Methane Production From Lipid Extracted Algal Residues

This book presents key recent developments in biofuel policy, products, processes, patents and innovative technologies. It presents several case studies, which maximize reader insights into how innovative green energy technologies can be implemented on an industrial scale, with illustrations, photos and new approaches. It also analyzes in detail several different technological aspects of the

research into and production of green fuels from the first, second and third generation, such as, bioethanol, biogas, biohydrogen, biobutanol, biofuels from pyrolysis, and discusses their economic and environmental impacts. A new source of information for engineers, technicians and students involved in production and research in the biofuels sector, this book also provides a valuable resource for industry, covering the current and future status of biofuels.
Fatty acids and lipids: structures, extraction and fractionation into classes -- Gas chromatography: theoretical aspects and instrumentation --

Preparation of methyl ester and other derivatives -- Gas chromatographic analysis of fatty acid derivatives -- Isolation of fatty acids and identification by spectroscopic and chemical degradative techniques -- Gas chromatography--mass spectrometry and fatty acids -- Gas chromatographic analysis of molecular species of lipids -- Alternative or complementary methods for the analysis of molecular species of lipids -- Some miscellaneous separations of lipids by gas chromatography.

Algae and Aquatic Macrophytes in Cities: Bioremediation, Biomass, Biofuels and Bioproducts

introduces the concept of using the natural ability of plants such as algae and aquatic macrophytes to remediate pollutants from water. The book provides scientists with a green, economical and successful option when tackling rising water pollution. The book's chapters cover a range of areas, including bioremediation, biomass, biofuels and bioproducts during the remediation of polluted water systems. It draws together research from eminent scientists from across the globe and includes case studies to help researchers, students, scientists, stakeholders, policymakers and environmentalists understand and

perform their research with greater ease. Presents multiple case studies from global perspectives Focuses on Bioremediation, Biomass, Biofuels and Bioproducts for water pollution–a new approach Provides basic knowledge on how to design, grow and use algae and aquatic macrophytes Microalgae could play an important role in the achievement of sustainability goals related to the generation of renewable energy and greenhouse gas (GHG) emissions. These photosynthetic microorganisms are able to capture CO2 and, therefore, can be used to produce biofuels such as

ethanol, methane and green diesel. Other factors, such as their high growth rate, ability to use wastewater as a culture medium and the ability to grow on non-arable land makes them a potentially economical source of biofuel production on a large scale. This monograph introduces the reader to the basic and applied science of microalgal biofuel production. Chapters in the volume give information about bioethanol and biogas production from microalgal sources, the fermentation process, optimization of culture parameters and industrial applications of biomass projects. The book is a

useful reference for biotechnology and environmental science graduates and professionals interested in biofuel production.

Proceedings of the International Conference on Energy Equipment Science and Engineering, (ICEESE 2015), May 30-31, 2015, Guangzhou, China

New Technologies, Challenges and Opportunities

Gas Chromatography and Lipids Biodegradation

Volume 2: Biorefinery Approaches of Wastewater Treatment

From Feedstock Cultivation to End-Products

The edited book covers all potential products from microalgal-based biorefinery having the focus on contemporary technologies and future outlook. Along with the focus on microalgal biorefinery products, the book also focuses on biotechnological advances via the utilization of modern molecular biology, system biology, synthetic biology, or metabolic engineering approach in microalgal biorefinery. The development of any technologies has a direct effect on the human being and the environment, therefore, the socio-economic, techno-economic, and

environmental impact of the microalgae-based biorefineries will also be included in the book. In microalgal biomass-based biorefinery different biofuel- biodiesel, bioethanol, bio-hydrogen, and value-added compounds such as carotenoids, fatty acids, and protein can be produced simultaneously. Understanding the technical advances to develop an integrated biorefinery approach with the motive of designing a consolidated self-sustainable microalga-based biorefinery. This book is equally beneficial for researchers and engineers in biomass-based biorefineries or the bachelors, master, or young budding

graduate students as a textbook.
This book focuses on chemical syntheses and processes for biofuel production mediated by microwave energy. This is the first contribution in this area serving as a resource and guidance manual for understanding the principles, mechanisms, design, and applications of microwaves in biofuel process chemistry. Green chemistry of microwave-mediated biofuel reactions and thermodynamic potentials for the process biochemistry are the focus of this book. Microwave generation, wave propagation, process design, development and

configurations, and biofuel applications are discussed in detail.

Biofuels production is one of the most extensively studied fields in the energy sector that can provide an alternative energy source and bring the energy industry closer to sustainability. Biomass-based fuel production, or renewable fuels, are becoming increasingly important as a potential solution for man-made climate change, depleted oil reserves, and the dangers involved with hydraulic fracturing (or "fracking"). The price of oil will always be volatile and changeable, and, as long as

industry and private citizens around the world need energy, there will be a need for alternative energy sources. The area known as "biofuels and biofeedstocks" is one of the most important and quickly growing pieces of the "energy pie." But biofuels and biofeedstocks are constantly changing, and new processes are constantly being created, changed, and improved upon. The area is rapidly changing and always innovative. It is important, therefore, that books like the volumes in this series are published and the information widely disseminated to keep the industry informed of the state-of-the-art.

This second volume in the Advances in Biofeedstocks and Biofuels series focuses on the production of biofuel, covering all of the major biofuels, such as biodiesel, biohydrogen, bioethanol, and others. This engaging text touches on all of the most important new processes and technologies, providing the most up-to-date coverage of the science available to industry. It is a must-have for any engineer or scientist working with biofuel technology.

