UNIDAD DE VIGILANCIA TECNOLÓGICA E INTELIGENCIA COMPETITIVA

Microalgas

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Presidencia de la Nación

Participan en Confección y Edición
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Contenido

En este boletín se presentan las publicaciones, patentes y noticias de interés del primer trimestre del año 2018 pertenecientes a la rama Bioprocesos del árbol de categorías.

PUBLICACIONES

Recovery of carrageenan from Solomon Islands red seaweed using ionic liquid-assisted subcritical water extraction.

Fecha de Publicación 8 May 2018
Fuente: Separation and Purification Technology, Volume 196
Autores: Collin Rudolf Nobbs Gereniu, Periaswamy Sivagnanam Saravana, Byung-Soo Chun

Abstract

The subcritical water extraction (SWE) was employed to extract κ-carrageenan from the red marine macroalgae Kappaphycus alvarezii. A series of extractions using different conditions were carried out with different ionic liquids (ILs) as catalyst, and 1% 1-Butyl-3-methylimidazolium acetate (BMIMAc) at 150°C/5MPa with 1:80gmL−1 (solid to liquid ratio) exhibited the highest yield (78.75%). Extracted material was compared with samples obtained by aqueous SWE and the conventional method. Characterization of the extracts was performed using Fourier transform infrared spectroscopy (FTIR), thermal gravimetric analysis (TGA) and X-ray diffraction (XRD). Hence, the results showed comparability to the standard confirming the extracted material as typical crude κ-carrageenan. Physical properties including gel strength and viscosity were minimal but emulsification index was relatively high for the sample obtained by SWE with IL catalyst. Antioxidant activity however was low compared to the other samples due to the low sulfate content but monosaccharide composition was close to the standard. The molecular weights of all samples were directly impacted by thermal degradation and IL dissolution which enhanced their bioavailability and functional properties. The SWE with IL catalyst is a potential technology that can be utilized for extraction of κ-carrageenan for commercial use in different industrial sectors.

Effects of hydrostatic pressure and supercritical carbon dioxide on the viability of Botryococcus braunii algae cells

Fecha de Publicación: May 2018
Fuente: Bioresource Technology, Volume 256
Autores: Ece Yildiz-Ozturk, Esra Ilhan-Ayisigi, Arnoud Togtema, Joao Gouveia, Ozlem Yesil-Celiktas

Abstract

In bio-based industries, Botryococcus braunii is identified as a potential resource for production of hydrocarbons having a wide range of applications in chemical and biopolymer industries. For a sustainable production platform, the algae cultivation should be integrated with downstream processes. Ideally the algae are not harvested, but the product is isolated while cultivation and growth is continued especially if the doubling time is slow. Consequently, hydrocarbons can be extracted while keeping the algae viable. In this study, the effects of pressure on the viability of B. braunii cells were tested hydrostatically and under supercritical CO2 conditions. Viability was determined by light microscopy, methylene blue uptake and by re-cultivation of the algae after treatments to follow the growth. It was concluded that supercritical CO2 was lethal to the algae, whereas hydrostatic pressure treatments up to 150 bar have not affected cell viability and recultivation was successful.

Catalytic and non-catalytic hydrothermal processing of Scenedesmus obliquus biomass for bio-crude production – A sustainable energy perspective

Fecha de Publicación: 1 May 2018
Fuente: Energy Conversion and Management, Volume 163
Autores: Shankha Koley, Mangesh S. Khadase, Thangavel Mathimani, Hifjur Raheman, Nirupama Mallick

Abstract

In the present study, hydrothermal liquefaction (HTL) of wet Scenedesmus obliquus biomass into bio-crude was carried out. Initially, the biochemical composition of S. obliquus biomass was examined, and it indicated high protein (56.1%) followed by carbohydrate (22.3%) and lipid (11.5%) contents. The ultimate analysis unveiled the presence of high carbon (48.1%) and oxygen (36.1%) in the biomass. This study had shed light on the selection of ideal reaction conditions such as temperature (200, 250, 300 °C), pressure (100, 200, 300 bar), and residence time (30, 60 min) for producing maximum bio-crude with/without catalyst aid. In the absence of the catalyst, a bio-crude yield of 35.7% was obtained at 300 °C temperature, 200 bar

pressure, and 60 min residence time. On an interesting note, bio-crude yield was increased from 35.7 to 45.1% by adding homogeneous acid catalyst CH3COOH at 300 °C reaction temperature, which was higher than the other acid catalysts HCOOH (40%), H2SO4 (38%), HCl (39%), H3BO3 (37%), and the base catalysts NaOH (38%), KOH (37%), Na2CO3 (40%), K2CO3 (36%), Ca(OH)2 (37%). Elemental analyses of bio-crudes indicated a higher heating value of 35–40 MJ/kg, carbon-74%, nitrogen-5.86%, hydrogen-10.9%, sulfur <0.5 and oxygen content of 8.85%, which is comparable with petro-crude. Using CH3COOH as a catalyst in HTL led to reducing the oxygen content and simultaneously increased the higher heating value of bio-crude. In addition, GC-MS characterization of bio-crude indicated the presence of mono-aromatics, nitrogen heterocycles, phenols, indole and fatty acids. Thus, based on the yield and characteristics, the bio-crude produced from S. obliquus biomass could be used in petroleum refinery for fuel production.

Extraction of bio-oils from algae with supercritical carbon dioxide and co-solvents.

