar systems as described by quantum chemistry and intermolecular interactions in condensed phases.

Karel Ch.A.M. Luyben is Rector Magnificus of the Delft University of Technology. In 1983 he was appointed as professor in Biochemical Engineering at the Delft University of Technology. From 1985-1990, he was Chairman of the Netherlands Biotechnology Society (NBV). He was Scientific Director of the Graduate School 'Biotechnological Sciences Delft Leiden' (BSDL) from its foundation in 1993 up until 1998.

Thomas Maskow is head of the Group Biocalorimetry/Ecothermodynamics, Department of Environmental Microbiology at the Helmholz Center for Environmental Research-UFZ, Germany.

Willem Norde (PhD, Wageningen University, The Netherlands) is professor emeritus in Bionanotechnology at Wageningen University and professor in Colloid and Interface Science at the University Medical Center Groningen, The Netherlands. He has a long expertise in studying interactions among (bio)colloidal particles, and between such particles and surfaces. He has been visiting professor at various universities around the world.

John M. Prausnitz is Professor in the Graduate School, Department of Chemical and Biomolecular Engineering, University of California, Berkeley. He is author of the widely-used textbook *Molecular Thermodynamics of Fluid-Phase Equilibria*. He is a member of the National Academy of Sciences, the National Academy of Engineering, and the American Academy of Arts and Sciences. He has received honorary doctoral degrees from four universities: L'Aquila, Padua, Berlin and Princeton. In 2005, he received the National Medal of Science.

Theodore W. Randolph accepted the Patton Associate Professor chair in the Department of Chemical Engineering at the University of Colorado, where he currently serves as the Gillespie Professor of Bioengineering and co-Director of the University of Colorado's Center for Pharmaceutical Biotechnology. His research interests

include biopharmaceutical formulation, lyophilization of proteins, protein-solvent interactions in non-aqueous environments, and protein refolding.

Urs von Stockar has been professor at the Swiss Federal Institute of Technology in Lausanne (EPFL) since 1977, where he has conducted research on gas-liquid mass transfer, integrated bioprocessing and biocalorimetry. He is an individual member of the scientific committee of the Swiss Academy of Technical Sciences.; chairman of the Swiss Coordination Committee for Biotechnology; and executive committee member of the European Federation of Biotechnology since 1990. Since 2007, he is honorary professor of the Swiss Federal Institute of Technology, Lausanne and adjunct professor of the Dublin City University.

Adrie Straathof is associate professor at the BioSeparation technology group of the Department of Biotechnology of the Delft University of technology. His research interests are (a) enzymatic and microbial manufacturing of fine chemicals, bulk chemicals and bio- fuels; (b) in situ product recovery using crystallization, adsorption, extraction, and membrane permeation; (c) model-based and experimental process integration; and (d) kinetics and thermodynamics for biotechnological processes.

Folke Tjerneld is professor in the Department of Biochemistry and Structural Biology, Lund University, Sweden. He has extensive research experience in separation processes involving aqueous two-phase systems and enzymatic conversions of cellulose.

Robin F. B. Turner is professor in the Michael Smith Laboratories, Electrical & Computer Engineering, and Chemistry (Associate) at The University of British Columbia. His current research activities focus on development of optical techniques and related signal processing & chemometric methods for biomolecular spectroscopy, as well as applications to problems in biochemistry, biotechnology, and biomedical engineering.

Luuk van der Wielen is Distinguished Professor for Biobased Economy, Delft University of Technology, The Netherlands (www.bt.tudelft.nl), Chairman of the Executive Board of BE-Basic Foundation, the public-private partnership for industrial and environmental biotechnology, executing a worldwide $ 60 mio per annum innovation program (www.be-basic.org), and various other international advisory and supervisory positions.

CONTENTS

PART I
FUNDAMENTALS

此为试读，需要完整PDF请访问：www.ertongbook.com

PART III
STABILITY AND ACTIVITY OF BIOMACROMOLECULES

PART IV
THERMODYNAMICS IN LIVING SYSTEMS

此为试读,需要完整PDF请访问: www.ertongbook.com