Biofuels produced from agricultural starch, sugar and oil crops such as corn, sugarcane, and palm, or first-generation biofuels, are

produced at commercial scales worldwide. Though most biofuels are produced with the intent to reduce greenhouse gas (GHG) emissions and fossil fuel dependency, these first-generation biofuels have increasingly been shown to be problematic; achieving little to no reduction in GHG emissions compared to their fossil fuel counterparts, competing with food and feed crops, and causing direct and indirect land use change. Second generation biofuel feedstocks, such as microalgae, are hoped to reduce or eliminate the drawbacks of first-generation feedstocks. This dissertation investigates the

environmental impacts of biodiesel production from microalgae, with the main focus on primary energy requirements and life cycle GHG emissions. The dissertation includes a critical review of existing studies; a mass balance model of a simulated microalgae biodiesel production system; a detailed life cycle assessment (LCA) of the production system with a variety of technology options for each step of the production process; and a scenario analysis with alternative utilization scenarios for the primary co-product from the system, lipid-extracted algal biomass residual. In addition to

assessing and informing technology choices and strategies for environmentally preferable pathways among current algal biodiesel technologies, this research also addresses an important methodological issue in LCA, co-product allocation, and proposes some possible solutions to reduce the uncertainty caused by this issue. Results of the critical review show that significant variation exists among existing LCA studies of algal biodiesel production, which arises from inconsistency in both parameter assumptions and methodological choices. Even after a meta-analysis was conducted, which corrected for

some differences in scope and key assumptions, the reviewed studies show a large range in life cycle primary energy and GHG emissions; 0.2 to 8.6 MJ per MJ of algal biodiesel, and -30 to 320 g of CO2e per MJ of algal biodiesel. This range is so large that very little can be concluded regarding the potential for algal biodiesel to meet the goals of second-generation biofuels, and provides the motivation for development an independent and original model for algal biodiesel production. A mass balance model for an integrated algal oil and biogas system was developed to understand nutrient, water

and carbon flows and identify recycling opportunities. The model showed that recycling growth media and recovering nutrients from residual algal biomass through anaerobic digestion can reduce the total demand for nitrogen (N) and phosphorus (P) by 66% and 35%, respectively. Freshwater and carbon dioxide requirements can also be reduced significantly under these conditions. The mass balance model provided the basis for developing a LCA model capable of incorporating multiple technology options and identifying preferable pathways. The LCA found the best performing scenario consists

of normal nitrogen cultivation conditions (as opposed to nitrogen deficient conditions which can increase algal lipid content, but decrease overall productivity), a combination of bioflocculation and dissolved air flotation for harvesting algal cells from cultivation media, centrifugation for dewatering of separated algae, oil extraction from wet biomass using hexane solvent, transesterification of algal oil to biodiesel, and anaerobic digestion of biomass residual with the liquid digestate returning to cultivation ponds. This pathway results in a life cycle energy requirement and GHG

emissions of 1.08 MJ and 73 g CO2-equivalent per MJ of biodiesel, with cultivation and oil extraction dominating energy use and emissions. This result suggests that current technologies can neither achieve a positive net energy return for algal biodiesel, nor achieve substantial reductions in CO2e emissions compared to petroleum diesel. A comparison between different scenarios for using the major co-product from algae biodiesel production, lipid-extracted algal biomass residual, suggests that utilizing the co-product within the production system for nutrient and energy recovery is preferable

than utilizing it outside as animal feed from a life cycle perspective. A number of possible ways to allocate the environmental burdens between co-products were tested. Among them, system expansion and economic allocation return favorable results compared value-based allocation methods; however, there are still unsolved issues when applying system expansion, for example, current practices do not consider future market values in the context of a consequential LCA. This dissertation shows that the near-term performance of biodiesel derived from microalgae does not achieve the significant

reductions in fossil energy dependence and GHG emissions hoped for from second-generation feedstocks. Furthermore, there is substantial uncertainty in technology performance and other key modeling parameters that could influence these findings. However, some promising, but still uncertain technologies, such as hydrothermal gasification, have the potential to achieve greater reduction in life cycle GHG emissions and energy consumption.

Algal Technologies for Wastewater Treatment and Resource Recovery

Biofuels

The Effect of Pretreatment Methods on Methane Yield and Nutrient Solubilization Furing Anaerobic Digestion of Microalgae
Microalgae as a Source of Bioenergy: Products, Processes and Economics
Advances in Feedstock Conversion Technologies for Alternative Fuels and Bioproducts
Alkanes—Advances in Research and Application: 2012 Edition

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Advances in Energy Equipment Science and Engineering contains selected papers from the 2015 International Conference on Energy Equipment Science and Engineering (ICEESE 2015, Guangzhou, China, 30-31 May 2015). The topics covered include:- Advanced design technology- Energy and chemical engineering- Energy and environmental engineering- Energy scien

Conversion of biomass into chemicals and biofuels is an active research and development area as trends move to replace traditional fossil fuels with renewable resources. By integrating processing methods with ultrasound and microwave irradiation into biorefineries, the time-scale of many operations can be greatly reduced while the efficiency of

the reactions can be remarkably increased so that process intensification can be achieved. "Production of Biofuels and Chemicals with Ultrasound" and "Production of Biofuels and Chemicals with Microwave" are two independent volumes in the Biofuels and Biorefineries series that take different, but complementary approaches for the pretreatment and chemical transformation of biomass into chemicals and biofuels. The volume "Ultrasound" provides current research advances and prospects in mechanistic principles of acoustic cavitation in sonochemistry, physical and chemical mechanisms in biofuel synthesis, reactor design for transesterification and esterification reactions, lipid extraction from algal biomass, microalgae extraction, biodiesel and bioethanol synthesis,

practical technologies and systems, pretreatment of biomass waste sources including lignocellulosic materials, manures and sludges for biogas production, vibration-assisted pelleting, combined chemical-mechanical methods, valorization of starch-based wastes and techno-economic methodology. Each of the 12 chapters has been peer-reviewed and edited to improve both the quality of the text and the scope and coverage of the topics. Both volumes "Ultrasound" and "Microwave" are references designed for students, researchers, academicians and industrialists in the fields of chemistry and chemical engineering and include introductory chapters to highlight present concepts of the fundamental technologies and their application. Dr. Zhen Fang is Professor

in Bioenergy, Leader and founder of biomass group, Chinese Academy of Sciences, Xishuangbanna Tropical Botanical Garden and is also adjunct Professor of Life Sciences, University of Science and Technology of China. Dr. Richard L Smith, Jr. is Professor of Chemical Engineering, Graduate School of Environmental Studies, Research Center of Supercritical Fluid Technology, Tohoku University, Japan. Dr. Xinhua Qi is Professor of Environmental Science, Nankai University, China.

