Biomass Conversion

The Interface of Biotechnology, Chemistry and Materials Science

Bearbeitet von
Chinnappan Baskar, Shikha Baskar, Ranjit S. Dhillon

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Preface

Conventional resources, mainly fossil fuels, are becoming limited because of the rapid increase in energy demand. This imbalance in energy demand and supply has placed immense pressure not only on consumer prices but also on the environment, prompting mankind to look for sustainable energy resources. Biomass is one of the few resources that has the potential to meet the challenges of sustainable and green energy systems. Biomass can be converted into three main products such as energy, biofuels and fine-chemicals using a number of different processes. Today, its a great challenge for researchers to find new environmentally benign methodologies for biomass conversion, which are industrially profitable as well.

This book aims to offer the state-of-the-art reviews, current research and the future developments of biomass conversion to bioenergy, biofuels, fatty acids, and fine chemicals with the integration of multi-disciplinary subjects which include biotechnology, microbiology, energy technology, chemistry, materials science, and engineering.

The chapters are organized as follows: Chaps. 1 and 2 provide an overview of biomass conversion into energy. Chapters 3 and 4 cover the application of ionic liquids for the production of bioenergy and biofuels from biomass (Green chemistry approach towards the biomass conversion). Chapter 5 focuses on the role of catalysts in thermochemical biomass conversion. This chapter also describes the role of nanoparticles for biomass conversion. Chapter 6 gives an overview of catalytic deoxygenation of fatty acids, their esters, and triglycerides for production of green diesel fuel. This new technology is an alternative route for production of diesel range hydrocarbons and can be achieved by catalytic hydrogenation of carboxyl groups over sulfided catalysts as well as decarboxylation/decarbonylation over noble metal supported catalysts, and catalytic cracking of fatty acids and their derivatives.

The common examples of biofuels are biobutanol, bioethanol, and biodiesel. Biobutanol continuously draws the attention of researchers and industrialists because of its several advantages such as high energy contents, high hydrophobicity, good blending ability, and because it does not require modification in present combustion engines, and is less corrosive than other biofuels.

Unfortunately, the economic feasibility of biobutanol fermentation is suffering due to low butanol titer as butanol itself acts as inhibitor during fermentation. To overcome this problem, several genetic and metabolic engineering strategies are being tested. In this direction, Chap. 7 outlines the overview of the conversion of cheaper lignocellulosic biomass into biobutanol.

Chapter 8 discusses some of the strategies to genetically improve biofuel plant species in order to produce more biomass for future lignocellulosic ethanol production. Chapter 9 describes the production of bioethanol from food industry waste. Hydrogen is an attractive future clean, renewable energy carrier. Biological hydrogen production from wastes could be an environmentally friendly and economically viable way to produce hydrogen compared with present production technologies. Chapter 10 reviews the current research on bio-hydrogen production using two-stage systems that combine dark fermentation by mixed cultures and photo-fermentation by purple non-sulfur bacteria.

Organosolv fractionation, one of the most promising fractionation approaches, has been performed to separate lignocellulosic feedstocks into cellulose, hemicelluloses, and lignin via organic solvent under mild conditions in a biorefinery manner. Chapter 11 focuses particularly on new research on the process of organosolv fractionation and utilization of the prepared products in the field of fuels, chemicals, and materials. Production and separation of high-added value compounds from renewable resources are emergent areas of science and technology with relevance to both scientific and industrial communities. Lignin is one of the raw materials with high potential due to its chemistry and properties. The types, availability, and characteristics of lignins as well as the production and separation processes for the recovery of vanillin and syringaldehyde are described in Chap. 12.

The production of consistent renewable-based hydrocarbons from woody biomass involves the efficient conversion into stable product streams. Supercritical methanol treatment is a new approach to efficiently convert woody biomass into bio-oil at modest processing temperatures and pressures. The resulting bio-oil consisted of partially methylated lignin-derived monomers and sugar derivatives which results in a stable and consistent product platform that can be followed by catalytic upgrading into a drop-in-fuel. The broader implications of this novel approach to obtain sustainable bioenergy and biofuel infrastructure is discussed in Chap. 13.

Industrialization and globalization is causing numerous fluctuations in our ecosystem including increased level of heavy metals. Bioextraction is an alternative to the existing chemical processes for better efficiency with least amount of by-products at optimum utilization of energy. The last chapter provides an overview of bioextraction methodology and its associated biological processes, and discusses the approaches that have been used successfully for withdrawal of heavy metals using metal selective high biomass transgenic plants and microbes from contaminated sites and sub grade ores.

This book is intended to serve as a valuable reference for academic and industrial professionals engaged in research and development activities in the

emerging field of biomass conversion. Some review chapters are written at an introductory level to attract newcomers including senior undergraduate and graduate students and to serve as a reference book for professionals from all disciplines. Since this book is the first of its kind devoted solely to biomass conversion, it is hoped that it will be sought after by a broader technical audience. The book may even be adopted as a textbook/reference book for researchers pursuing energy technology courses that deal with biomass conversion.

All chapters were contributed by renowned professionals from academia and government laboratories from various countries and were peer reviewed. The editors would like to thank all contributors for believing in this endeavor, sharing their views and precious time, and obtaining supporting documents. Finally, the editors would like to express their gratitude to the external reviewers whose contributions helped improve the quality of this book.

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Dr. Chinnappan Baskar
Dr. Shikha Baskar
Dr. Ranjit S. Dhillon