



CO₂ Biofixation by Microalgae

Modeling, Estimation and Control

**Sihem Tebbani, Filipa Lopes, Rayen Filali
Didier Dumur and Dominique Pareau**

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CO₂ Biofixation By Microalgae Automation Process Focus:

CO₂ Biofixation by Microalgae Sihem Tebbani, Rayen Filali, Filipa Lopes, Didier Dumur, Dominique Pareau, 2014-07-09 Due to the consequences of global warming and significant greenhouse gas emissions several ideas have been studied to reduce these emissions or to suggest solutions for pollutant removal. The most promising ideas are reduced consumption, waste recovery and waste treatment by biological systems. In this latter category studies have demonstrated that the use of microalgae is a very promising solution for the biofixation of carbon dioxide. In fact these microorganisms are able to offset high levels of CO₂ thanks to photosynthesis. Microalgae are also used in various fields: food industry, fertilizers, biofuel, etc. To obtain an optimal CO₂ sequestration using microalgae their cultivation has to be carried out in a favorable environment corresponding to optimal operating conditions: temperature, nutrients, pH, light, etc. Therefore microalgae are grown in an enclosure i.e. photobioreactors which notably operate in continuous mode. This type of closed reactor notably enables us to reduce culture contamination, to improve CO₂ transfer and to better control the cultivation system. This last point involves the regulation of concentrations: biomass, substrate or by product, in addition to conventional regulations: pH, temperature. To do this we have to establish a model of the system and to identify its parameters to put in place estimators in order to rebuild variables that are not measured online: software, sensor and finally to implement a control law in order to maintain the system in optimal conditions despite modeling errors and environmental disturbances that can have an influence on the system: pH variations, temperature, light, biofilm appearance, etc.

Algae for Biofuels and Energy Michael A. Borowitzka, Navid R. Moheimani, 2012-12-11 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.

Microalgae Biotechnology and Sustainable Development Anish Khan, Khalid A. Alzahrani, 2026-01-01 This book highlights the main challenges of utilizing microalgae biotechnology with chemical absorption technologies as a combined technique for applications in biofixation of carbon dioxide (CO₂) and feedstock production for biofuels and other bioproducts. The higher carbon dioxide (CO₂) concentration in the atmosphere has been widely associated with global warming and climate change. Thus chemical, physical and biological methods have been studied as strategies to capture CO₂. This book looks at the biological method of CO₂ fixation by microalgae or CO₂ biofixation which stands out because in addition to capturing this greenhouse gas (GHG) microalgae convert it into biomass that can be applied as a feedstock for biofuels and other bioproducts. It also describes the cultivation of microalgae using waste resources such as flue gas and wastewater as nutrients for their

growth However the efficiency of CO₂ biofixation by microalgae may be a limiting factor in this process This book demonstrates the integration with another method chemical absorption as an alternative not only to improve the CO₂ fixation but also to produce biomass with higher applicability due to the increase in the biomolecule concentration such as proteins carbohydrates and lipids exopolysaccharides and pigments The book is also useful to postgraduate researchers and academics biotechnologists and industrial practitioners interested in minimizing carbon footprint via microalgae as a biological capture and production of other bioproducts

Microalgae Biofixation Processes ,2006 **Microalgae Biotechnology and Sustainable Development** Anish Khan,Khalid A. Alzahrani,2025-12-02 This book highlights the main challenges of utilizing microalgae biotechnology with chemical absorption technologies as a combined technique for applications in biofixation of carbon dioxide CO₂ and feedstock production for biofuels and other bioproducts The higher carbon dioxide CO₂ concentration in the atmosphere has been widely associated with global warming and climate change Thus chemical physical and biological methods have been studied as strategies to capture CO₂ This book looks at the biological method of CO₂ fixation by microalgae or CO₂ biofixation which stands out because in addition to capturing this greenhouse gas GHG microalgae convert it into biomass that can be applied as a feedstock for biofuels and other bioproducts It also describes the cultivation of microalgae using waste resources such as flue gas and wastewater as nutrients for their growth However the efficiency of CO₂ biofixation by microalgae may be a limiting factor in this process This book demonstrates the integration with another method chemical absorption as an alternative not only to improve the CO₂ fixation but also to produce biomass with higher applicability due to the increase in the biomolecule concentration such as proteins carbohydrates and lipids exopolysaccharides and pigments The book is also useful to postgraduate researchers and academics biotechnologists and industrial practitioners interested in minimizing carbon footprint via microalgae as a biological capture and production of other bioproducts