Methane emission in ruminant production is not only a global greenhouse gas, but also a loss of feed energy. Therefore, there is huge interest in identifying mitigation strategies that reduce ruminant derived methane, which guarantees

sustainable ruminant production. Tannins have been reported to inhibit methanogenic activity, but may also limit feed intake and nutrient digestibility. While dietary nitrate has been noted as an efficient hydrogen sink in the rumen, its effectiveness may be dependent on the application method among others. The objectives of this study are: (i) to evaluate the effects of nitrate supplementation and nitrate treatment on the in vitro digestibility and methane production in Eragrostis hay; (ii) evaluate the effect of supplementing acacia tannin extract and nitrate on feed intake, nutrient digestibility, methane emission and health status of Merino lambs; (iii) prepare and evaluate an encapsulated acacia tannin extract formulation suitable for ruminants; (iv) evaluate the effect of encapsulated acacia

tannin extract on feed intake, nutrient digestibility and enteric methane emission in Merino rams. A series of experiments (laboratory trials, and stall-feeding experiments) were conducted at the NUTRILAB and Hatfield Experimental Farm of the University of Pretoria, South Africa to evaluate the potential improvements in the use of nitrate and tannin extract using Sheep as model animal. Treating Eragrostis hay with urea improved its in vitro organic matter digestibility better than treatment with nitrate. However, nitrate treatment significantly reduced enteric methane and improved digestibility compared with the control, this suggests that nitrate could be incorporated as a hydrolytic agent in treating poor-quality roughage feeds, with the aim of improving their

utilization. The combination of urea or calcium nitrate with or without Acacia tannin extract as dietary supplements in a growth trial revealed that lambs receiving nitrate-based TMR diets experienced superior growth performance compared to those on the urea-based TMR diets. Meanwhile, tannin inclusion did not improve growth or reduced methane emission from the lambs irrespective of the non-protein nitrogen source. A slight increase in haemoglobin, haematocrit and RBC count was associated with the use of calcium nitrate compared to urea. In this study, no clinical or subclinical signs of morbidity or tannin intoxication symptom was detected from the haematology and biochemical parameters evaluated in the Merino lambs. The trial on the

preparation and evaluation of an encapsulated Acacia tannin extract (ATE) showed that Gum Arabic-maltodextrin and native starch could only encapsulate the tannin extract at low inclusion levels while the in vitro release was not sustained. However, palm oil was found to be an effective wall material in encapsulating ATE using the double phase solid-in-oil-in-water encapsulation method where up to 80% w/w inclusion of tannin extract in the lipid wall material was achieved. This extract exhibited good morphological characteristics and high encapsulation efficiency even under high loading percentage. The lipid-encapsulated extract significantly reduced enteric methane production in vitro. Under in vivo evaluation with cannulated Merino rams, encapsulated Acacia tannin extract

resulted in considerable reduction in methane per neutral detergent fibre intake, compared to the crude extract.
Using Anaerobic Digestion to Break Down Microalgae Cell Walls and Enhance Lipid Extraction
Modern Techniques and Solvents for the Extraction of Microbial Oils
A Practical Guide

Processes and Technologies
Fundamentals and Advances in Energy, Food, Feed, Fertilizer, and Bioactive Compounds
This book addresses microalgae, which represent a very promising biomass resource for wastewater treatment and producing biofuels.

Accordingly, microalgae are also an expanding sector in biofuels and wastewater treatment, as can be seen in several high-profile start-ups from around the globe, including Solix Biofuels, Craig Venter's Synthetic Genomics, PetroSun, Chevron Corporation, ENN Group etc. In addition, a number of recent studies and patent applications have confirmed the value of modern microalgae for biofuels production and wastewater treatment systems. However, substantial inconsistencies have been observed in terms of system boundaries, scope, the cultivation of microalgae and oil extraction systems, production costs and economic viability, cost-lowering components, etc. Moreover, the downstream technologies and core principles involved in liquid fuel extraction from microalgae cells are still in their early stages, and not always adequate for industrial production. Accordingly, multilateral co-operation between

universities, research institutes, governments, stakeholders and researchers is called for in order to make microalgae biofuels economical. Responding to this challenge, the book begins with a general introduction to microalgae and the algae industry, and subsequently discusses all major aspects of microalgal biotechnology, from strain isolation and robust strain development, to biofuel development, refinement and wastewater treatment. This edited volume focuses on comprehensive state-of-the-art information about the practical aspects of cultivation, harvesting, biomass processing and biofuel production from algae. Chapters cover topics such as synthetic ecological engineering approaches towards sustainable production of biofuel feedstock, and algal biofuel production processes using wastewater. Readers will also discover more about the role of biotechnological engineering in

improving ecophysiology, biomass and lipid yields. Particular attention is given to opportunities of commercialization of algal biofuels that provides a realistic assessment of various techno-economical aspects of pilot scale algal biofuel production. The authors also explore the pre-treatment of biomass, catalytic conversion of algal lipids and hydrothermal liquefaction with the biorefinery approach in detail. In a nut shell, this volume will provide a wealth of information based on a realistic evaluation of contemporary developments in algal biofuel research with an emphasis on pilot scale studies. Researchers studying and working in the areas of environmental science, biotechnology, genetic engineering and biochemistry will find this work instructive and informative.

Microalgae are one of the most studied potential sources of biofuels

and bioenergy. This book covers the key steps in the production of renewable biofuels from microalgae - strain selection, culture systems, inorganic carbon utilisation, lipid metabolism and quality, hydrogen production, genetic engineering, biomass harvesting, extraction. Greenhouse gas and techno-economic modelling are reviewed as is the 100 year history of microalgae as sources of biofuels and of commercial-scale microalgae culture. A summary of relevant basic standard methods used in the study of microalgae culture is provided. The book is intended for the expert and those starting work in the field.?

This book contains a collection of different research activities where several technologies have been applied to the optimization of biodegradation processes. The book has three main sections: A) Hydrocarbons biodegradation, B) Biodegradation and anaerobic

digestion, and C) Biodegradation and sustainability.