Fecha de Publicación: May 2018
Fuente: The Journal of Supercritical Fluids, Volume 135
Autores: Prafulla D. Patil, Kodanda Phani Raj Dandamudi, Jun Wang, Qiang Deng, Shuguang Deng

Abstract

Supercritical carbon-dioxide (SC-CO2) is a clean and green technology for extracting bio-oil/lipids from algae (Nannochloropsis salina) for biofuel production and high-value co-products development. A mixed-polarity azeotropic mixture (hexane/ethanol) modifier/co-solvent was added to enhance the SC-CO2 fluid affinity towards neutral lipid and polar lipids. The benefits of inducing mixed polarity solvents include enhanced solvent properties, favorable mass transfer, higher lipid yield, and better lipid quality. A microwave pretreatment prior to supercritical extraction was employed to improve lipid extraction efficiency and reduce extraction energy consumption. The effects of pressure, temperature and co-solvents to algae ratio on lipid extraction yield and fatty acid composition were investigated. A micro-elemental analysis (CHNOS) of total and neutral algal lipid samples was performed according to ASTM methods. The algal biomass characterization and algal lipid analysis were performed using several analytical instruments such as FTIR, SEM-EDS, TGA, Confocal microscopy and GC–MS.

Multistage wet lipid extraction from fresh water stressed Neochloris oleoabundans slurry – Experiments and modelling.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Ying Du, Boelo Schuur, Sascha R.A. Kersten, D.W.F. (Wim) Brilman

Abstract

Algae are considered an important renewable feedstock for lipid extraction to produce biofuels. Algae strain Neochloris oleoabundans used in this research can yield a high lipid content under stressed conditions. N-ethyl butylamine (EBA) as a switchable solvent has previously shown outstanding performance on energy efficient lipid extraction from non-broken wet algae slurry. In this work, a model was developed that describes the equilibrium state of lipid extraction from fresh water (FW)-stressed Neochloris oleoabundans algae slurry using EBA as solvent. When assuming that the cell interior is almost completely filled with the solvent phase during extraction, the model estimated extraction yields showed good agreement with those obtained in experiments. The developed model can predict the amount of crude lipid being recovered from any stage of a multistage extraction process.

Effect of pulsed electric fields and high pressure homogenization on the aqueous extraction of intracellular compounds from the microalgae Chlorella vulgaris.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Daniele Carullo, Biresaw Demelash Abera, Alessandro Alberto Casazza, Francesco Donsì, Patrizia Perego, Giovanna Ferrari, Gianpiero Pataro

Abstract

Pulsed Electric Fields (PEF) and High Pressure Homogenization (HPH) are promising and scalable cell disruption technologies of microalgae cells. In this work, the permeabilization degree, morphological properties, and extractability of intracellular compounds from microalgae Chlorella vulgaris suspensions (1.2%, w/w) were investigated as a function of PEF treatment at different electric field strengths (10–30 kV/cm) and total specific energy input (20–100 kJ/kg), in comparison with the more disruptive HPH treatment (150 MPa) at different number of passes (nP = 1–10). The conductivity and the particle size analyses, as well as the SEM images, clearly showed that PEF induces the permeabilization of the cell membranes in an intensity-dependent manner, without producing any cell debris, whereas HPH

treatment causes the total disruption of the algae cells into small fragments. Coherently with the lower permeabilization capability, PEF promoted the selective extraction of carbohydrates (36%, w/w, of total carbohydrates), and low molecular weight proteins (5.2%, w/w, of total proteins). On the other hand, HPH induced the undifferentiated release of all the intracellular content, resulting in a 1.1 and 10.3 fold higher yields than PEF, respectively of carbohydrates and protein. These results suggest that, in a multi-stage biorefinery, PEF could represent a suitable cell disruption method for the selective recovery of small-sized cytoplasmic compounds, while HPH should be placed at the end the cascade of operations allowing the recovery of high molecular weight intracellular components.

Enhancement of fermentative hydrogen production from Spirogyra sp. by increased carbohydrate accumulation and selection of the biomass pretreatment under a biorefinery model.

Fecha de Publicación: Available online 23 March 2018
Fuente: Journal of Bioscience and Bioengineering
Autores: Tiago Pinto, Luísa Gouveia, Joana Ortigueira, Ganesh D. Saratale, Patrícia Moura

Abstract

In this work, hydrogen (H2) was produced through the fermentation of Spirogyra sp. biomass by Clostridium butyricum DSM 10702. Macronutrient stress was applied to increase the carbohydrate content in Spirogyra, and a 36% (w/w) accumulation of carbohydrates was reached by nitrogen depletion. The use of wet microalga as fermentable substrate was compared with physically and chemically treated biomass for increased carbohydrate solubilisation. The combination of drying, bead beating and mild acid hydrolysis produced a saccharification yield of 90.3% (w/w). The H2 production from Spirogyra hydrolysate was 3.9 L H2 L−1, equivalent to 146.3 mL H2 g−1 microalga dry weight. The presence of protein (23.2 ± 0.3% w/w) and valuable pigments, such as astaxanthin (38.8% of the total pigment content), makes this microalga suitable to be used simultaneously in both food and feed applications. In a Spirogyra based biorefinery, the potential energy production and food-grade protein and pigments revenue per cubic meter of microalga culture per year was estimated on 7.4 MJ, US $412 and US $15, respectively, thereby contributing to the cost efficiency and sustainability of the whole bioconversion process.

Aquatic weeds as the next generation feedstock for sustainable bioenergy production.

