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RECENT ADVANCES IN RENEWABLE ENERGY

VOLUME 1

MICROALGAE AS A SOURCE OF BIOENERGY: PRODUCTS, PROCESSES AND ECONOMICS

Editor:
José C.M. Pires

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Recent Advances in Renewable Energy

(Volume 1)

*(Microalgae as a Source of Bioenergy:
Products, Processes and Economics)*

Edited by

José Carlos Magalhães Pires

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Recent Advances in Renewable Energy

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Microalgae as a Source of Bioenergy: Products, Processes and Economics

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CONTENTS

PREFACE	i
LIST OF CONTRIBUTORS	iii
PART 1 PART I ENERGY FROM MICROALGAE: PRODUCTS AND PROCESSES	
CHAPTER 1 PERSPECTIVES OF ENERGY PRODUCTION FROM MICROALGAE: THE BIODIESEL AND COGENERATION CASES	
<i>Ectru'COEctf qpc. 'F cplgrc 'Rcttc 'cpf 'Ugdcuk^a p'Ugtpc"</i>	1
INTRODUCTION	1
Microalgae for Energy Production	3
Biofuel Production Processes from Microalgae	6
Biochemical Conversion	6
<i>Anaerobic Digestion</i>	7
<i>Alcoholic Fermentation</i>	9
<i>Photobiological Hydrogen Production</i>	10
<i>Thermochemical Conversion</i>	10
<i>Algal Biomass to Biodiesel</i>	13
<i>Biorefineries</i>	13
Challenges in the Use of Microalgae for Energy Production	15
SCENARIOS ANALYSIS: SIMULATION FOR COGENERATION AND BIODIESEL CASES	17
Cogeneration from Extraction Cake Residues	18
Biodiesel Production Using Basic Catalysis	19
CONCLUSION	22
CONFLICT OF INTEREST	22
ACKNOWLEDGEMENTS	23
REFERENCES	23
CHAPTER 2 ENERGETIC PRODUCTS FROM MICROALGAE: BIOETHANOL	
<i>Ej qqp'I gniMj qq. 'Ocp 'Mgg'Nco 'cpf 'Mgev'Vgqpi 'Ngg</i>	30
OVERVIEW ON THE RENEWABLE ENERGY DEVELOPMENT	30
BIOETHANOL FROM MICROALGAE	31
EFFECT OF CULTIVATION CONDITIONS TO IMPROVE CARBO-HYDRATE PRODUCTION	32
Effect of Sulfur	32
Effect of Nitrogen	33
Effect of Phosphorus	34
Effect of Carbon Source	34
<i>Inorganic Carbon</i>	34
<i>Organic Carbon</i>	35
Light Intensity	35
CARBOHYDRATE IN MICROALGAE	36
Cellulose	38
Starch	38
MICROALGAE BIOETHANOL PRODUCTION	39
PRE-TREATMENT & HYDROLYSIS	40
Physical Pre-treatment	40
Chemical Pre-Treatment	41
Enzymatic Pre-treatment	41
FERMENTATION PROCESS	42