Life-cycle Analysis of Energy Use, Greenhouse Gas Emissions, and Water Consumption in the 2016 MYPP Algal Biofuel Scenarios

Sustainable Design and Industrial Applications in Mitigation of GHG Emissions

Handbook of Microalgae-Based Processes and Products

Microalgae Cultivation for Biofuels Production

Mass Balance Modeling and Life Cycle Assessment of Microalgae-derived Biodiesel Production

Biomass, Biofuels, Biochemicals

Large scale biofuel production from microalgae is expected to be integrated with point source CO2 sources, such as coal fired power plants. Flue gas

(CO2) integration represents a required nutrient source for accelerated growth while concurrently providing an environmental service. Heavy metals inherent in coal will ultimately be introduced into the culture system. The introduced heavy metals have the potential to bind to microalgae cells, impact growth due to toxicity, and negatively impact the quality of biofuel and other microalgal derived products. Heavy metals As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Se, Sn, V and Zn, commonly present in coal, were introduced to the microalgae growth medium at a concentration expected from a 7 day growth period using coal

flue gas. Experimentation was conducted with Nannochloropsis salina cultivated in photobioreactors at a light intensity of 1000 Îơmol m-2 s-1. Heavy metals negatively impacted the growth with the average productivity being 0.54 ℗ł 0.28 g L-1 d-1, corresponding to a decrease of 52% in biomass yield compared to control growths. Heavy metal analysis showed significant binding of the majority of the heavy metals to the biomass. A lipid content analysis found a decrease in lipid content from 38.8 ℗ł 0.62% to 31.58 ℗ł 0.50% (percent dry biomass). Control and heavy metal contaminated biomass were

processed into biofuel through one of two different in-situ transesterification techniques, either acid-catalyzed or supercritical methanol conversion. The acid-catalyzed conversion resulted in an average crude biofuel production decrease from 0.31 ±0.03 grams biofuel/gram microalgae for the control algae to 0.28 ±0.02 grams biofuel/gram microalgae for the heavy metal algae, representing a 9.7% reduction. Supercritical methanol conversion exhibited a similar trend corresponding to a 15.8% reduction. Compared to the control, the total production of biofuel from the contaminated system was

decreased by 51% for the acid-catalyzed conversion and 55% for the supercritical methanol conversion. Heavy metal analyses were performed on the biofuel, lipid extracted algae, and other biofuel conversion byproducts. Biochemical methane potential testing was performed on the lipid extracted algae to determine the effect of heavy metals on the generation of biogas. The effects of heavy metals in combination with the effects of acid catalyzed transesterification were found to have a positive effect on the amount of methane produced with an average productivity of 105.89 mL g-COD-1

from the heavy metals contaminated LEA compared to the control microalgae biomass which produced 53.25 mL g-COD-1.

The Department of Energy (DOE) Bioenergy Technologies Office (BETO) Multi-year Program Plan (MYPP) describes the bioenergy objectives pursued by BETO, the strategies for achieving those objectives, the current state of technology (SOT), and a number of design cases that explore cost and operational performance required to advance the SOT towards middle and long term goals (MYPP, 2016). Two options for converting algae to biofuel intermediates were considered in

the MYPP, namely algal biofuel production via lipid extraction and algal biofuel production by thermal processing. The first option, lipid extraction, is represented by the Combined Algae Processing (CAP) pathway in which algae are hydrolyzed in a weak acid pretreatment step. The treated slurry is fermented for ethanol production from sugars. The fermentation stillage contains most of the lipids from the original biomass, which are recovered through wet solvent extraction. The process residuals after lipid extraction, which contain much of the original mass of amino acids and proteins, are directed to

anaerobic digestion (AD) for biogas production and recycle of N and P nutrients. The second option, thermal processing, comprises direct hydrothermal liquefaction (HTL) of the wet biomass, separation of aqueous, gas, and oil phases, and treatment of the aqueous phase with catalytic hydrothermal gasification (CHG) to produce biogas and to recover N and P nutrients. The present report describes a life cycle analysis of energy use and greenhouse gas (GHG) emissions of the CAP and HTL options for the three scenarios just described. Water use is also reported. Water use during algal biofuel

production comes from evaporation during cultivation, discharge to bleed streams to control pond salinity ("blowdown"), and from use during preprocessing and upgrading. For scenarios considered to date, most water use was from evaporation and, secondarily, from bleed streams. Other use was relatively small at the level of fidelity being modeled now.

A valuable reference presenting many processes that facilitate lipid extraction from micro-organisms. Amongst the techniques included are Folch, Bligh and Dyer methods, and the Soxhlet technique as well as intensified green processes

(ultrasound, microwave, supercritical fluid extraction, agro-solvent, accelerated solvent extraction, enzyme-assisted extraction, instant controlled pressure drop, pulse electric field). In addition to a section featuring the analysis of fatty acids by Gas Chromatography and lipids by High-Performance Thin-Layer Chromatography (HPTLC), this brief contains a valuable bibliography on microorganisms (classes, structures) and their applications as a source of value added oils and compounds for food and non-food applications such as biojet fuel.

Advances in Feedstock Conversion Technologies

for Alternative Fuels and Bioproducts: New Technologies, Challenges and Opportunities highlights the novel applications of, and new methodologies for, the advancement of biological, biochemical, thermochemical and chemical conversion systems that are required for biofuels production. The book addresses the environmental impact of value added bio-products and agricultural modernization, along with the risk assessment of industrial scaling. The book also stresses the urgency in finding creative, efficient and sustainable solutions for environmentally conscious biofuels, while

underlining pertinent technical, environmental, economic, regulatory and social issues. Users will find a basis for technology assessments, current research capability, progress, and advances, as well as the challenges associated with biofuels at an industrial scale, with insights towards forthcoming developments in the industry. Presents a thorough overview of new discoveries in biofuels research and the inherent challenges associated with scale-up Highlights the novel applications and advancements for biological, biochemical, thermochemical and chemical conversion systems that are required for biofuels

production Evaluates risk management concerns, addressing the environmental impact of value added bio-products and agricultural modernization, and the risk assessment of industrial scaling

Advances in Bioenergy

Bioremediation, Biomass, Biofuels and Bioproducts

Energy from Microalgae

Waste Biorefinery

Opportunities and Perception

A Novel Integrated Biorefinery Process for Diesel Fuel Blendstock Production Using Lipids from the

