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Book review

BIOREFINERIES – INDUSTRIAL PROCESSES AND PRODUCTS

Status Quo and Future Directions

Brigit Kamm, Patrik R. Gruber, Michael Kamm, (Editors), vol. 2
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The topic of biorefineries as means of processing industrial material and efficient utilization of renewable products is well known and applied worldwide, in almost every developed and emerging country. This tendency is motivated by the rising cost of oil and the need to move away from petrochemical-based systems.

This book, edited in two volumes, describes and discusses some aspects belonging to the topic of biorefineries, providing a general framework for the subject, types of biorefineries, the status of the technology, the principles and basics of biorefinery systems, industrial products which fall within the scope of biorefineries. The authors discuss not only the important scientific and technical issues, but also economics, infrastructure and policy, in order to ensure the sustainability of the system.

The second volume of this book offers valuable information on biobased industrial products, materials and consumer products, structured on three parts:
Part I: *Biobased Products Family Trees*
Part II: *Biobased Industrial Products, Materials and Consumer Products*
Part III: *Biobased Industry: Economy Commercialization and Sustainability*

The family trees of biobased products discussed within Part I refers to:
(i) carbohydrate based product lines considering: the availability, present of non-food uses and potential future development lines of the key sugars of biomass; status-quo of production modification and application on industrial starch platforms; lignocellulose-based chemical products and product family trees; (ii) lignin line an lignin-based product family trees, including: lignin chemistry and its role in biomass conversion; industrial lignin production and applications; (iii) protein line and amino acid-based product family trees, referring to: intergration of biorefinery and microbial amino acid production; mechanistic foundations for bioproduction and engineering applied for protein-based polymers; (iv) biobased fats and oils, considering: new syntheses with oils and fats as renewable raw materials for the chemical industry; industrial development and applications of biobased oleochemicals; (v) special ingredients and subsequent

products: phytochemicals, dyes and pigments in the biorefinery context; fundamentals and potential of chlorophylls.

Part II deals first with industrial concepts on chemicals from biomass. Also, a model building block for chemical production from renewable resources is a topic that includes products as: succinic acid, polylactic acid. Biobased consumer products for cosmetics as other outputs of biorefinery include: betaine, chitosan, biopol, apple-peel wax, ilex resin, all accounted considering their occurrence, chemical properties, production, use and field of application, biodegradability.

Part III: comprises aspects like economy, commercialization and sustainability of biobased industry, considering some case study in order to assess the overcoming challenges.

The whole text provides reliable descriptions of industrial implementations, strategies and future developments. It is underlined non-food utilization of inexpensive, bulk scale-accessible, low-molecular-weight carbohydrates (sucrose, glucose, xylose and fructose) as a rather modest level in terms of large-scale manufactured commodities currently on the market. The unusually diverse stock of readily accessible products lies mostly unexploited, for economic reason mainly because equivalent products based on petrochemical raw materials are distinctly cheaper.

For fuel utilization of the "biogold" lying in carbohydrates, widely available from plants and easily recoverable at low cost generous supports are needed in order to exploit the economically sound biobased alternatives to petrochemicals. In recent years, the demand for starch has grown constantly and this scenario will be boasted by the development of new application areas, new technologies in starch modification resulting in new properties, and tailor-made starches produced mainly by applying biotechnological processes.

In a biobased economy, lignocelluloses represent the main source of raw materials. There are a variety of sources of lignocelluloses (wood, straw, reeds, grass) that contain organic structures serving as source for a variety of derivatives and conversion products. Lignocelluloses are, to a large extent, independent of economic policy that makes this very interesting for industrial use. Also, lignocelluloses can be produced even in environmentally sound less intensive agriculture and forestry, which is another positive effect, in addition to the CO_2-neutraly for biomass. Improved understanding of the structure of lignins and their derivative helps researches to relate their experimentation to a fundamentally sound framework of ideas.

The use to which polymeric lignin products can be put may be broadly separated into three classes: combustion; utilization of the surface active properties of salts of a lignin derivative; condensation of lignin so that it becomes an integral part of the product. Degradation of the lignin polymer occurs in the side chains, which are oxidized with formation of carboxyl and carboxyl groups, and in the aromatic nuclei. Lignin can be recovered from conventional chemical pulping operations, establishing a significant commercial market in numerous industries and applications. Biorefineries should be more flexible and better suited to produce and market some of the specialized lignin that will emerge from them.