Potential for Production of Microalgal Biomass in CO₂ Enhanced Gas Streams with Specific Focus on the Bio-fixation of Carbon by Microalgae ,2013 **Pattern light simulation and sensing automation of flat plate photobioreactor for sustainable growth and cultivation of Microalgae** Erim Sezer,2015-08-17 Bachelor Thesis from the year 2015 in the subject Engineering Industrial Engineering and Management grade 1 0 University of Applied Sciences Esslingen Bachelor Thesis ITESM Mexico course International Engineering Management language English abstract Nowadays microalgae are considered as a promising new sustainable feedstock due to its higher photosynthetic activity and growth rates compared to other plants However its high energy need in the cultivation process the prevalence of manual work and the high costs deem the production and commercialization of it difficult Consequently the challenge of artificial microalgae production is not only to replicate and enhance the optimum natural growth conditions but to make it automated and profitable The purpose of this research was to develop an automated system to monitor and control specific growth conditions in order to improve the algae biomass production process This

research required the planning and installation of a control cabinet on a flat plate photobioreactor components selection installation of sensors and software programming in LabVIEW The result of this research was a system that monitors the basic environmental growth parameters which are temperature light and pH In addition to the monitoring system a control system for light and CO₂ flow was integrated to simulate specific growth conditions of microalgae Further research is required in order to strengthen the idea of a fully automated flat plate photobioreactor for a more efficient microalgae cultivation This approach may lead to a technology that can be used as a base model for future applications on more reactors

Handbook of Microalgae-Based Processes and Products Eduardo Jacob-Lopes, Mariana Manzoni Maroneze, Maria Isabel Queiroz, Leila Queiroz Zepka, 2020-07-23 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

Modeling and Optimization of CO₂ Fixation Using Microalgae Cultivated in Oil Sands Process Water Sepideh Kasiri, 2015 Biological fixation of CO₂ using microalgae is a potential CO₂ reduction strategy which can be applied to the oil sands operations in Alberta These operations also produce large amounts of oil sands process water OSPW which can act as a growth medium for the microalgae In this thesis three different microalgae *Botryococcus braunii* *Chlorella pyrenoidosa* and *Chlorella kessleri* were investigated for their ability to

grow in OSPW and to uptake CO₂. Also the effect of phosphate nitrate CO₂ concentrations and light intensity were studied using a fractional two level and a full two level factorial designs. These investigations eliminated *Botryococcus braunii* as it cannot grow in OSPW and demonstrated that *Chlorella kessleri* has a higher CO₂ uptake rate than *Chlorella pyrenoidosa*. Moreover CO₂ concentration, light intensity and phosphate concentration proved to have the strongest effects in that order on the growth and CO₂ uptake rate of *Chlorella kessleri*. To make biological fixation of CO₂ economically competitive compared to other CO₂ capture techniques it is necessary to optimize CO₂ fixation rate and operate the algal culture at the optimal process conditions. Response surface methodology (RSM) was also used to develop statistical models for the CO₂ uptake rate and specific growth rate of *Chlorella kessleri*. The quadratic models developed were used to determine the optimal sets of CO₂ concentration, phosphate concentration and light intensity for CO₂ uptake rate and specific growth rate in batch operation. A multi objective optimization technique was then used to maximize the CO₂ uptake rate and specific growth rate simultaneously. Moreover to have a better understanding of microalgal dynamic behaviour data generated using a central composite experimental design (CCD) with varying light intensity, CO₂ and phosphate concentration was used to develop a mathematical model that describes the kinetics of algal growth and CO₂, phosphate nitrate and ammonium uptake rate of *Chlorella kessleri* cultivated in OSPW. This nonlinear dynamic model was used to determine the optimal CO₂ concentration, phosphate concentration and light intensity for CO₂ uptake and algal growth over a period of time in a batch culture using a multi objective optimization technique to maximize CO₂ fixation and algal growth simultaneously. Finally a lab scale closed raceway photobioreactor was designed and assembled for cultivation of *Chlorella kessleri* in OSPW with the aim of combining CO₂ capture and algal production. A fed batch model describing the dynamics of microalgae growth and CO₂, phosphate and ammonium uptake rate was developed based on the modification of a previously developed model for batch cultures and was successfully validated against experimental data. The CO₂ uptake rate and algal growth can be maximized by properly manipulating the CO₂ and phosphate concentrations and availability and intensity of light. A model based optimization method was used to calculate the optimal feeding strategies for CO₂, phosphate and light intensity.

Microalgae-Based Systems Eduardo Jacob-Lopes, Rosângela Rodrigues Dias, Leila Queiroz Zepka, 2023-10-04. Process integration and intensification are means to improve the sustainability metrics of the industrial processes balancing the pillars of economy, environment and social demand. The book covers a sequential framework for the design and operation of microalgae based facilities using process integration and intensification, discusses products and applications and provides a global perspective with contributions from renowned experts. Covers relevant opportunities of process integration and intensification applied to microalgae based systems. Provides a complete review of the state of the art of these industrial approaches. Presents new insights into industrial sustainability.