Methanotroph, Methylomicrobium Buryatense

Pretreatment of Biomass provides general information, basic data, and knowledge on one of the most promising renewable energy sources—biomass for their pretreatment—which is one of the most essential and critical aspects of biomass-based processes development. The quest to make the environment greener, less polluted, and less hazardous has led to the concept of biorefineries for developing bio-based processes and products using biomass as a feedstock. Each kind of biomass requires some kind of pretreatment to make it suitable for bioprocess. This book provides state-of-art information on the methods

currently available for this. This book provides data-based scientific information on the most advanced and innovative pretreatment of lignocellulosic and algal biomass for further processing. Pretreatment of biomass is considered one of the most expensive steps in the overall processing in a biomass-to-biofuel program. With the strong advancement in developing lignocellulose biomass- and algal biomass-based biorefineries, global focus has been on developing pretreatment methods and technologies that are technically and economically feasible. This book provides a comprehensive overview of the latest developments in methods used for the pretreatment of

biomass. An entire section is devoted to the methods and technologies of algal biomass due to the increasing global attention of its use. Provides information on the most advanced and innovative pretreatament processes and technologies for biomass Covers information on lignocellulosic and algal biomass to work on the principles of biorefinery Useful for researchers intending to study scale-up Provides information on integration of processes and technologies for the pretreatment of biomass Bioreactors: Sustainable Design and Industrial Applications in Mitigation of GHG Emissions presents and compares the foundational concepts, state-of-the-

art design and fabrication of bioreactors. Solidly based on theoretical fundamentals, the book examines various aspects of the commercially available bioreactors, such as construction and fabrication, design, modeling and simulation, development, operation, maintenance, management and target applications for biofuels production and bio-waste management. Emerging issues in commercial feasibility are explored, constraints and pathways for upscaling, and techno-economic assessment are also covered. This book provides researchers and engineers in the biofuels and waste management sectors a clear, at-a-glance understanding of the actual potential of

different advanced bioreactors for their requirements. It is a must-have reference for better-informed decisions when selecting the appropriate technology models for sustainable systems development and commercialization. Focuses on sustainable bioreactor processes and applications in bioenergy and bio-waste management Explores techno-economic and sustainability assessment aspects through a comparative approach, catering to diverse arrays and applications Offers comprehensive coverage of the most recent technology, from fundamentals to applications

Over 80% of globally produced wastewater receives

little or no treatment before it is disposed into the environment. Therefore, it is urgent to develop new wastewater treatment technologies that are sustainable in the broad sense of the word, i.e. not only produce high quality effluents, but also minimise energy expenses, recover energy and nutrients, and apply technology that is appropriate in relation to the availability of skilled personnel. This book compiles the main outcomes of recent efforts to improve the design of waste stabilisation ponds, and confirms the superior performance of high rate algal ponds as a result of process intensification. Anaerobic digestion devoted to biogas production continues to be the preferred

strategy for the energy valorisation of the algal biomass, co-digestion with multiple high C/N ratio substrates gathering significant attention over the past years. The potential of algal biomass as a biosorbent for heavy metal removal (Cu, Ni, F) maintains its share in the research field of water bioremediation, while research on nutrient removal has focused on providing new insights on the mechanism of nitrogen and phosphorus removal from wastewater in algal–bacterial systems. Finally, it is worth noticing that breakthroughs in complementary fields of research such as nanotechnology or lighting technology are gradually being implemented in algal biotechnology, with new

products such as nanoparticles for water disinfection or photobioreactors illuminated by low intensity LED panels. In Focus – a book series that showcases the latest accomplishments in water research. Each book focuses on a specialist area with papers from top experts in the field. It aims to be a vehicle for in-depth understanding and inspire further conversations in the sector.

Microalgae Cultivation for Biofuels Production explores the technological opportunities and challenges involved in producing economically competitive algal-derived biofuel. The book discusses efficient methods for cultivation, improvement of harvesting and lipid

extraction techniques, optimization of conversion/production processes of fuels and co-products, the integration of microalgae biorefineries to several industries, environmental resilience by microalgae, and a techno-economic and lifecycle analysis of the production chain to gain maximum benefits from microalgae biorefineries. Provides an overview of the whole production chain of microalgal biofuels and other bioproducts Presents an analysis of the economic and sustainability aspects of the production chain Examines the integration of microalgae biorefineries into several industries Advances in Biofeedstocks and Biofuels, Volume 2

Biofuels from Algae
Algal Biofuels
Impact of Heavy Metal Contamination From Coal Flue Gas on Microalgae Biofuel and Biogas Production Through Multiple Conversation Pathways
Application of Microalgae in Wastewater Treatment Recent Advances and Future Prospects

Increasing demand for energy along with the limitations of fossil fuel sources and their negative impacts on the environment, have made the effort for finding a suitable replacement for energy a high priority. Microalgae as feedstock for bio-fuels has several benefits, including their fast growth, their

ability to grow on land and water sources not suitable for crops, their high lipid content, and their potential to serve as sink for CO2. As a result, they have been proposed as feedstock for biodiesel production through lipid extraction. The residual waste after the lipid extraction is called lipid extracted algae (LEA). This research investigated the feasibility of using LEA as feedstock for the production of methane through anaerobic digestion. The research involved four tasks, namely cultivation and harvesting, lipid extraction, LEA purification, and anaerobic digestion. Chlorella Vulgaris (C. vulgaris), one of the most researched algal species,

was grown in the lab. Lipid extraction performed on the C. vulgaris biomass at 10% solids resulted in about 200 mg lipid per gram of dry mass of algae which is equivalent to 7.66 kJ/gram of C. vulgaris. A number of methods were investigated for the purification of LEA, including evaporation with water bath, distillation by Rotovap, and evaporation by heating at 90, 95 and 100°C. The results showed that a two-step method, distillation by Rotovap followed by heating at 100°C was the best method for the purification of LEA. Bench-scale anaerobic digesters were set up and a number of processes and operational parameters were examined to

establish the optimum condition for the digestion of LEA. The results revealed that an LEA to inoculum ratio of 1 to 1 on the basis of volatile solids, alkalinity of 3000 mg/L as CaCO3, digestion time of 20-day, and pH of ~7.0 produced the highest CH4 yield under mesophilic condition. On average, the CH4 yield per mass of LEA was determined as 108.8 mL/gram or 87 mL per gram of C. vulgaris at 25°C and 1 atm, which is equivalent to 3.16 kJ/gram of C. vulgaris processed. This resulted in ~40% increase in energy recovery from C. vulgaris.