Separate Hydrolysis and Fermentation (SHF)	44
Simultaneous Saccharification and Fermentation (SSF)	44
Microorganism for Fermentation of Microalgae Biomass	44
PRODUCTS RECOVERY	45
CONCLUSIONS	45
CONFLICT OF INTEREST	45
ACKNOWLEDGEMENTS	45
REFERENCES	45
CHAPTER 3 BIOETHANOL PRODUCTION PROCESS	53
<i>Hcdkpc'Tgi lpc'Zcxkgt'Devknc.'Lwrkpc'f'g'Uqw'c'Hgtt'gk'c'c'p'f'Xlegro'c'Nwk' 'Ectf'quq</i>	
DIFFERENT ROUTES TO ETHANOL PRODUCTION	53
MICROALGAE CONTRIBUTIONS TO THE BIOETHANOL PRODUCTION	55
General Algae Information	55
Brown and Green Algae Used as Feedstock	55
Self Fermentation or Intracellular Bioethanol Production Excreted to Supernatant	57
RESEARCH AND DEVELOPMENT OF THE USE OF ALGAE RELATED TO BIOETHANOL PRODUCTION	60
CONCLUDING REMARKS	62
CONFLICT OF INTEREST	63
ACKNOWLEDGEMENTS	63
REFERENCES	63
CHAPTER 4 METHANE PRODUCTION PROCESS FOR MICROALGAE CONVERSION	67
<i>Octv'p'Rednq'Ecr'qi'pq.'Gwj'gt'Vq'tt'g'p'u'c'p'f' 'Ej't'knqrj'g'Dgpi'qc</i>	
INTRODUCTION	67
BIOGAS FROM MICROALGAE: THE HISTORY	70
THE ANAEROBIC DIGESTION PROCESS	71
Parameters Affecting AD of Microalgae	74
<i>Substrate Characteristics</i>	75
<i>Mixing</i>	77
<i>Retention Time</i>	77
<i>Temperature</i>	81
<i>Alkalinity and pH</i>	82
<i>Nutrients</i>	83
<i>Other Causes of Inhibition</i>	83
LIMITATIONS OF MICROALGAE AS SUBSTRATES FOR AD	84
Resistance of the Cell Walls	84
Microalgae Concentration	88
Carbon:Nitrogen Ratio	89
CONFLICT OF INTEREST	90
ACKNOWLEDGEMENTS	90
REFERENCES	90
CHAPTER 5 MICROALGAE, TAKING OVER THE ROLE IN THE HYDROGEN FUTURE	98
<i>Uwj'k'UQ'pegn</i>	
INTRODUCTION	98
MICROALGAE: WHEN AND WHY	102
MICROALGAE: A PHOTOSYNTHETIC GREEN FACTORY	112
MICROALGAL HYDROGEN PRODUCTION CONSIDERING BOTH PROKARYOTES AND EUKARYOTES	114
MICROALGAL HYDROGEN PRODUCTION SYSTEMS: THE PHOTOBIOREACTORS	117

MICROALGAL HYDROGEN PRODUCTION SUCCESS STORY: THE CHLAMYDOMONAS CASE	122
MICROALGAL HYDROGEN PRODUCTION: KEYS FOR THE FUTURE	128
CONCLUSION	130
CONFLICT OF INTEREST	131
ACKNOWLEDGEMENTS	131
REFERENCES	131
CHAPTER 6 ALGAL PRODUCTION PLATFORMS	150
<i>Crguucpftq'Octeq'Nk wrlcpf'Clxqt'Ngmwqpc/Co wpfctckp</i>	
INTRODUCTION	150
IMPORTANT CONSIDERATIONS	151
Lighting	151
Mixing and Mass Transfer	153
Control Systems and Construction Materials	155
CULTIVATION SYSTEMS	156
Pond Based Systems	156
Plate Based Systems	159
Horizontal Tubular Systems	160
Bubble Columns	163
Airlift Reactors	165
PHOTOBIOREACTOR DESIGN SUMMARY	168
PHOTOBIOREACTOR USE FOR BIOFUELS	168
CONFLICT OF INTEREST	169
ACKNOWLEDGEMENTS	169
REFERENCES	169
CHAPTER 7 USE OF FLUE GAS AS CARBON SOURCE	173
<i>Lqti g'Crlgtvq'X0Eqtac.'Cftkcpq'WCOJ gptctf.'Nwk'c'Oqt cgu'Gvkrg'T'OOqtcku'Kqt</i>	
<i>Wl qp±xngu'cpf'Okej grg'T'OOqtcku</i>	
INTRODUCTION	173
GLOBAL WARMING AND GREENHOUSE GASES	174
MEASURES FOR GREENHOUSE GASES REDUCTION	175
CYCLIC MICROALGAE PRODUCTION PROCESS	176
POTENTIAL USE OF FLUE GASES IN MICROALGAE CULTIVATION	177
FACTORS INFLUENCING CO₂ FIXATION FROM FLUE GAS BY MICROALGAE	179
Microalgae Strains	179
CO ₂ Concentration in Flue Gas	180
pH	180
NO _x , SO _x and Particulate Materials	181
Temperature and Light	182
Mass Transfer in Bioreactors	183
Bioreactor Application in CO ₂ Fixation by Microalgae	183
CO ₂ BIOFIXATION METABOLISM	185
BIOPRODUCTS FROM MICROALGAL BIOMASS GROWN WITH FLUE GAS	186
Biofuels	186
Biopigments	188
Biopolymers	189
CONCLUDING REMARKS	191
CONFLICT OF INTEREST	191
ACKNOWLEDGEMENTS	191
REFERENCES	191