Biotechnological Applications of Microalgae Faizal Bux, 2013-05-22. Microalgae are an invaluable biomass source with potential uses that could lead to environmental and

economic benefits for society **Biotechnological Applications of Microalgae Biodiesel and Value Added Products** presents the latest developments and recent research trends with a focus on potential biotechnologically related uses of microalgae It gives an analysis of microalgal biology ecology biotechnology and biofuel production capacity as well as a thorough discussion on the value added products that can be generated from diverse microalgae The book provides a detailed discussion of microalgal strain selection for biodiesel production a key factor in successful microalgal cultivation and generation of desired biofuel products It also describes microalgal enumeration methods harvesting and dewatering techniques and the design and the pros and cons of the two most common methods for cultivation open raceway ponds and photobioreactors Chapters cover lipid extraction and identification chemical and biological methods for transesterification of microalgal lipids and procedures involved in life cycle analysis of microalgae They also examine the importance of microalgal cultivation for climate change abatement through CO₂ sequestration and microalgae involvement in phycoremediation of domestic and industrial wastewaters The book concludes with a general discussion of microalgal biotechnology and its potential as a modern green gold rush The final chapter provides an overview of advanced techniques such as genetic engineering of microalgae to increase lipid yield This book provides a one stop benchmark reference on microalgal biotechnology considering all aspects from microalgal screening to production of biofuels and other value added products

Sustainable Downstream Processing of Microalgae for Industrial Application Kalyan Gayen, Tridib Kumar Bhowmick, Sunil Kumar Maity, 2019-09-05 Microalgae can be future resource for industrial biotechnology In current energy crisis era microalgae are under tremendous research focus for the production of biodiesel due to their high photosynthetic efficiency growth rate and high lipid content compared to territorial plants However the large scale production of algal biomass and downstream processing of harvested algae towards bio fuels are facing several challenges from economic viability perspective Apart from bio fuels the microalgae synthesize number of bio molecules such as pigments e g chlorophyll carotenoid protein e g lectin phycobiliprotein and carbohydrates e g agar carrageenan alginate fucodian which are available in the various forms of microalgal products Therefore developing a strategy for large scale production and use of algal biomass for the co production of these value added macromolecules is thus imperative for the improvement of the economics of algal biorefinery In the above context this book covers three major areas i commercial scale production of bio molecules from microalgae ii sustainable approach for industrial scale operation and iii optimization of downstream processes Each of these sections is composed of several chapters written by the renowned academicians industry experts Furthermore in this book a significant weightage is given to the industry experts around 50% to enrich the industrial perspectives We hope that amalgamate of fundamental knowledge from academicians and applied research information from industry experts will be useful for forthcoming implementation of a sustainable integrated microalgal biorefinery This book highlights following

Explores biomolecules from microalgae and their applications Discusses microalgae cultivations and harvesting Examines

downstream processing of biomolecules Explores sustainable integrated approaches for industrial scale operations Examines purification techniques specific for microalgal proteins Omega 3 fatty Acids carbohydrates and pigments **Microalgae as a Sustainable Source of Green Energy Generation and Bioeconomy** Javid A Parray,Niraj Singh,A. K. Haghi,2024-11-26 The primary focus of the topic is on the production of energy Here energy production typically refers to the conversion of waste algal biomass into various forms of usable energy This could include electricity biofuels e g biodiesel bioethanol biogas or other forms of renewable energy Conversion of algal biomass to fuels via extraction of lipids and potentially other components through algal lipid upgrading or ALU pathway combined algal process CAP and parallel algal process PAP ALU approach based on a biochemical processing strategy to selectively recover and convert select algal biomass components to fuels namely carbohydrates to ethanol and lipids to a renewable diesel blendstock RDB product The scope of the topic encompasses the various methods and technologies used to convert waste algal biomass into energy This could involve processes like anaerobic digestion fermentation pyrolysis hydrothermal liquefaction or other innovative techniques The topic may touch upon ongoing research technological advancements and potential areas of improvement related to waste algal biomass based energy production **Microalgae for Biofuel Production and CO2 Sequestration** Bei Wang,Christopher Lan,2010 Owing to their vast diversity and high growth rate microalgae offer numerous advantages as the most promising photosynthetic organisms for biofuel production and CO2 bio sequestration Two different processes have been proposed for these purposes microalgal farming and ocean fertilisation This book focuses primarily on the former while providing a brief introduction to the latter Technology Development and Process Optimization of CO2 Biofixation and C-phycoyanin Production with Spirulina Sp [?],2013

The Enigmatic Realm of **Co2 Biofixation By Microalgae Automation Process Focus**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing lacking extraordinary. Within the captivating pages of **Co2 Biofixation By Microalgae Automation Process Focus** a literary masterpiece penned by a renowned author, readers embark on a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting effect on the hearts and minds of those that partake in its reading experience.

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