This book presents the dynamic role of algae in a sustainable environment. Two major aspects,

namely bioenergy and bioremediation, have been elaborated in various chapter contributed by scientists and teachers from different geographical areas throughout the world. Algal biofuels is an emerging area of equal interest to researchers, industries, and policy makers working or focusing on alternative (i.e. renewable) fuels. Algae have been an area of interest due to their wide range of applications. Over the last 5 decades, eukaryotic algae have been used in the aquaculture industry as feed for invertebrates, providing a rich source of antioxidants, dietary fiber, minerals and protein. More recently, there has been a focus on the use of

algal biomass in the development of alternative fuels. The extraction of oil from algae has been widely explored as a much more viable feedstock than plant-based oils in large-scale fuel production. using algae as feedstock has the advantages that it doesn't require arable land and that wastewater can be used as a source of nutrients in their culture. The multifunctional approach of algae includes pollution remediation, carbon sequestration, biofuels production, and delivery of value-added products. However, there are still some obstacles that need to be overcome to make their use as potential feedstock for biofuels techno-economically feasible.

In order to maintain the sustainability aspect of algal biofuels, various aspects have to be studied and critically analyzed to assess the long-term sustainability of algal derived biofuels. This book discusses the role of algae as a promising future feedstock for biofuels. They are known to sequester carbon in much larger amounts than plants and as such the book also describes their phycoremediation potential for conventional as well as emerging contaminants. It describes the role of anaerobic digestion in algal biorefineries; bioreactions and process parameters; biogas recovery and reuse. The role of algal biofilm based

technology in wastewater treatment and transforming waste into bio-products is discussed, and remediation of sewage water through algae is assessed. The book also describes the production of biohydrogen, bio-oil, biodiesel; and the major bottlenecks in their usage. The emerging characterization techniques of these biofuels (bio-oil and biodiesel) are described, as are the decolorizing potential of algae and the genetic engineering techniques that could enhance the production of lipids in algae. Other aspects of the book include the role of remote sensing technology in the monitoring of algae and a life cycle

assessment of algal biofuels.

Anaerobic Digestion of Lipid Extracted Algae

This volume focuses on the prospects of the conversion of biomass into biofuels including ethanol, butanol, biogas, biohydrogen, biodiesel, syn-gas and other useful products. Biomass-derived fuels have gained tremendous attention worldwide. However, due to high raw material and processing costs, biofuels produced from lignocelluloses have been found to be more expensive than conventional fuels. Therefore, a concept of biorefining has been introduced, where more than one product or each and every component of biomass may be derived

into useful products in a manner of petroleum refinery.

Pretreatment of Biomass

The Use of Condensed Tannins and Nitrate to Reduce Enteric Methane Emission and Enhance Utilization of High-forage Diets in Sheep

Production of Biofuels and Chemicals with Ultrasound

Methane Production from Anaerobic Co-digestion of Chlorella Vulgaris and Wastewater Sludge

Microalgae-Based Biofuels and Bioproducts

Disruptive Technologies to Enable Commercial Production

Biomass, Biofuels and Biochemicals: Biofuels from Algae, Second Edition provides information on strategies for commercial microalgae based biofuel production, including their cultivation, pre-treatment and conversion methods. The book discusses methods for producing microalgal biomass in large scale by outdoor culturing and outlines new technologies for their use. In addition, it explains how modern genetic engineering enables the generation of recombinant strains that generate higher quantities of feedstock. The complete utilization of microalgal biomass, which can also be obtained from valorizing nutrients from wastewater and industrial

exhaust gases, can be efficiently converted to energy rich biofuels and high value pharmaceuticals in a well-defined biorefinery. Includes the current technologies for the cultivation and conversion of energy rich microalgal biomass into biofuels Provides information on all the conversion methods – biochemical and thermochemical conversions Covers other high value products from microalgae and less conventional applications, such as fine chemical production and aviation fuel generation Discusses the economics of microalgal biofuel production and how to accomplish cost competitive results Microalgae-Based Biofuels and Bioproducts: From

Feedstock Cultivation to End Products compiles contributions from authors from different areas and backgrounds who explore the cultivation and utilization of microalgae biomass for sustainable fuels and chemicals. With a strong focus in emerging industrial and large scale applications, the book summarizes the new achievements in recent years in this field by critically evaluating developments in the field of algal biotechnology, whilst taking into account sustainability issues and techno-economic parameters. It includes information on microalgae cultivation, harvesting, and conversion processes for the production of liquid and gaseous

biofuels, such as biogas, bioethanol, biodiesel and biohydrogen. Microalgae biorefinery and biotechnology applications, including for pharmaceuticals, its use as food and feed, and value added bioproducts are also covered. This book ' s comprehensive scope makes it an ideal reference for both early stage and consolidated researchers, engineers and graduate students in the algal field, especially in energy, chemical and environmental engineering, biotechnology, biology and agriculture. Presents the most current information on the uses and untapped potential of microalgae in the production of bio-based fuels and chemicals Critically reviews the state-of-

the-art feedstock cultivation of biofuels and bioproducts mass production from microalgae, including intermediate stages, such as harvesting and extraction of specific compounds Includes topics in economics and sustainability of large-scale microalgae cultivation and conversion technologies

Advances in Bioenergy, Volume Six in this ongoing series, highlights new advances in the field, with this new volume presenting interesting chapters written by an international board of authors. New sections in this release include Microalgae wastewater treatment and biomass utilization, Lipid Metabolism and Metabolic Engineering of

Eukaryotic Microalgae, Aquaculture, Microalgae Cultivation, Life Cycle Assessment, Integration of algae cultivation with anaerobic digestion, Bioenergy and Bioproducts from Industry Hemp, Integration of algae to anaerobic digestion for biofuel and bioenergy production, and more. Provides the authority and expertise of leading contributors from an international board of authors Presents the latest release in the Advances in Bioenergy serial