CHAPTER 8	HARVESTING, THICKENING AND DEWATERING PROCESSES	202
	<i>Ftkgu'Xcpfcoog</i>	
	INTRODUCTION	202
	GENERAL REQUIREMENTS FOR EFFECTIVE MICROALGAE HARVESTING	203
	MULTI-STAGE APPROACH OF HARVESTING, THICKENING AND DEWATERING	204
	COAGULATION-FLOCCULATION-SEDIMENTATION	206
	Coagulation Mechanisms	206
	Chemical Flocculation	207
	Auto/Alkaline Flocculation	208
	Electro-coagulation	209
	Bioflocculation	209
	Enhanced Settling	210
	FLOTATION	210
	CENTRIFUGATION	211
	FILTRATION	212
	Screening	212
	Membrane Filtration	212
	COMPARING HARVESTING METHODS	212
	CONCLUSION	213
	CONFLICT OF INTEREST	214
	ACKNOWLEDGEMENTS	214
	REFERENCES	214
CHAPTER 9	OIL EXTRACTION PROCESSES IN MICROALGAE	224
	<i>Ogpi {wg'I qpi . 'I wkp"J w: 'Uj t g{cu' I gfcj cnk'cpf 'Co ctlgg' Dcuuk</i>	
	INTRODUCTION	224
	GENETIC ENGINEERING OF MICROALGAE FOR ENHANCEMENT OF LIPID PRODUCTION	225
	Lipid Production in Microalgae - Mechanism	226
	EXTRACTION OF LIPIDS FROM MICROALGAE	229
	Conventional Solvent Extraction	231
	Super-/Sub-Critical Solvent Extraction	232
	Ionic Liquid Extraction	235
	Novel Approaches	236
	CELL DISRUPTION	237
	Mechanical Disruption Methods	239
	<i>Grinding</i>	239
	<i>Bead Milling</i>	240
	<i>High Pressure Homogenizer</i>	240
	Physical or Chemical Methods	240
	<i>Steam Explosion</i>	240
	<i>Autoclave</i>	241
	<i>Enzymatic Hydrolysis</i>	241
	<i>Osmotic Shock, Acid/ Alkaline Treatment</i>	242
	Recent Approaches for Lipid Extraction from Microalgae	242
	<i>Microwave</i>	242
	<i>Ultrasonication</i>	243
	<i>Pulsed Electric Field</i>	243
	Comparison of Various Methods	244
	CONVERSION OF MICROALGAE TO BIO-OIL USING HYDROTHERMAL LIQUEFACTION	245