Major hurdles must be also overcome to generate value in industrial production of amino-acids. Potential new products streams must be of low cost and characterized by low concentrations of impurities and by low fluctuations in raw material composition. It will be a prerequisite for the success of the biorefinery concept to yield new well defined carbon sources of high purity and lower cost compared with starch or sugar-based feedstock. The processing of natural compounds requires extensive equipment size and energy consumption for water handling. This problem must be addressed to improve cost structure. Proximity to the market and to the large-scale customers guarantees low transport and distribution costs which mean that sophisticated optimization of the supply chain must be performed.

Bioproduction of protein-based polymers has been under consideration using tobacco, mushrooms, yeast, seeds. An attractive approach to ensure low-cost production would be to express protein-based polymers in seed as a value-added product under circumstances where the cost of production would be the cost of purification. It is recommended that water-based purification using the inverse temperature transition, would allow selected removal of the protein-based polymer and return the remaining protein for cattle feed.

Gene technology is considered to be a very suitable breeding instrument in order to induce new genetic variation for improvements in natural oils and fats by plant breeding. From the viewpoint of industry, demand will only be generated if new materials of vegetable origin are available in sufficient quantities at competitive prices, economically viable isolation of the relevant components is possible, and they are held in a higher esteem and preference to alternatives which come, for example, from the petrochemical industry.

To ensure high product safety for consumers and the environment, renewable resources have often been shown to have advantages compared with petrochemicals raw materials and can, therefore, be regarded as being ideal raw material. Results from oleochemistry show that the use of vegetable fats and oils enables the development of competitive, powerful products which are both consumer-friendly and environmentally friendly.

One of the most overlooked areas is chlorophyll chemistry, in the view of its use for new materials. There are currently no large-scale commercial uses of chemically pure chlorophyll-derived materials. The few specialized applications there are very narrow in focus and require only small amounts of material, which is conveniently prepared from a dedicated source. On the other hand, well-establish major industrial uses of tetrapyrroles, for example use as coloring agent in inks, paints or plastics and rubber, are exclusively based on non-natural technical pigments. Those industrial applications must be found for natural pigment products and developed to provide an economic stimulus for this area.

The fermentation of glucose and other sugars derived from biomass for the production of succinic acid provides a valuable building block for the production of industrially important chemicals. The specific cost barriers include reducing the medic requirements so that a low cost nutrient sources could be used, improving the volumetric productivity of the organisms. From a process perspective reducing the cost of separation/purification would have a significant overall economic impact. Separation and catalysis are critical steps for realization of economically viable biobased products from renewals.

Because all of the carbon of polylactic acid (PLA) originated from carbon in the atmosphere, it is regarded as a renewable resource-based material. This combined with useful material properties and processability makes it attractive. Today, PLA made from corn is competitive with traditional petrochemical-based polymers given its combination of performance in applications, cost and the environmental benefits.

In raw materials for some cosmetics are derived from nature. Chemical transformations of natural substances to obtain more effective products are known from antiquity. Ilex resin is a natural material with many useful cosmetic properties. As an active ingredient it enhances the performance of numerous product of cosmetics group. There are no supply problems and being renewable the substance is large available. The potential for industrial biotech is assessed in order to set conditions to capitalize on the economic potential. Chemical and biotech companies are starting to move into this space and increase their presence. The success of biotechnological processes for vitamin production, the growth of the enzyme industry and the introduction of cost-competitive biopolymers hints at the possibilities, in order to transform this potential into economic value, as main challenges.

The book reveals the effect that biotech is changing industrial production in three specific ways: sugars, vegetable oils, waste biomass are replacing fossil fuel feedstock (oil and natural gas); bioprocesses (fermentation, biocatalysis, plant-and animal-based production) may replay chemical syntheses; new bioproducts are emerging including bio-based polymers, enzymes for use in textiles or feed, and innovative nutritional ingredients.

A growing number of case studies demonstrate that all these challenges can be overcome, in order to ensure a framework of designing for sustainability, considering that any sustainable future must ensure that the materials on which the economic infrastructure is based are renewable than depleting.

This book discusses not only important scientific and technical issues, but also necessary topic of economics, infrastructure and policy. It is obviously a very valuable tool for specialist in the field, researchers, teachers and students for enlarging their horizon on biotechnology, as a sustainable alternative for conventional chemical industry.

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