The Handbook of Microalgae-based Processes and Products provides a complete overview of all aspects involved in the production and utilization of microalgae

resources at commercial scale. Divided into four parts (fundamentals, microalgae-based processes, microalgae-based products, and engineering approaches applied to microalgal processes and products), the book explores the microbiology and metabolic aspects of microalgae, microalgal production systems, wastewater treatment based in microalgae, CO2 capture using microalgae, microalgae harvesting techniques, and extraction and purification of biomolecules from microalgae. It covers the largest number of microalgal products of commercial relevance, including biogas, biodiesel, bioethanol, biohydrogen, single-cell protein, single-cell oil,

biofertilizers, pigments, polyunsaturated fatty acids, bioactive proteins, peptides and amino acids, bioactive polysaccharides, sterols, bioplastics, UV-screening compounds, and volatile organic compounds. Moreover, it presents and discusses the available engineering tools applied to microalgae biotechnology, such as process integration, process intensification, and techno-economic analysis applied to microalgal processes and products, microalgal biorefineries, life cycle assessment, and exergy analysis of microalgae-based processes and products. The coverage of a broad range of potential microalgae processes and products in a single volume makes this

handbook an indispensable reference for engineering researchers in academia and industry in the fields of bioenergy, sustainable development, and high-value compounds from biomass, as well as graduate students exploring those areas. Engineering professionals in bio-based industries will also find valuable information here when planning or implementing the use of microalgal technologies. Covers theoretical background information and results of recent research. Discusses all commercially relevant microalgae-based processes and products. Explores the main emerging engineering tools applied to microalgae processes, including techno-economic analysis,

process integration, process intensification, life cycle assessment, and exergy analyses.

Biorefining of Biomass to Biofuels

Potential and Perspectives

Green Fuels Technology

3rd Generation Biofuels

Contemporary Technologies and Future Outlook

Algae and Environmental Sustainability

Waste Biorefinery: Potential and Perspectives offers data-based information on the most cutting-edge processes for the utilisation of biogenic waste to produce biofuels, energy

products, and biochemicals – a critical aspect of biorefinery. The book explores recent developments in biochemical and thermo-chemical methods of conversion and the potential generated by different kinds of biomass in more decentralized biorefineries. Additionally, the book discusses the move from 200 years of raw fossil materials to renewable resources and how this shift is accompanied by fundamental changes in industrial manufacturing technologies (from chemistry to biochemistry) and in logistics and manufacturing concepts (from petrochemical refineries to biorefineries).

Waste Biorefinery: Potential and Perspectives designs concepts that enable modern biorefineries to utilize all types of biogenic wastes, and to integrate processes that convert byproduct streams to high-value products, achieving higher cost benefits. This book is an essential resource for researchers and students studying biomass, biorefineries, and biofuels/products/processes, as well as chemists, biochemical/chemical engineers, microbiologists, and biotechnologists working in industries and government agencies. Details the most advanced and innovative

methods for biomass conversion Covers biochemical and thermo-chemical processes as well as product development Discusses the integration of technologies to produce bio-fuels, energy products, and biochemicals Illustrates specific applications in numerous case studies for reference and teaching purposes

This book presents an authoritative and comprehensive overview of the production and use of microalgal biomass and bioproducts for energy generation. It also offers extensive information on engineering approaches to energy production, such as process

integration and process intensification in harnessing energy from microalgae. Issues related to the environment, food, chemicals and energy supply pose serious threats to nations' success and stability. The challenge to provide for a rapidly growing global population has made it imperative to find new technological routes to increase the production of consumables while also bearing in mind the biosphere's ability to regenerate resources. Microbial biomass is a bioresource that provides effective solutions to these challenges. Divided into eight parts, the book explores microalgal production systems,

life cycle assessment and the bio-economy of biofuels from microalgae, process integration and process intensification applied to microalgal biofuels production. In addition, it discusses the main fuel products obtained from microalgae, summarizing a range of useful energy products derived from algae-based systems, and outlines future developments. Given the book's breadth of coverage and extensive bibliography, it offers an essential resource for researchers and industry professionals working in renewable energy.

This book sheds new light on how microbes can

be used as effective and sustainable resources to produce green energy in the form of biogas, algal diesel, ethanol, hydrogen and direct electricity. It discusses topics such as microbial energy conversion technologies, including ethanol production by microbial catalytic reaction, biomethanization, biodiesel from microalgae, microbial fuel cells, and the microbiological production of hydrogen. The book will inspire scientists to find new approaches to meet local energy demands with the help of sustainable microbial resources available in and around a given location.

In light of the availability of low-cost methane (CH4) derived from natural gas and biogas along with increasing concerns of the greenhouse gas emissions, the production of alternative liquid biofuels directly from CH4 is a promising approach to capturing wasted energy. A novel biorefinery concept integrating biological conversion of CH4 to microbial lipids together with lipid extraction and generation of hydrocarbon fuels is demonstrated in this study for the first time. An aerobic methanotrophic bacterium, Methylomicrobium buryatense capable of using CH4 as the sole carbon

source was selected on the basis of genetic tractability, cultivation robustness, and ability to accumulate phospholipids in membranes. A maximum fatty acid content of 10% of dry cell weight was obtained in batch cultures grown in a continuous gas sparging fermentation system. Although phospholipids are not typically considered as a good feedstock for upgrading to hydrocarbon fuels, we set out to demonstrate that using a combination of novel lipid extraction methodology with advanced catalyst design, we could prove the feasibility of this approach. Up to 95% of the total fatty acids from

membrane-bound phospholipids were recovered by a two-stage pretreatment method followed by hexane extraction of the aqueous hydrolysate. The upgrading of extracted lipids was then demonstrated in a hydrodeoxygeation process using palladium on silica as a catalyst. Lipid conversion in excess of 99% was achieved, with a full selectivity to hydrocarbons. Lastly, the final hydrocarbon mixture is dominated by 88% pentadecane (C15H32) based on decarbonylation/decarboxylation and hydrogenation of C16 fatty acids, indicating that a biological gas-to-liquid fuel (Bio-

GTL) process is technically feasible.

