

## Book review

# Biorefinery: from biomass to chemicals and fuels

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The increase in fossil-fuel demand, due to the increase in world energy consumption, and the limitation of the fossil carbon reservoir are forcing human beings to consider another alternative, biofuel, which is renewable and produced with quasi-zero CO<sub>2</sub>. Biorefinery is a new term that is related to two main subjects, value-added bioproducts (chemical building blocks, materials), and bioenergy (biofuels, power, and heat) from biomass, considering sustainability assessment and life cycle. Research, development, and the integration of innovative technologies are the most important prerequisites for the development of sustainable biorefineries, assessing the technical and economic feasibility of advanced biorefineries.

This book is written based on the view and achievements of the EuroBioRef project (European Multilevel Integrated Biorefinery Design for Sustainable Biomass Processing: FPA/2007–2013 no. 241718), which aims to improve cost-efficiency, reduce energy consumption, and produce almost zero waste in applying biomass.

Chapter 1 introduces the concept of the EuroBioRef project, its objectives and methodology in line with reaching its objectives in detail. By reading chapter 1, the reader will gain a brief overview of the whole project. To improve familiarity with the biorefineries, chapter 2 reviews some practical examples of biorefineries based on vegetable oils, wood, and sugars. By analyzing their capital cost, the authors convincingly indicate the ways in which more cost-efficient biorefineries can be achieved. While chapter 3 is devoted to terrestrial biomass formation, chapter 4 briefly covers aquatic biomass production. In both chapters 3 and 4, relevant examples are given and compared theoretically and economically.

Another issue is started with chapter 5, which explains the physical and chemical biomass pretreatment processes. At the end of this chapter, the author also summarizes the main advantages and drawbacks of each process,

which gives readers a good point of comparison. Chapters 6, 7, and 8 are related to the conversion of biomass into platform molecules and more added-value molecules.

One of the best forms of biomass is lignocellulose, which is generally available as waste biomass, as wood, and as a fast rotation crop. This polymer consists of lignin, cellulose, and hemicelluloses that should then be depolymerized to building blocks. Conversion of biomass into platform molecules occurs via two main routes. The first route, which is the chemical route, is explained entirely in chapter 6. Chapter 7 covers the biotechnological approach. Conversion of lignin, the most important component of lignocellulose, is of particular significance. For this reason, the development of parallel processes in its conversion into fuels and chemicals is discussed in chapter 8.

Chapter 9 comprehensively explains the process development of bioethanol production from lignocellulosic materials from a metabolic engineering point of view. Chapter 10 is devoted to the homogeneous catalytic conversion of two biosourced feedstocks: lignocelluloses and vegetable oils. In this chapter, the benefits of homogenous catalysis are highlighted, particularly in the fractionation of the biomass, and a comparison is made and supported by introducing some examples. In addition, catalytic conversion of terrestrial plant-based oils is presented in chapter 11. Although heterogeneous catalysis conversion of cellulosic biomass is discussed in earlier chapters of this book, selected examples of natural compound conversions into molecules with special applications, along with the use of heterogeneous catalysts in a new water-free approach, are discussed in chapter 12.

Chapters 13 and 14 deal with synthesis gas (or syngas) formation. Syngas is a stoichiometric mixture of CO and H<sub>2</sub> that is produced by the gasification of carbonaceous compound such as coal, petroleum, biofuels, or biomass. In chapter 13, gasification of biomass is explained in detail, starting from the basics and introducing theoretical factors, such as the process of thermodynamics. The potential applications of syngas as a chemical feedstock, as a fuel by itself, and as an intermediate for the production of fuels or biofuels, are mentioned in chapter 14. Each application is supported by relevant examples.

Once again, the conversion of biomass to fuels and chemicals by thermochemical processes is covered in chapter 15. The biomass thermochemical conversion

process consists of gasification, biocarbonization, liquefaction, and thermal decomposition. Although some of these processes are introduced in former chapters, chapter 15 briefly introduces the first three, reviews the biomass pyrolysis process, and compares their feasibility.

Chapter 16 comprehensively covers a case study of economic performance and greenhouse gas emissions. In this case study in northern Sweden, the development of cellulosic ethanol production is summarized in detail. The author supports the content with well-sketched figures.

The fundamental study of biogas production is discussed in chapter 17, while methane production technologies are mainly discussed in chapter 18. Chapter 17 also introduces the enzymes used in the production of biogas and the role of catalysts, such as iron and nickel, during anaerobic fermentation. The conversion process in the absence of oxygen, is explained.

The final chapter, chapter 18, is the most applied, since it provides an overview of the topics covered in the book. This chapter starts by studying laboratory-scale

biomethane and then goes into deep theoretical knowledge, introducing design criteria and different types of appropriate reactors. In other words, this chapter offers the reader an applicable example of the scaling up of a biogas plant.

This book is an appealing and well-organized book with focus on aspects of biorefinery. It starts from the point of relatively basic knowledge of biomass conversion and then delves into the formation process of biofuels and chemicals from biomass, keeping an eye on the economic side of biorefinery projects.

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