Fecha de Publicación: March 2018
Fuente: Bioresource Technology, Volume 251
Autores: Manpreet Kaur, Manoj Kumar, Sarita Sachdeva, S.K. Puri

Abstract

Increasing oil prices and depletion of existing fossil fuel reserves, combined with the continuous rise in greenhouse gas emissions, have fostered the need to explore and develop new renewable bioenergy feedstocks that do not require arable land and freshwater resources. In this regard, prolific biomass growth of invasive aquatic weeds in wastewater has gained much attention in recent years in utilizing them as a potential feedstock for bioenergy production. Aquatic weeds have an exceptionally higher reproduction rates and are rich in cellulose and hemicellulose with a very low lignin content that makes them an efficient next generation biofuel crop. Considering their potential as an effective phytoremediators, this review presents a model of integrated aquatic biomass production, phytoremediation and bioenergy generation to reduce the land, fresh water and fertilizer usage for sustainable and economical bioenergy.

Inhibition of Nitzschia ovalis biofilm settlement by a bacterial bioactive compound through alteration of EPS and epiphytic bacteria.

Fecha de Publicación: May 2018
Fuente: Electronic Journal of Biotechnology, Volume 33
Autores: Claudia D. Infante, Francisca Castillo, Vilma Pérez, Carlos Riquelme

Abstract

Background Marine ecosystems contain benthic microalgae and bacterial species that are capable of secreting extracellular polymeric substances (EPS), suggesting that settlement of these microorganisms can occur on submerged surfaces, a key part of the first stage of biofouling. Currently, anti-fouling treatments that help control this phenomenon involve the use of biocides or antifouling paints that contain heavy metals, which over a long period of exposure can spread to the environment. The bacterium Alteromonas sp. Ni1-LEM has an inhibitory effect on the adhesion of Nitzschia ovalis, an abundant diatom found on submerged surfaces. Results We evaluated the effect of the bioactive compound secreted by this bacterium on the EPS of biofilms and associated epiphytic bacteria. Three methods of EPS extraction were evaluated to determine the most appropriate and efficient methodology based on the presence of soluble EPS and the total protein and

carbohydrate concentrations. Microalgae were cultured with the bacterial compound to evaluate its effect on EPS secretion and variations in its protein and carbohydrate concentrations. An effect of the bacterial supernatant on EPS was observed by assessing biofilm formation and changes in the concentration of proteins and carbohydrates present in the biofilm. Conclusions These results indicate that a possible mechanism for regulating biofouling could be through alteration of biofilm EPS and alteration of the epiphytic bacterial community associated with the microalga.

Improving cell disruption efficiency to facilitate protein release from microalgae using chemical and mechanical integrated method.

Fecha de Publicación: Available online 3 April 2018
Fuente: Biochemical Engineering Journal
Autores: Win Nee Phong, Pau Loke Show, Cheng Foh Le, Yang Tao, Jo-Shu Chang, Tau Chuan Ling

Abstract

One of the critical challenges in releasing protein from microalgae is to effectively disrupt their rigid thick cell walls. This study could provide some guidance on the implementation of a simple, cost-effective and scalable cell disruption in a downstream processing of microalgal industry for the recovery of protein from microalgae. The effects of solvent types, alkalis, and ultrasonication in disrupting microalgal cell wall and protein solubility were studied. It was found that alkaline treatment played a key role in cell disruption and protein solubilisation. From the industrial perspective, water is an excellent choice of extractive solvent due to low-cost, safety, and scalability. Among all the tested methods, the combination of both alkaline and ultrasonication treatment demonstrated the greatest cell disruption efficiency and was thus suggested to be use at large scale.

Investigations in ultrasound–induced enhancement of astaxanthin production by wild strain Phaffia rhodozyma MTCC 7536.

Fecha de Publicación: April 2018
Fuente: Bioresource Technology, Volume 254
Autores: Amit H. Batghare, Neha Singh, Vijayanand S. Moholkar

Abstract

This work reports ultrasound–induced enhancement of astaxanthin production in batch fermentation using wild strain of P. rhodozyma MTCC 7536. The methodology

adopted in this study comprises of statistical optimization of the medium and fermentation parameters, followed by application of sonication at optimized conditions. P. rhodozyma fermentation at conditions of 20 g/L glucose, pH 4.4, temperature 21 °C, 4% v/v inoculum, shaking at 205 rpm with nitrogen sources of (NH4)2SO4 and yeast extract yielded 6.8 mg/L or 1360 µg/g DCW astaxanthin in 84 h. Application of 33 kHz and 140 kPa sonication at 10% duty cycle in final 12 h of fermentation enhanced the astaxanthin yield to 8.6 mg/L or 1728 µg/g DCW, which is higher than several mutant strains reported in literature. These results are essentially manifestations of intense microturbulence generated by sonication in fermentation mixture.

Utilization of microalgae feedstock for concomitant production of bioethanol and biodiesel.

Fecha de Publicación: 1 April 2018
Fuente: Fuel, Volume 217
Autores: Ramachandran Sivaramakrishnan, Aran Incharoensakdi

Abstract

The present study focuses on the biorefinery approach of integrated production of bioethanol and biodiesel from microalgae feedstock. Various pretreatment methods were used to determine the maximum recovery of sugars from Scenedesmus sp. The total sugar yield of 93% was obtained when the biomass was pretreated by acid hydrolysis. The hydrolysate produced 86% of ethanol (theoretical yield) after the fermentation using Saccharomyces cerevisiae. Enzyme catalyzed direct transesterification of the biomass was performed using dimethyl carbonate as a solvent and the maximum yield of 92% methyl ester, 1.86% glycerol carbonate and 4.93% glycerol dicarbonate was achieved. The integrated process of bioethanol and biodiesel production was optimally achieved when direct transesterification was done first followed by ethanol fermentation yielding 92 and 93% of methyl ester and ethanol, respectively.

Hybrid two-stage culture of Halamphora coffeaeformis for biodiesel production: Growth phases, nutritional stages and biorefinery approach.