CONCLUSION	247
CONFLICT OF INTEREST	248
ACKNOWLEDGEMENTS	248
REFERENCES	248
PART 2 PART II: PRODUCTION AND ECONOMICS IN MICROALGAL APPLICATIONS	
CHAPTER 10 RESEARCH AND DEPLOYMENT OF RENEWABLE BIOENERGY	
PRODUCTION FROM MICROALGAE	259
<i>Nkxg'O ONNcwt gpi'cpf 'O graf kg'Ej gp/I rv uugt</i>	
INTRODUCTION	259
CURRENT AND PROJECTED FUTURE ENERGY LANDSCAPE	260
PROMISE AND OPPORTUNITY FOR ALGAE TECHNOLOGY	262
INTERNATIONAL BIOFUELS POLICY	264
GLOBAL SUPPORT FOR RESEARCH AND COMMERCIAL DEPLOYMENT	267
CONCLUSION	274
CONFLICT OF INTEREST	274
ACKNOWLEDGEMENTS	274
REFERENCES	275
CHAPTER 11 CURRENT PRODUCTION OF MICROALGAE AT INDUSTRIAL SCALE	
<i>Nwku'I OTco #/gl/O²tlf c.'Ngkv'S wgt ql \ gr ne'cpf 'Gf wctf q'Lceqd/Nqr gu</i>	
INTRODUCTION	278
ELEMENTS OF MICROALGAL CULTURE	279
MICROALGAL BIOREACTORS	282
OPERATIONAL MODES TO MICROALGAE CULTURE	284
INDUSTRIAL PRODUCTION OF MICROALGAL-BASED PRODUCTS	285
COMPARISON BETWEEN TECHNOLOGICAL ROUTES (OPEN VS. CLOSED SYSTEMS)	288
FRONTIERS IN INDUSTRIAL PHOTOBIOREACTORS	290
THE BIOECONOMY OF MICROALGAE-BASED PROCESSES AT INDUSTRIAL SCALE	291
CONCLUSION	292
CONFLICT OF INTEREST	292
ACKNOWLEDGEMENTS	292
REFERENCES	292
CHAPTER 12 ENVIRONMENTAL APPLICATIONS OF MICROALGAE: CO₂ CAPTURE AND NUTRIENT RECYCLING	
<i>O gpi 'Y cpi</i>	
INTRODUCTION	297
N AND P REMOVAL BY ALGAE	298
Mechanism of N and P Utilization by Algae	299
Impact of N on Intercellular and Extracellular Compounds Production	300
REACTOR CONFIGURATIONS	300
Open Pond Systems	301
Closed Photobioreactors	301
Immobilized Algal Cultivation Systems (Algal Biofilm Reactors)	302
Enhanced Algal - Prokaryotic Wastewater Treatment Systems (EAPS) for N Removal	303
A CASE STUDY ON NUTRIENT RECYCLE IN A CONCENTRATED ANIMAL FEEDING OPERATIONS (CAFOS) ADAPTING ALGAL-BASED WASTEWATER TREATMENT	304
CO ₂ CAPTURE BY ALGAE	304

Impact of pH and CO ₂ on Algae Growth	305
Factors Affecting the Gas Transfer Efficiency	306
Gas Supply Systems	307
<i>Airlift Photobioreactor</i>	307
<i>Membrane Sparged Systems</i>	307
CONCLUDING REMARKS	308
CONFLICT OF INTEREST	308
ACKNOWLEDGEMENTS	308
REFERENCES	308
CHAPTER 13 MAXIMISING VALUE: THE BIO-REFINERY CONCEPT	315
<i>Fcttgp'NOQcvgf/Tcf erdtg.'Vj gc'Gmkpu/Eqy ctf 'cpf 'TqdgtyY ONqxlw</i>	
INTRODUCTION	315
THE QUEST FOR SUSTAINABLE ALGAL MANUFACTURING	317
ARE HIGH VALUE PRODUCTS FROM ALGAL SOURCES REALISABLE?	324
ASTAXANTHIN AS A MODEL PRODUCT	326
CONCLUSION	328
CONFLICT OF INTEREST	328
ACKNOWLEDGEMENTS	328
REFERENCES	328
CHAPTER 14 ENERGY AND ECONOMIC CHALLENGES IN THE GROWTH AND HARVESTING OF MICROALGAE. THE CHLORELLA VULGARIS CASE	332
<i>Fckauq'Nqt gpc'Tgut grq'Ugt pc.'Lwcp'Ectru'J ki wkc 'X' us wgl 'cpf 'Ectru'Clkn'Ectf qpc Cl cvg</i>	
CULTURE OF MICROALGAE TODAY	332
Microalgae and their Importance	332
Microalgae <i>Chlorella vulgaris</i>	334
<i>Applications</i>	334
CHALLENGES IN THE PROCESS OF OIL EXTRACTION FROM MICROALGAE	336
Culture Stage	337
Harvesting Stage	338
Extraction Stage	340
PROCESS DESIGN FOR THE PRODUCTION OF OIL FROM MICROALGAE	341
Conditions for the Culture Medium	341
Definition of the Harvesting Process	342
Oil Extraction Method	342
ECONOMIC ANALYSIS OF CHLORELLA VULGARIS PRODUCTION	342
METHODOLOGY	343
Definition of Variables for the Simulation Procedure	343
<i>Equipment Description</i>	344
ANALYSIS OF THE YIELDS COMPARED WITH LITERATURE	345
Economic Analysis	346
CONCLUSION	348
CONFLICT OF INTEREST	349
ACKNOWLEDGEMENTS	349
REFERENCES	349
CHAPTER 15 TECHNO-ECONOMICS OF A MICROALGAL ROUTE TO GREEN DIESEL	352
<i>Nkp^j qw'Lco gu'NOO cpi cpctq'cpf 'Cf gpk kNcy cl'</i>	
RENEWABLE FUELS	353
BIOFUEL FEEDSTOCKS	353

