

Preface

Filamentous cells and organisms are of major biotechnological importance. The technical requirements for the cultivation of *Penicillium* and *Aspergilli* gave a fundamental impulse for the development of sophisticated and powerful bioreactors, enzymes of *Trichoderma* are key players in modern biorefineries, and hairy roots of plant cells are expected to be the producer of interesting new secondary metabolites for pharmaceutical and other applications.

There exist many publications in which the specific biotechnological processes are described and evaluated. Nevertheless, a methodological compendium from the viewpoint of Bioprocess Engineers is missing. This gap shall be filled by this volume of Advance in Biochemical Engineering/Biotechnology. All reviews have a strong focus on new monitoring methods and to some extent their combination, with respect to characterize the morphological structure of the cells or organisms. The generation of mathematical multi-scale models and the application of appropriate control strategies for exploiting the high potential of these interesting and challenging biological systems are described in detail by the corresponding reviews in this issue.

The first review article by Walisko and Moench-Tegeder et al. (Institute of Biochemical Engineering, Technische Universität Braunschweig, Germany) highlights the progress in the characterisation and control of filamentous morphology with particular regard to fungal (eukaryotic) and bacterial (prokaryotic) filamentous morphologies since the mid of the 20th century. Recent strategies for the control of bioparticle shape and bioprocess performance for high product yields of filamentous systems with classical biochemical engineering parameters, targeted morphology engineering and genetic engineering will be discussed.

The contribution of Quintanilla et al. (Department of Chemical and Biochemical Engineering, Technical University of Denmark (DTU), Lyngby, Novozymes A/S, Kalundborg/Bagsværd, Denmark) outlines the important aspects concerning the ways that morphology can be measured in fungal systems. The review discusses critically the main problems to identify unique key parameters and to provide clear relationships between morphology, productivity, shear forces and rheology.

Serrano-Carreón and Galindo et al. (Departamento de Ingeniería Celular y Biocatálisis, Instituto de Biotecnología, Universidad Nacional Autónoma de México, Cuernavaca, México) present the current knowledge on the influence of hydrodynamic conditions on macroscopic morphology development in mycelial microorganisms such as filamentous fungi. Basic aspects of hydrodynamic mechanical stress and mass transfer on mycelial development and their consequences on growth and productivity of pelleted and dispersed mycelia are focused.

The most important scientific issues connected with the research of *Aspergilli*, their metabolites and their omics technologies are summarized in the contribution of Meyer et al. (Institute of Biotechnology, Department Applied and Molecular Microbiology, and Institute of Process Engineering, Department Measurement and Control, Berlin University of Technology, Berlin, Germany). Their overview illustrates the broad portfolio of methods and tools in molecular biotechnology and control engineering to quantify and model fungal morphology.

The contribution of Bizukojc and Ledakowicz (Lodz University of Technology, Department of Bioprocess Engineering, Lodz, Poland) concisely reviews the aspects in bioprocess engineering of the production of the antihypercholesterolemia drug lovastatin by the fungus *Aspergillus terreus* in the submerged cultivation in various scales. As key factors broth viscosity in conjunction with non-Newtonian behaviour of the cultivation broths, and multi-stage oxygen transfer processes were identified. Microscopic (e.g. cell concentration and morphology) and macroscopic (e.g. rheological behaviour, transfer limitation) process parameters as well as biological kinetics during *A. terreus* cultivation considering industrial realistic operating conditions are discussed.

In the review of Sugai-Guério et al. (Departamento de Engenharia Química e Engenharia de Alimentos, Universidade Federal de Santa Catarina, Florianópolis, Brazil, Departamento de Bioquímica e Biologia Molecular and Departamento de Química, Universidade Federal do Paraná, Paraná, Brazil) from the Mitchell-group, the problem of modeling the growth of filamentous fungi is addressed. Such models are necessary for a rational design and processing of solid state fermentations. The authors point out that, until now, there was not a comprehensive modeling approach in this field. They claim that a combination of biological and mass transfer phenomena should be considered in such a model, and they conclude that a discrete lattice-based model which uses differential equations to describe mass balances would be most appropriate for this application.

Solid-state fermentation is recommended for the cultivation of basidiomycetes since it mimics the natural habitat of these fungi. There are some major advantages of solid-state fermentation; however, monitoring key variables like biomass is difficult and makes process design, scale up, and control a real challenge. Steudler and Bley (Institute of Food Technology and Bioprocess Engineering, Technische Universität Dresden, Germany) give, in this review, a current overview of various direct and indirect biomass determination methods, discussing their advantages and disadvantages.

Questions and solutions in the field of monitoring and modeling the growth of hairy roots in bioprocesses are documented and discussed in the review of Lenk and

Bley (Institute of Food Technology and Bioprocess Engineering, Technische Universität Dresden, Germany). It is described that there are no online direct measurement methods for biomonitoring of those processes, but reliable indirect methods for these processes were developed. Four independent modeling architectures in this field are described and compared: continuous models, metabolic flux models, agent-based models, and neural networks. A new agent-based macroscopic with 3D visualization of simulation results is presented in detail.

Tian (Department of Plant Sciences, University of California, Davis, USA) argues that hairy root culture presents an excellent platform for producing valuable plant secondary metabolites. This chapter focuses on several major groups of secondary metabolites that are manufactured by hairy roots established from different plant species, and gives a very broad and thorough survey of this type of new bioprocesses. Additionally, the methods for preservation of hairy roots are also reviewed.

In their article Nguyen et al. (Université de Toulouse; INSA; INRA, Toulouse, France) share their broad expertise concerning the ways that morphological structure of pre-treated particulate lignocellulose suspensions can be characterized by elaborated rheological methods. These media show similar characteristics as particulate cultivation media and broths with filamentous microorganisms. Thus, the described rheological techniques are suitable tools that could be transferred to cultivation media with filamentous microorganisms and/or will be subject of further research with filamentous cultivation broths.

We would like to thank all the authors for their valuable contributions and discussions on this fascinating and inspiring topic. We also want to thank Springer for implementation of this project as well as Thomas Scheper and the Springer team for suggestions, ideas, and patience during the preparation of this volume.

Braunschweig
Dresden
March 2015

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Filaments in Bioprocesses

Krull, R.; Bley, Th. (Eds.)

2015, X, 364 p. 64 illus., 28 illus. in color., Hardcover

ISBN: 978-3-319-20510-6