Fecha de Publicación: April 2018
Fuente: Renewable Energy, Volume 118
Autores: Lucas A. Martín, Cecilia A. Popovich, Ana M. Martínez, Paola G. Scodelaro Bilbao, María C. Damiani, Patricia I. Leonardi

Abstract

The growth, lipid accumulation and bioproducts of the marine diatom Halamphora coffeaeformis were evaluated in a hybrid two-stage culture using seawater enriched with nutrients and without vitamins. The influence of dissolved and internal nutrients on growth and lipid accumulation was also analyzed. Total lipid content increased in the declining phase up to 33.4% ash-free dry weight, due to an increase in neutral lipids, which reached 87% of total lipids. The observed delay in triacylglycerol (TAG) accumulation could be explained by the accumulation of large internal pools of nitrogen in H. coffeaeformis. TAG, frustules (silica-containing cell wall) and soluble exopolysaccharides are analyzed and proposed as bioproducts of commercial interest. A biorefinery approach for the economic and environmentally sustainable production of biodiesel from the hybrid two-stage culture of H. coffeaeformis is suggested.

A critical review on anaerobic digestion of microalgae and macroalgae and co-digestion of biomass for enhanced methane generation.

Fecha de Publicación: Available online 9 March 2018
Fuente: Bioresource Technology
Autores: Rijuta Ganesh Saratale, Gopalakrishnan Kumar, Rajesh Banu, Ao Xia, Sivagurunathan Periyasamy, Ganesh Dattatraya Saratale

Abstract

Biogas production using algal resources has been widely studied as a green and alternative renewable technology. This review provides an extended overview of recent advances in biomethane production via direct anaerobic digestion (AD) of microalgae, macroalgae and co-digestion mechanism on biomethane production and future challenges and prospects for its scaled-up applications. The effects of pretreatment in the preparation of algal feedstock for methane generation are discussed briefly. The role of different operational and environmental parameters for instance pH, temperature, nutrients, organic loading rate (OLR) and hydraulic retention time (HRT) on sustainable methane generation are also reviewed. Finally, an outlook on the possible options towards the scale up and enhancement strategies has been provided. This review could encourage further studies in this area, to intend and operate continuous mode by designing stable and reliable bioreactor systems and to analyze the possibilities and potential of co-digestion for the promotion of algal-biomethane technology.

Energetic valorization of algal biomass in a hybrid anaerobic reactor.

Fecha de Publicación: 1 March 2018
Fuente: Journal of Environmental Management, Volume 209
Autores: Paula Assemany, Isabel de Paula Marques, Maria Lúcia Calijuri, Teresa Lopes da Silva, Alberto Reis

Abstract

This study evaluated the operation of a hybrid anaerobic reactor fed with algal biomass cultivated in effluent from the brewery industry. Three stages of operation were distinguished during the 72 days of semi-continuous functioning of the reactor: Stage 1 (S1), in which algal biomass was used as substrate; Stage 2 (S2), in which 10% (v/v) of the algal biomass was substituted by olive mill wastewater (OMW); and Stage 3 (S3), in which algal biomass was heat pre-treated. During S1, a loss of solids was observed, with an increment of organic matter in the outlet. The substitution of 10% of the volume of algal biomass by OMW tripled the methane productivity obtained in the previous stage by digestion of pure algal biomass. Heat pre-treatment was not efficient in rupturing the cell wall, and consequently did not have any effect on the increase in biogas production. The complementarity of substrates in the assessed conditions led to better results than the pre-treatment of the algal biomass.

Downstream processing of microalgae for pigments, protein and carbohydrate in industrial application: A review.

Fecha de Publicación: Available online 13 February 2018
Fuente: Food and Bioproducts Processing
Autores: Saumyakanti Khanra, Madhumanti Mondal, Gopinath Halder, O.N. Tiwari, Kalyan Gayen, Tridib Kumar Bhowmick

Abstract

Numbers of high valued and low volume products from microalgae are already in the market and more number of products is yet to be launched. Downstream processing is the key steps to maintain the quality of the products. Therefore, this review is focused on the downstream processing of the microalgae and cyanobacterial cells for commercial production of biomolecules such as pigments (chlorophyll and carotenoid), protein, carbohydrate (agar, carageenan, alginate, fucoidan) and biopolymers. It also covers the most recent preferred downstream processes for the industries for accomplishing the desired quality of the product and recent important filed patents on downstream processing of microalgae. Further, this article highlights

the recent investments made by the industries towards commercial production of microalgal-based biofuels and bio-products worldwide.

Microalgae digestive pretreatment for increasing biogas production.

Fecha de Publicación: February 2018
Fuente: Renewable and Sustainable Energy Reviews, Volume 82, Part 3
Autores: Olivia Córdova, Julissa Santis, Gonzalo Ruiz-Fillipi, María Elvira Zuñiga, Fernando G. Fermoso, Rolando Chamy

Abstract

Microalgae have many advantages for the production of biogas by anaerobic digestion process. However, the anaerobic digestion process has been reported to be limited in the hydrolytic stage due to the specific characteristics of the cell wall components thus resulting in an inefficient conversion of biomass to biogas. Pre-treatments aim to achieve an increase in the biogas production by increasing solubilization. Enzymatic pretreatment is described as an environmentally-friendly process, due to the low energy consumption, great yield of freed, fermentable sugars from the biomass under light operational conditions, the absence of corrosive problems, and few derivatives produced. Within the category of enzymatic pretreatments, it might identify two types, which are related to the origin of the enzymes and which may be classified as endogenous enzymes, and commercial exogenous enzymes. It should also be considered that enzyme production costs for commercial enzymes might be a negative factor in the process. The objective of the present review is to analyze and discuss the application of digestive pretreatments on the solubilization of microalgae, with a focus on the cell wall, and its relation to biogas production increase.