Lipid-based Biomass Feedstocks	353
<i>First Generation Lipid-Based Biomass Feedstocks</i>	354
<i>Second Generation Lipid-Based Biomass Feedstocks,</i>	355
<i>Microalgae Oil</i>	356
<i>Summary of Lipid-Based Biomass Feedstocks</i>	358
Non-Lipid-Based Biomass Feedstocks	358
BIOFUEL PRODUCTION	359
Biodiesel Production	360
Green Diesel Production	363
<i>Green Diesel Production Pathways</i>	363
<i>Green Diesel Production from Microalgae Oil</i>	366
TECHNO-ECONOMIC ANALYSIS OF MICROALGAL ROUTE TO GREEN DIESEL ...	367
INTRODUCTION	367
Process description	367
<i>Design Basis and Base Case</i>	368
<i>Growth, Harvest and Extraction</i>	369
<i>Calculation of Pond Area Productivity and Production Rate</i>	370
<i>Harvesting and Extraction</i>	372
ECONOMICS	372
<i>Capital Cost</i>	372
<i>Variable Costs</i>	374
<i>Utility Usages</i>	375
<i>Credits</i>	375
<i>Fixed Costs</i>	378
<i>Case Studies</i>	378
<i>Effect of Capital Cost, Oil Content and Productivity</i>	381
CONCLUSION	383
NOMENCLATURE	384
CONFLICT OF INTEREST	384
ACKNOWLEDGEMENTS	384
REFERENCES	384
CHAPTER 16 GREENHOUSE GAS BALANCES OF MICROALGAL BIOFUELS	391
<i>Nwecu T gkpf gt u</i>	
ESTIMATING GREENHOUSE GAS BALANCES	391
EVALUATION OF AVAILABLE PEER-REVIEWED LIFE CYCLE ASSESSMENTS OF MICROALGAL BIOFUELS	392
The Use of Credits	394
System Boundaries	395
Dealing with Methane	396
Assumptions about Microalgal Yields from Ponds	396
Decarbonization of Energy Supply	397
Allocation of Greenhouse Gas Emissions Based on Prices	397
Dealing with Uncertainty	397
CONCLUSION	398
CONFLICT OF INTEREST	398
ACKNOWLEDGEMENTS	398
REFERENCES	398
CHAPTER 17 TRIPLE BOTTOM LINE ASSESSMENT OF ALGAE BIO-CRUDE PRODUCTION	402
<i>Ct wplø c'O crkm</i>	

INTRODUCTION	402
METHODOLOGY	403
A Brief Introduction to Input-Output (IO) Analysis	403
Hybrid Life-Cycle Assessment	404
Hybridisation of Process Data with Input-Output Data	404
RESULTS AND DISCUSSION	405
Comparison: Algae Bio-crude Supply Chain vs. Crude Oil Supply Chain	405
Triple Bottom Line Footprints of Algae Bio-crude Production	409
CONCLUDING REMARKS	409
CONFLICT OF INTEREST	410
ACKNOWLEDGEMENTS	410
REFERENCES	410
SUBJECT INDEX	436

PREFACE

The book “Microalgae as a Source of Bioenergy: Products, Processes and Economics” presents recent advances in biofuel production with microalgae. It is composed of 17 well written chapters by leading researchers in this field.

