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B. Kamm, P.R. Gruber, M. Kamin (Eds.), Biorefineries—Industrial Processes and Products: Status Quo and Future Directions, Vol. 1 Wiley-VCG Verlag GmbH & Co., KgaA, Weinheim, Germany (2006). 475 pp., US$ 375.00 (for both volumes), ISBN: 3-527-31027-4

As I began to review this book, a notice appeared on my computer announcing the construction of a biorefinery in the United States. Clearly, the topic (as the book notes) currently is very popular; green chemistry and green processes are much in the news.

In the Preface, the editors note that ". . .technologies for bioconversion have advanced to a state in which they are becoming practical on a large scale, economics are leaning more favorably to the direction of renewable feedstocks, and chemical process knowledge is being applied to biobased systems."

Writing in a Foreword to the book, Paul T. Anastas, Director of the Green Chemistry Institute in Washington, DC, notes:

> This book addresses the essential questions and challenges of moving toward a sustainable society in which bio-based feedstocks, processes, and products are fundamental pillars of the economy. The authors discuss not only the important scientific and technical issues surrounding this transition but also the necessary topics of economics, infrastructure, and policy. It is only by means of this type of holistic approach that movement toward genuine sustainability will be able to occur where the societal, economic and environmental needs are met for the current generation while preserving the ability of future generations to meet their needs.

This book and its companion (Volume 2) are the work product of 85 scientists from 11 different countries on three continents.

This volume has 17 chapters published under four major headings as noted below:

- Part I: Background and Outline—Principles and Fundamentals:
  1. Biorefinery systems—an overview.
  2. Biomass refining global impact—the biobased economy of the 21st century.
  3. Development of biorefineries—technical and economic considerations.
  4. Biorefineries for the chemical industry—a Dutch point of view.
- Part II: Biorefinery Systems:
  Lignocellulose Feedstock Biorefinery:
  5. The lignocellulosic biorefinery—a strategy for returning to a sustainable source of fuels and industrial organic chemicals.
  6. Lignocellulosic feedstock biorefinery: history and plant development for biomass hydrolysis.
  7. The biofine process—production of levulinic acid, furfural, and formic acid from lignocellulosic feedstocks.

  Whole Crop Biorefinery:
  8. A whole crop biorefinery system: a closed system for the manufacture of non-food products from cereals.

  Fuel-Oriented Biorefineries:
  9. Iogen's demonstration process for producing ethanol from cellulosic biomass.
  10. Sugar-based biorefinery—technology for integrated production of poly(3-hydroxybutyrate), sugar, and ethanol.

  Biorefineries Based on Thermal Chemical Processing:
  11. Biomass refineries based on hybrid thermochemical-biological processing—an overview.

  Green Biorefineries:
  12. The green biorefiner concept—fundamentals and potential.
  13. Plant juice in the biorefinery—use of plant juice as fermentation medium.
- Part III: Biomass Production and Primary Biorefineries:
  14. Biomass commercialization and agriculture residue collection.
  15. The corn wet milling and corn dry milling industry—a base for biorefinery technology developments.
- Part IV: Biomass Conversion: Processes and Technologies:
  16. Enzymes for biorefineries.
  17. Biocatalytic and catalytic routes for the production of bulk and fine chemicals from renewable resources.

Brown of Iowa State University reports that the Biomass Research and Development Technical Advisory Committee defines a biorefinery as: "A processing and conversion facility that (1) efficiently separates its biomass raw materials into individual components and (2) converts these components into marketplace products including biofuels, biopower, and conventional and new bioproducts."

The goal, of course, is to develop a sustainable society, one which does not depend on a limited resource such as oil. Thus, we turn to renewable resources to produce fuels, solvents, chemicals, plastics and food. Products that can be produced from biomass include ethanol, butanol, acetone and lactic, itaconic and amino acids. The future holds promise for much more according to the U.S. Biomass Technical Advisory Committee which is comprised of representatives of several chemical companies. The members of this committee project consumption of bioproducts will increase significantly from current use by 2030. The numbers projected include increases in biopower production from 2.8 to 5%, in biofuels from 0.5 to 20%, and bioproducts from 5 to 25%.