Highly efficient adsorption of dyes by biochar derived from pigments-extracted macroalgae pyrolyzed at different temperature.

Fecha de Publicación: July 2018
Fuente: Bioresource Technology, Volume 259
Autores: Yi-di Chen, Yen-Chang Lin, Shih-Hsin Ho, Yan Zhou, Nan-qi Ren

Abstract

Biochar is known to efficiently adsorb dyes from wastewater. In this study, biochar was derived from macroalgae residue by pyrolysis, and the influence of varying temperature (from 400 °C to 800 °C) on biochar characteristics was investigated. Among the biochar samples tested, macroalgae-derived biochar possessing highly

porous structure, special surface chemical behavior and high thermal stability was found to be efficient in removing malachite green, crystal violet and Congo red. The biochar derived by pyrolysis at 800 °C showed the highest adsorption capacity for malachite green (5306.2 mg g−1). In this study, the transformation of microalgae residue into a highly efficient dye adsorbent is a promising procedure for economic and environmental protection.

Mixotrophic and heterotrophic production of lipids and carbohydrates by a locally isolated microalga using wastewater as a growth medium.

Fecha de Publicación: June 2018
Fuente: Bioresource Technology, Volume 257
Autores: Jean Claude Nzayisenga, Karolina Eriksson, Anita Sellstedt

Abstract

The biomass production and changes in biochemical composition of a locally isolated microalga (Chlorella sp.) were investigated in autotrophic, mixotrophic and heterotrophic conditions, using glucose or glycerol as carbon sources and municipal wastewater as the growth medium. Both standard methods and Multivariate Curve Resolution-Alternating Least Squares (MCR-ALS) analysis of data acquired by Fourier-transform IR (FTIR) spectrometry showed that autotrophic and mixotrophic conditions promoted carbohydrate accumulation, while heterotrophic conditions with glycerol resulted in the highest lipid content and lowest carbohydrate content. Heterotrophic conditions with glycerol as a carbon source also resulted in high oleic acid (18:1) contents and low linolenic acid (18:3) contents, and thus increasing biodiesel quality. The results also show the utility of MCR-ALS for analyzing changes in microalgal biochemical composition.

Engineering Escherichia coli for the production of terpene mixture enriched in caryophyllene and caryophyllene alcohol as potential aviation fuel compounds.

Fecha de Publicación: June 2018
Fuente: Metabolic Engineering Communications, Volume 6
Autores: Weihua Wu, Fang Liu, Ryan W. Davis

Abstract

Recent studies have revealed that caryophyllene and its stereoisomers not only exhibit multiple biological activities but also have desired properties as renewable candidates for ground transportation and jet fuel applications. This study presents

the first significant production of caryophyllene and caryolan-1-ol by an engineered E. coli with heterologous expression of mevalonate pathway genes with a caryophyllene synthase and a caryolan-1-ol synthase. By optimizing metabolic flux and fermentation parameters, the engineered strains yielded 449mg/L of total terpene, including 406mg/L sesquiterpene with 100mg/L caryophyllene and 10mg/L caryolan-1-ol. Furthermore, a marine microalgae hydrolysate was used as the sole carbon source for the production of caryophyllene and other terpene compounds. Under the optimal fermentation conditions, 360mg/L of total terpene, 322mg/L of sesquiterpene, and 75mg/L caryophyllene were obtained from the pretreated algae hydrolysates. The highest yields achieved on the biomass basis were 48mg total terpene/g algae and 10mg caryophyllene/g algae and the caryophyllene yield is approximately ten times higher than that from plant tissues by solvent extraction. The study provides a sustainable alternative for production of caryophyllene and its alcohol from microalgae biomass as potential candidates for next generation aviation fuels.

A comparative study on the quality of bio-oil derived from green macroalga Enteromorpha clathrata over metal modified ZSM-5 catalysts.

Fecha de Publicación: May 2018
Fuente: Bioresource Technology, Volume 256
Autores: Shuang Wang, Bin Cao, Xinlin Liu, Lujiang Xu, Yamin Hu, Stephen Afonaa-Mensah, Abd El-Fatah Abomohra, Zhixia He, Qian Wang, Shannan Xu

Abstract

The green macroalga Enteromorpha clathrata was pyrolyzed with or without catalysts at the temperature of 550 °C for producing high-quality bio-oil. The ZSM-5 and 1,2,3 mmol Mg-Ce/ZSM-5 catalysts were introduced to investigate the yields and components distribution of bio-oil. Increase of bio-oil production was obtained with the use of ZSM-5 and 1,2,3 mmol Mg-Ce/ZSM-5 catalysts. The 1 mmol Mg-Ce/ZSM-5 catalyst exhibited more promising property for promoting the relative content of C5–C7 compounds, and decreasing the relative content of acids in bio-oil. The results suggested that E. clathrata had potential as pyrolysis feedstocks for producing the high-quality bio-oil with large amounts of C5–C7 compounds and low relative content of acids when the 1 mmol Mg-Ce/ZSM-5 catalyst was used. Furthermore, the physicochemical properties of ZSM-5 and 1 mmol Mg-Ce/ZSM-5 catalysts were investigated by scanning electron microscopy, transmission electron microscopy, X-ray diffraction, X-ray photoelectron spectroscopy and temperature-programmed desorption of ammonia.

Diminution of arsenic accumulation in rice seedlings co-cultured with Anabaena sp.: Modulation in the expression of lower silicon transporters, two nitrogen dependent genes and lowering of antioxidants activity.