Microalgae Biotechnology for Development of Biofuel and Wastewater Treatment

Algae for Biofuels and Energy

Microwave-Mediated Biofuel Production

Algae and Aquatic Macrophytes in Cities

Bioreactors

Anaerobic Digestion of Lipid Extracted Algae

Microalgal biomass is a candidate feedstock for biofuel production. To improve the sustainability of algae biofuel production, following biofuel recovery, the biomass nutrients should be recycled for additional

algae growth. Anaerobic digestion of algae or oil-extracted algae is a means of recovering carbon and other nutrients, while offsetting algae production electricity demand. The major limiting factor in microalgae digestion is the low biodegradability of the cell walls. In the present study, various pretreatment technologies were tested at bench scale for their ability to improve raw, non-lipid-extracted algae biodegradability, which was assessed in terms of methane yield, volatile solids destruction, and solubilization of N, P,

and K. The microalgae were harvested by sedimentation from outdoor wastewater-fed raceways ponds operated in coastal southern California. Four pretreatment methods (sonication, high-pressure homogenization, autoclaving, and boiling) were used on the algae slurries, each followed by batch anaerobic digestion (40 days at 35oC). Biomass sonication for 10 minutes showed the highest methane yield of 0.315 L CH4/ g VSIN, which is a 28% increase over the untreated control. Conversely, autoclaved

algae slurry inhibited methane production (0.200 vs. 0.228 L CH4/ g VSIN for the treatment and control). A preliminary energy balance indicated that none of the pretreatments led to a net increase in energy conversion to biomethane. However, pretreatment did increase the initial N and P solubilization rates, but, after digestion, the ultimate N and P solubilization was nearly the same among the treatments and controls. After 40 days of digestion, solubilization of N, P, and K reached, respectively, 50-60% of

average total Kjeldahl N, 40-50% of average total P, and 80-90% of average total K. Descriptive first-order models of solubilization were developed. Overall, certain pretreatments marginally improved methane yield and nutrient solubilization rate, which cast doubt on the efficacy of, or even the need for, algae biomass pretreatment prior to anaerobic digestion.

3rd Generation Biofuels: Disruptive Technologies to Enable Commercial Production is a comprehensive volume on all

aspects of algal biofuels, offering the latest advances on commercial implementation. In addition to the fundamentals, the book discusses all applied aspects of 3rd generation biofuels production, including design approaches, unit operations of the upstream and downstream biomass processing, and every potential microalgae-based energy product, including microbial fuel cells. Policy, economic, environmental, and regulatory issues are addressed in a dedicated section. Finally, the book presents

pilot and demonstration-scale projects for 3rd generation biofuels production in the format of a white paper. Each chapter reviews the state of the art, discusses the disruptive technological approaches that will potentially enable large-scale production, and concludes with specific recommendations on how to achieve commercial competitiveness. The book provides readers with an invaluable reference for researchers, graduates, and practitioners working in the areas of renewable energy, bioenergy and alternative

fuels, and biotechnology. Offers a sequential framework for the design of process plants using 3rd generation feedstock Presents dedicated sections on case studies at pilot and demonstration scales as well as on policy, economic, and environmental issues Provides a global perspective on biofuels production, with more than 40 contributions from world-renounced experts

This two-volume work presents comprehensive, accurate information on the present status and contemporary

development in phycoremediation of various types of domestic and industrial wastewaters. The volume covers a mechanistic understanding of microalgae based treatment of wastewaters, including current challenges in the treatment of various organic and inorganic pollutants, and future opportunities of bioremediation of wastewater and industrial effluents on an algal platform. The editors compile the work of authors from around the globe, providing insight on key issues and state-of-the-art developments in

algal bioremediation that is missing from the currently available body of literature. The volume hopes to serve as a much needed resource for professors, researchers and scientists interested in microalgae applications for wastewater treatment. Volume 2 addresses the various biorefinery aspects and applications of algal-based wastewater treatment in industrial and domestic contexts. The analyses are approached from multiple perspectives, including biotechnology, commercial,

economic, and sustainability. The authors discuss the potential of microalgae for integrated biomass production utilizing various resources to treat wastewaters, and include evaluations of the economical and commercialization potential for such processes.

Increasing demand for energy coupled with concerns over limited fossil fuel reserves and apprehensions over their contributions to greenhouse gas emissions have made the search for low carbon energy sources a high

priority. Algal biomass could serve as an alternative source of renewable biofuels. Research efforts to date have primarily focused on the production of algal biofuels through lipid extraction, which involves high temperature and high pressure, resulting in an energy intensive process. In this research, the use of algal biomass as a supplementary feedstock to anaerobic digesters for the production of methane gas is evaluated. To test the potential of algal biomass as a supplementary feedstock, labscale anaerobic

digesters are set-up. The methane gas production of various combinations of thickened waste activated sludge (TWAS) and algal biomass is investigated. Chlorella vulgaris (C. vulgaris) is used as representative microalgae. In addition, the effects of operational parameters, such as biomass loading, temperature and alkalinity, on biogas production are investigated. The results show that the biogas production for all biomass loading combinations of C. vulgaris and TWAS ranged from 0.47-0.57 mL per mg volatile

solids (VS) digested. On average, VS and chemical oxygen demand (COD) were reduced 48 and 38%, respectively, at 35°C. Average total coliform (TC) and fecal coliform (FC) concentrations of 6.3x104 and 1.0x104 CFU per gram of total solids (TS), respectively, were measured in the digested waste at 35°C. Thus, the residual meets the USEPA requirements for pathogen reduction (FC 2x106 CFU per g TS) and vector attraction reduction (38% reduction in VS) for land application. The total nitrogen and

phosphorus content of the residual was determined to be in the range of 9-17% as N and 3-7% as P (7-16% as P2O5), respectively, revealing its potential value as a fertilizer. It was also observed that decreased digestion temperatures resulted in lower biogas yields, while initial alkalinity in digesters did not appear to affect biogas production. From the results of the research, it can be inferred that algae can be co-digested with wastewater sludge, or by itself, to produce methane gas at wastewater treatment plants (WWTPs).

This suggests that algae can be utilized as an energy source through anaerobic co-digestion with wastewater sludge. This is significant because algae can be grown with the nutrient and CO2 contained in waste streams at WWTPS, thereby minimizing the release of nutrients and effluent water to the environment. This reduced nutrient load results in treatment cost savings, while the reduction in effluent discharge decreases environmental pollution.

Engineering and Technology

Production Technologies for Biofuels
Advances in Energy Science and Equipment Engineering
Micro-algae: Next-generation Feedstock for Biorefineries
Microbial Resources for Sustainable Energy