European Union (EU) defined targets for each Member State regarding climate and energy. Microalgae are considered a promising and sustainable source of energy, due to their biomass productivity and ability to capture CO₂. Several research studies were performed and new procedures to reduce the biomass production cost were developed. In this context, the proposed book have the contributions of relevant researchers in microalgal research area, focusing on the energy product yields, process developments and economics.

Biodiesel is one of the most studied biofuels, which can be produced by several raw materials. Microalgal biodiesel is the third generation biofuel and it is considered the most sustainable route for the production of this renewable form of energy. Microalgae present high areal productivities and their production does not compete with food market. Besides the biodiesel production with extracted oil, the residual biomass can be used for other energetic applications, reducing the cost of each type of produced energy. Chapter 1 presents the integration of biodiesel production and cogeneration and concludes that microalgae is an economic viable energy solution, if the biorefinery concept is applied, taking part from several products that microalgae can offer. Chapter 2 presents the potential of microalgae for bioethanol production, focusing on cultivation strategies to enhance carbohydrate productivity (which is easier to break down to simple reducing sugar), biomass pre-treatment methods, and hydrolysis and fermentation process. Chapter 3 presents different routes to produce bioethanol and presents a review of the research works about bioethanol production from algae. Chapter 4 introduces the basic principles of anaerobic digestion (biogas production), particularly when using microalgae as substrate. The influence of the most important operating parameters is also described. Biohydrogen is the last focused biofuel product. Chapter 5 shows the recent progresses regarding microalgal cellular mechanisms and production processes. As biofuel should present a lower price, several strategies should be implemented to reduce the production costs. Chapter 6 shows the main characteristics of the most used configurations of photobioreactors. Chapter 7 presents CO₂ biofixation from industrial flue gases by microalgae, describing the microalgal metabolism. The use of CO₂ from this source has dual benefit: (i) reduction of biomass production cost; and (ii) mitigation of industrial emissions of CO₂, which is one of the most important greenhouse gas. Harvesting, thickening and dewatering processes represent a significant cost in the production of microalgal biomass. Chapter 8 gives an overview of the related technologies, presenting their advantages. Chapter 9 summarizes recent developments in microalgal oil extraction processes, including drying methods, cell disruption methods, conventional or supercritical solvent extraction methods, and recent approaches for direct biodiesel production.

Concerning the current production and economics of microalgal production, Chapter 10 places international energy policy in the context of the current and projected energy landscape. It gives an overview of the global and commercially installed infrastructure. Some important research projects are also presented. Chapter 11 presents a current view of the commercial production of microalgae cultivation at a large scale worldwide. It also presents the main variables that influence microalgal cultures and compares different types of photobioreactors. Chapter 12 describes the environmental applications of microalgae: CO₂ capture and nutrient recycling. Mechanisms of assimilation of nitrogen and phosphorus are discussed in this chapter. Configurations of photobioreactors are compared in terms of

wastewater treatment enhancement (and downstream processes) and improving mass transfer of CO₂ from the gaseous stream to the culture. Chapter 13 presents a wide range of products obtained from microalgal biomass (biorefinery context) that can enhance the economic viability of biofuel production. Chapter 14 performs a techno-economic assessment of microalgal oil production. Process modelling was performed through simulation software Aspen Plus. Chapter 15 reviews biofuel production from different feedstocks, focusing on the techno-economic challenges. Sensitivity analysis was performed to examine the economic parameters are the sales price was highly dependent on algae doubling time. Chapter 16 presents a life cycle assessment of the greenhouse gases of microalgal biofuels. Chapter 17 shows the results of the triple bottom line (for sustainability evaluation) assessment of algal bio-crude production. The considered stages in the analysis are the cultivation of algae, extraction of bio-crude and transport of bio-crude to a refinery. A region of Australia was selected for algae production. The results show that algae bio-crude production is more sustainable than crude oil production.

I would like to thank all the authors for their efforts in writing such excellent chapters. I also acknowledge the entire team of Bentham Science Publishers, particularly Ms. Fariya Zulfiqar (Assistant Manager Publications) due to the important orientations at different stages in the publication of the book. I am confident that this book will attract the attention of researchers and professionals of microalgal biofuel production.

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