Fecha de Publicación: 30 April 2018
Fuente: Ecotoxicology and Environmental Safety, Volume 151
Autores: Ruma Ranjan, Navin Kumar, Arvind Kumar Dubey, Ambedkar Gautam, Shyam Narain Pandey, Shekhar Mallick

Abstract

The present study was intended to investigate the role of algae, Anabaena sp. in the amelioration of As toxicity, when co-cultured with rice seedlings. The reduction of growth in rice seedlings against As(III) and As(V) was recovered with Anabaena sp. The Anabaena sp. also reduced the accumulation of As, where it was more efficient against 60μM As(III) (49%) than As(V) (23%) in rice shoot. Similarly, with reduction of As accumulation, lower silicon transporters (Lsi-1 and Lsi-2) was found to be suppressed against As treatments. However, the expression of two nitrogen dependent genes i.e., NR and SAMT were found to be enhanced with the Anabaena sp. Likewise, the activity of antioxidant enzyme, GST, was enhanced, whereas, the activity of other enzymes such as SOD, APX, GPX, GR and DHAR were decreased with As+Algae combinations. Overall, the result suggested that the Anabaena sp. reduces As accumulation, modulates gene expressions and antioxidants to ameliorate the As toxicity in Oryza sativa L.

Identification of harmful protozoa in outdoor cultivation of Chlorella and the use of ultrasonication to control contamination.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Yao Wang, Yingchun Gong, Lili Dai, Milton Sommerfeld, Chengwu Zhang, Qiang Hu

Abstract

Contaminating organisms in mass cultivation present one of the major challenges that must be overcome for successful commercialization of algal biofuels. The present study identified a range of contaminating organisms in Chlorella cultures cultivated in outdoor raceway ponds at the Arizona Center for Algae Technology and Innovation (Mesa, AZ). Nineteen organisms or Operational Taxonomic Units (OTU) in the Chlorella culture were identified by a combination of microscopic observation

and 18S rRNA denaturing gradient gel electrophoresis (DGGE). More detailed analyses identified these contaminating organisms as 2 fungi, 7 flagellates, 3 amoebae, 4 ciliates, 1 rotifer, and 2 large insects. Among them Poterioochromonas sp., a small flagellate, appeared to be one of the most harmful causing culture collapse. In order to control Poterioochromonas sp., various operational parameters and application strategies of ultrasonic treatment were investigated. During sixteen-day consecutive Chlorella cultivation in batch mode, the ultrasonication conditions of 6 L min−1 flow rate with the power of 495 W at 100% amplitude and a treatment frequency of once for 1 h every day, was proven to be the most effective in preventing Poterioochromonas outbreak in Chlorella culture with volume of 60 L. The above ultra-sonication method was also effective at destroying an unknown fungus, an amoeba (Acanthocystis sp.), and ciliates (a member of the family Orchitophryidae). Our findings can serve as a technical foundation for the application of ultrasonication to control some of the contaminating microorganisms in mass cultivation of microalgae including Chlorella.

Microalgal dewatering using a polyamide thin film composite forward osmosis membrane and fouling mitigation.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Jing Ye, Quan Zhou, Xuezhi Zhang, Qiang Hu

Abstract

In this study, the dewatering of Scenedesmus acuminatus suspensions using a polyamide thin film composite (TFC) forward osmosis (FO) membrane with enhanced surface shearing was investigated. The influence of the draw solution (DS) concentration and microalgal properties were studied, and a fouling mitigation method using mechanical shearing was developed. S. acuminatus suspension dewatering by the same FO membrane was repeated 8 times to test the membrane's recoverability and durability. The results showed that the membrane flux and the concentration of magnesium chloride DS presented a non-linear relationship. In addition, membrane flux did not increase once the DS concentration increased to 2 mol L−1, when serious fouling occurred. However, the membrane flux was significantly improved by mechanical shearing across the membrane surface. At shear rate of 4 (1000 rpm), a 2 mol L−1 MgCl2 solution resulted in an average flux as high as 25.9 L m−2 h−1 during the dewatering of a 1.0 g L−1 microalgal suspension. Microalgal cells and algogenic organic matter (AOM) were tested to determine the membrane fouling mechanism. The results showed that the microalgal cells and AOM resulted in 15.4% and 9.4% water flux loss in 1 h, respectively, whereas the combination of microalgal cells and AOM resulted in 24.7% water flux loss. After dewatering for 8 h, microalgal suspensions were concentrated 20 times, and the

average membrane flux was 23.3 L m−2 h−1. In addition, most of the membrane fouling was reversible by simple hydraulic flushing; the pure water flux remained more than 97% of original pure water flux after 8 repeated dewatering processes, which demonstrated the potential application of FO in microalgal dewatering.

The influence of exogenous organic carbon assimilation and photoperiod on the carbon and lipid metabolism of Chlamydomonas reinhardtii.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Richard T. Smith, D. James Gilmour

Abstract

Microalgae are a promising platform for the production of renewable fuels and oleochemicals. Despite significant research efforts to understand the mechanisms of algal lipid accumulation, the influence of commercially relevant growth conditions on the lipid metabolism is poorly understood. To characterise the impact of differing organic carbon availabilities and photoperiod on the response of the model alga Chlamydomonas reinhardtii to nitrogen stress, the expression of key genes involved in the central carbon metabolism were monitored over a time-course of nitrogen deprivation. In addition, the growth, PSII integrity, chlorophyll content, triacylglycerol (TAG) content, starch content, and fatty acid composition were characterised. Results indicate that both organic carbon availability and photoperiod regulate the lipid accumulation response of C. reinhardtii. Under mixotrophic conditions, organic carbon uptake is favoured over photosynthesis, transcript abundance of lipid synthesis genes rapidly increase and acetate is funnelled to TAG synthesis. In contrast, autotrophic cultures lacking organic carbon experienced a slower rate of photosynthetic degradation and funnelled the majority of sequestered carbon to starch synthesis. Dark periods induced catabolism of both starch and TAG in autotrophic cultures but TAG alone in mixotrophic cultures. Furthermore, diurnal light enhanced starch synthesis under mixotrophic conditions. Finally, transcript analysis indicated that PGD1, important for the routing of oleic acid to TAG, was reliant on organic carbon availability, resulting in reduced C18:1 fatty acid accumulation in autotrophic cultures.