Dale and Kim of Michigan State University began the Chapter 2 with the following statement: "We are in the early phases of a truly historic transition—from an economy largely based on petroleum to a more diversified economy in which renewable plant biomass will become a significant feedstock for both fuel and chemical production." Significant raw materials in this system will be corn, corn stover, soy beans, alfalfa and poplar.

Each contribution (as in the chapter above) is unique. The material supplied by each author deserves more space in review than I can use. Hence, I have abstracted a few items that caught my attention:

- "As a major policy goal for 2020, the Dutch government has stipulated that 10% of its energy use should be provided by renewable resources to meet the Kyoto objectives."
- "An essential component of the structural shift from petroleum to biomass as a source of carbon is a 'two-use' ethic. Everything that grows or is derived from organic sources (even plastics) should have at least two uses. MSW is collected and recycled to the biorefinery."
- "The production of fuel alcohol from cellulosic biomass is of growing interest around the world. Cellulosic biomass can be used to produced transportation fuel, with the overall process having little net production of greenhouse gases."
- "Green biorefineries are integrated technologies and technology systems for production of materials and energy processing of green plants and parts of green plants." "Green plants parts are a virtually inexhaustible raw material reservoir which is fast-growing, available world-wide, and may have ecological advantages." "In the next 10 year[s], biorefineries may be processing 100 million metric dry tonnes (dt) biomass annually for production of fuels and chemicals if a stretch goal set by the U.S. Department of Energy is met."

The chapters go well beyond a description of the raw materials, their sources, and their potential use. Many of the articles have process flow sheets, equipment schematics (including one photograph of a prototype plant), mass and energy balances, and waste treatment systems.

It is difficult to do justice in a brief review (or perhaps in this case not so brief) to a book such as this. In my opinion, the editors and contributors have done a marvelous job of reviewing the current state of biorefining. The future for this technical area is bright; indeed, it must be as renewable resources are virtually the only way of sustaining life in the future.

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A recent press release I received described an innovative project to use the fermentation of grain to produce ethanol (which clearly is not new) but what is new is that this project proposes to extract biodiesel fuel from the residue that is left after removal of the alcohol. Additionally, the process will utilize cattle manure to produce methane to be burned in the production process. What is new is the system integration and energy (input) minimization.

This book is the second of two in a series that deal broadly with the "green chemistry" interest in developed countries. This volume contains 16 multi-authored chapters which are:

- *Part I*: Biobased Product Family Trees
  Carbohydrate-based Product Lines
  1. The key sugars of biomass: availability, present non-food uses and potential future development lines.
  2. Industrial starch platform—status quo of production, modification and application.
  3. Lignocellulose-based chemical products and product family trees.
  Lignin Line and Lignin-based Product Family Trees
  4. Lignin chemistry and its role in biomass conversion.
  5. Industrial lignin production and applications.
  Protein Line and Amine Acid-based Product Family Trees
  6. Towards integration of biorefinery and microbial amino acid production.
  7. Protein-based polymers: mechanistic foundations for bioproduction and engineering.
  Biobased Fats (Lipids) and Oils
  8. New syntheses with oils and fats as renewable raw materials for the chemical industry.
  9. Industrial development and application of biobased oleochemicals.
  Special Ingredients and Subsequent Products
  10. Phytochemicals, dyes, and pigments in the biorefinery context.
  11. Adding color to green chemistry? An overview of the fundamentals and potential of chlorophylls.
- *Part II*: Biobased Industrial Products, Materials and Consumer Products
  12. Industrial chemicals from biomass—industrial concepts.
  13. Succinic acid—a model building block for chemical production from renewable resources.
  14. Polylactic acid from renewable resources.
  15. Biobased consumer products for cosmetics.
- *Part III*: Biobased Industry: Economy, Commercialization and Sustainability
  16. Industrial biotech—setting conditions to capitalize on the economic potential.