

BIORENEWABLE RESOURCES

Engineering New Products from Agriculture

Second Edition

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Engineering New Products from Agriculture

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Preface

Biorenewable Resources was originally published in 2003 as a textbook to support a new interdisciplinary graduate program in Biorenewable Resources and Technology at Iowa State University. This was two years before the passage of the Energy Policy Act of 2005 launched the biofuels boom in the United States. At the time there was relatively little current scientific literature to support the preparation of the book due to many of the sources dating back a decade or more. The field has grown tremendously since then, encouraging the publication of a second edition of *Biorenewable Resources*.

As with the first edition, the second edition is intended as a text for upper level undergraduate students and first year graduate students in science and engineering who are seeking a broad perspective of the emerging field of biorenewable resources. Traditional academic disciplines are organized to provide students in-depth training and intellectual focus in a single field such as agriculture, chemistry, engineering, environmental science, or economics. *Biorenewable Resources* brings together these disciplines to provide students with an appropriate system perspective valued by prospective employers and those seeking to work in this field.

The thirteen chapters of this book do not assume any previous training in biorenewable resources, although most students should have undergraduate training in science or engineering. Chapter 1 is an introduction to the field of biorenewable resources, which includes a brief history of the use of biorenewable resources and a description of the motivations for advancing the biobased products industry. Chapters 2 and 3 provide fundamental concepts of engineering thermodynamics and organic chemistry important to understanding bioenergy and biobased products. These two chapters are aimed at students who may have deficiencies in these concepts or who desire a review of the topics. The chapter on engineering thermodynamics includes expanded descriptions of mass and molar balances applied to conversion, yield, and selectivity of chemical reactions. It also includes discussions on energy return on energy invested and the role of exothermic versus endothermic reactions in the manufacture of energy products. Chemical equilibrium receives more extensive treatment than in the first edition. The chapter on organic chemistry includes descriptions of anhydrosugars, important in thermochemical conversion of carbohydrate-rich biomass, and lignin chemical composition.

Chapter 4 is a description of biorenewable resources. This chapter includes sections that defines the resource base, categorizes the different kinds of biorenewable resources, including both waste materials and dedicated energy crops, describes properties that are important to the handling and processing of biorenewable resources, provides information on yields of various kinds of biomass, and assesses the availability of different kinds of biorenewable resources. The second edition includes extensive coverage of oleaginous (lipid-rich) biomass such as microalgae. Chapter 5 is an introduction to production of biorenewable resources. In addition to descriptions of growing and harvesting herbaceous energy crops and short rotation woody crops, the second edition describes cultivation and recovery of microalgae, considered a promising aquatic species for production of biofuels and biobased products. This chapter also includes descriptions of storage systems and the prospects for using transgenic crops in production of biorenewable resources. Chapter 6 is an introduction to the wide array of bioenergy and biobased products that are currently produced or anticipated from biorenewable resources. Major topics in this chapter include process heat, biopower, biofuels, commodity chemicals, synthetic biopolymers (new to the second edition), and natural fibers.

The next four chapters are devoted to the processes by which biorenewable resources are transformed into bioenergy and biobased products. Chapter 7 focuses on biochemical conversion of carbohydrate-rich feedstocks to ethanol and other products, including hydrocarbons (new to the second edition). Chapter 8 describes thermochemical conversion of lignocellulosic biomass. The second edition expands coverage of gasification technology to include syngas cleaning and catalytic upgrading to fuels and chemicals. Considering the increasing interest in pyrolysis as a pathway to biofuels, this topic has been expanded to include fundamentals of pyrolysis, different kinds of pyrolysis processes and equipment, and catalytic upgrading of bio-oil to biofuels. Solvolysis has been added as an alternative approach to producing bio-oil or sugars. Chapter 9 considers both biochemical and thermochemical processes for the conversion of oleaginous biomass into fuels and other products. Chapter 10 explains how natural fibers can be separated from biorenewable resources for use in the manufacture of paper and building materials.

The final three chapters deal with environmental, economic, and policy issues. Chapter 11 describes the environmental impact of producing and processing biorenewable resources and using the resulting products. Extensive discussion of land use change (both direct and indirect) associated with production of biofuels is included in the new edition. Chapter 11 also describes environmental concerns associated with the use of transgenic crops as biorenewable resources. Chapter 12, an introduction to the economics of biorenewable resources, has been extensively updated to reflect current methodologies in technoeconomic analysis of biorenewables. The chapter includes separate discussions on estimating the costs of producing crops and manufacturing biobased products. The chapter concludes with specific cost estimates for various biobased products. Chapter 13, new to the

second edition, explores the role of government policy in promoting the adoption of biofuels as an alternative to fossil fuels and imported petroleum. The chapter describes the various policies employed by governments around the world to promote bioenergy.

Although many colleagues influenced the preparation of the first and second edition, we would like to especially acknowledge the assistance of Kaige Wang in reviewing some of the chapters; Chris Deal in researching the biorenewable resources described in Appendix A; Trevor Brown for preparing the illustrations new to this edition; Carolyn Brown in assisting with indexing; and Justin Jeffries and Stephanie Dollan at Wiley for providing assistance and encouragement in preparing the second edition. Of course, errors and omissions are solely the responsibility of the authors. We would also like to thank our wives, Carolyn and Kate, for tolerating this father-son collaboration, which cut into much “free time” during the last year.

Robert C. Brown and Tristan R. Brown
Ames, IA
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