Poly-β-hydroxybutyrate (PHB) production by Synechocystis PCC6803 from CO2: Model development.

Fecha de Publicación: January 2018
Fuente: Algal Research, Volume 29
Autores: Roberta Carpine, Francesca Raganati, Giuseppe Olivieri, Klaas J. Hellingwerf, Antonino Pollio, Piero Salatino, Antonio Marzocchella

Abstract

The biosynthesis of poly-β-hydroxybutyrate (PHB) by bioconversion of CO2 is a sustainable alternative to the non-renewable, petroleum-based polymer production. Indeed, the PHB production by conversion of CO2 contributes to the reduction of the greenhouse-gas concentration in the atmosphere. A kinetic dynamic model of PHB production by autotrophic cultures of Synechocystis PCC6803 was proposed and developed by means of the biochemical networks simulator COPASI. Two classes of cells were assumed to be present in the broth: growing cells, PHB producing cells. The model included the two classes of cells and their nitrogen and phosphate internal quota. The dynamics of the cell growth and PHB production were described taking into account: cellular growth rate; lysis rate; nitrate and phosphate utilization rate; PHB production rate. The assessment of the kinetic parameters and of the yields (model calibration) was carried out by the regression of experimental data. Tests were carried out in photobioreactors under dynamic light system (light/dark cycle) using media characterized by initial nitrate concentration ranging between 0 and 1.5g/L. The developed model was validated with respect to independent experimental set. The proposed model successfully reproduced the experimental data (cell concentration, nitrogen and phosphate concentration and PHB content): the square correlation coefficient of the investigated variable concentrations ranged between 0.81 and 0.99. Parameter sensitivity analysis was carried out to assess the role of the selected parameters on cell growth and PHB accumulation. The dynamics of cellular growth were not significantly affected by a ±20% variation of maximum specific growth rate, of velocity of conversion to PHB producing cells, and of maximum uptake rate of nitrate. The PHB accumulation dynamics were particularly sensitive to the variation of the value of the investigated parameters. The proposed model may support the design and the optimization of a PHB production process by means of autotrophic cultures.

Enhancing cadmium bioremediation by a complex of water-hyacinth derived pellets immobilized with Chlorella sp.

Fecha de Publicación: June 2018
Fuente: Bioresource Technology, Volume 257
Autores: Ying Shen, Wenzhe Zhu, Huan Li, Shih-Hsin Ho, Jianfeng Chen, Youping Xie, Xinguo Shi

Abstract

A complex of water-hyacinth derived pellets immobilized with Chlorella sp. was applied, for the first time, in the bioremediation of Cadmium (Cd). The Cd(II) removal efficiency of the complex was optimized by investigating several parameters, including the pellet materials, algal culture age, and light intensity. Results showed that the Cd(II) removal efficiency was positively related to the algal immobilization efficiency and the algal bioaccumulation capacity. Since higher surface hydrophilicity leads to higher immobilization efficiency, the water-hyacinth leaf biochar pellet (WLBp) was selected as the optimal carrier. A maximum Cd(II) removal efficiency of 92.45% was obtained by the complex of WLBp immobilized with algal cells in stationary growth phase and illuminated with a light intensity of 119 μmol m−2 s−1. Recovery tests on both microalgal cells and the WLBp demonstrated that the algal cells and the biochar pellet can be economically recycled and reused.

In-situ self-assembly of plant polyphenol-coated Fe3O4 particles for oleaginous microalgae harvesting.

Fecha de Publicación: 15 May 2018
Fuente: Journal of Environmental Management, Volume 214
Autores: Xiaoyu Wang, Yuan Zhao, Xiaoxue Jiang, Lijun Liu, Xue Li, Huixian Li, Wenyan Liang

Abstract

Plant polyphenol (PP), a natural polymer from the Larix gmelinii, was selected as the surfactant to synthesize Fe3O4. The Fe3O4-PP composite was prepared by in-situ self-assembly in solvothermal synthesis, and characterized using FE-SEM, TEM, XRD, FTIR, XPS, TGA, and VSM. The harvesting efficiency of Chlorella vulgaris was investigated under different parameters, including algal organic matter, dosage, and pH. The results showed that the core-shell sphere of Fe3O4-PP (~150 nm) was coated by ~50 nm PP with a saturated magnetization of 40.0 emu/g. The Fe3O4-PP could be directly applied to the culture broth (1.5 g dry cell weight/L, pH = 9.03), achieving 93.0% of harvesting efficiency at 20 g/L. Cells were detached from the harvested aggregates by adjusting pH value to 9.80 and with ultrasonication, which

achieved 95.6% of recovery efficiency. The recycled Fe3O4-PP showed high stabilities in surface properties, maintaining more than 87.5% of harvesting efficiency after five recycles.

Marsilea spp.—A novel source of lignocellulosic biomass: Effect of solubilized lignin on anaerobic biodegradability and cost of energy products.

Fecha de Publicación: May 2018
Fuente: Bioresource Technology, Volume 255
Autores: J. Rajesh Banu, S. Sugitha, R. Yukesh Kannah, S. Kavitha, Ick Tae Yeom

Abstract

The present study concerns the liquefying potential of an unusual source of lignocellulosic biomass (Marsilea spp., water clover, an aquatic fern) during combinative pretreatment. The focus was on how the pretreatment affects the biodegradability, methane production, and profitability of thermochemical dispersion disintegration (TCDD) based on liquefaction and soluble lignin. The TCDD process was effective at 12,000 rpm and 11 min under the optimized thermochemical conditions (80 °C and pH 11). The results from biodegradability tests imply that 30% liquefaction was sufficient to achieve enhanced biodegradability of about 0.280 g-COD/g-COD. When biodegradability was >30% inhibition was observed (0.267 and 0.264 g-COD/g-COD at 35–40% liquefaction) due to higher soluble lignin release (4.53–4.95 g/L). Scalable studies revealed that achievement of 30% liquefaction was beneficial in terms of the energy and cost benefit ratios (0.956 and 1.02), when compared to other choices.

Evaluation of various cell drying and disruption techniques for sustainable metabolite extractions from microalgae grown in wastewater: A multivariate approach.

Fecha de Publicación: 1 May 2018
Fuente: Journal of Cleaner Production, Volume 182
Autores: Faiz Ahmad Ansari, Sanjay Kumar Gupta, Mahmoud Nasr, Ismail Rawat, Faizal Bux

Abstract

This study attempted to determine the yield of extractable metabolites and the cost of oil production from Scenedesmus obliquus cultivated in municipal wastewater.

The microalgae achieved a biomass concentration of 1.64 g L−1 as well as pollutant removal efficiencies of 87.86% COD, 86.16% NH4 +-N, and ≈100% PO4 3−-P. The harvested microalgae were subjected to different drying and cell disruption techniques for lipid extraction, and the residual biomass was used to recover proteins and carbohydrates. Principal component analysis was employed to evaluate the metabolic yields obtained from sun-, freeze-, and oven-drying methods and microwave-, sonication-, autoclaving-, and osmotic shock-disruption techniques. The lipid yield varied between 4.90± 0.42% for sun-dried biomass subjected to osmotic shock and 25.39± 1.08% for freeze-drying with microwave-assisted extraction. Protein yield of the whole microalgae cells (31.26± 3.76%) was comparable (p > 0.05) to that resulting from lipid-extracted microalgae by either autoclaving or osmotic shock. Carbohydrate yield of the intact microalgae cells (19.80± 1.49%) was comparable (p > 0.05) to that of lipid-extracted microalgae from amongst all the cell disruption methods. Results of a techno-economic analysis indicated that the cost of oil production from microalgae varied between $0.883 and $2.088 per liter. These results revealed the feasibility of using a sequential extraction of lipids followed by proteins and carbohydrates.

High-rate algal pond coupled with a matrix of Spirogyra sp. for treatment of rural streams with nutrient pollution.

Fecha de Publicación: 1 May 2018
Fuente: Journal of Environmental Management, Volume 213
Autores: Taeeung Kim, Xianghao Ren, Kyu-Jung Chae

Abstract

This study evaluated the unique features of a filamentous algae matrix (FAM) that can be applied to high rate algal ponds (HRAPs) as a promising way to remove nutrient from polluted rural streams. The results show that the HRAPs, coupled with the FAM, effectively removed nitrogen and phosphorus (79.8% and 81.2%, respectively), and achieved high production of DO, with a maximum of 11.0 g O2 g FAM−1 d−1. The FAM functioned wells as a screen to prevent excessive algae loss from the system and obtained relatively high biomass growth rate (0.032 mg L−1 d−1 for nitrogen and 0.344 mg L−1 d−1 for phosphorus). The harvested FAM was a useful fertilizer and the rate of addition of FAM were 1.52 kg d−1 ha−1 of nitrogen and 0.44 kg d−1 ha−1 of phosphorus. Thus, combining the HRAP with the FAM was an effective nutrient removal and resource utilization system for rural streams.

Selection of microalgae with potential for cultivation in surfactant-stabilized foam.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: María Vázquez, Juan L. Fuentes, Adriana Hincapié, Inés Garbayo, Carlos Vílchez, María Cuaresma

Abstract

Recently, microalgal cultivation in liquid foams has been developed. Compared to the traditional systems, this concept is expected to offer advantages such as increased mass transfer and reduced biomass harvesting costs and water consumption. However, there is limited information, thus far, on the microalgal performance in foam-bed photobioreactors. Therefore, this study was aimed at comparing the foaming properties of six algal strains to identify the criteria that could be broadly employed for assessing the microalgal potential for cultivation in a foam-bed photobioreactor. The microalgal strains investigated were selected based on their different nature and potential uses. All the microalgal strains could not naturally produce stable foam, thus necessitating the use of a surfactant. To investigate the differences in the foaming properties of the selected microalgae, the natural surfactant, bovine serum albumin, was employed. Factors such as culture age, algal hydrophobicity, and biomass concentration differently influenced the key foaming properties (foamability, microalgal partitioning, and foam stability) depending on the microalgal strain. In conclusion, the assessment of the foaming properties of microalgal strains together with their inherent growth characteristics revealed large differences in the potentiality of microalgae to be cultivated in a foam-bed photobioreactor. In particular, among the microalgal strains tested, the commercial strains Chlorella sorokiniana, Nannochloropsis gaditana, and Scenedesmus obliquus showed the highest potentiality for cultivation in foam. Overall, the following criteria could be broadly applied to select suitable microalgae for cultivation in a foam-bed photobioreactor: high or moderate foamability of the microalga-surfactant suspension, and microalgal partitioning, stability of the foam formed, and robustness and fast growth of the strains.

Use of freshwater macroalgae Spirogyra sp. for the treatment of municipal wastewaters and biomass production for biofuel applications.

Fecha de Publicación: April 2018
Fuente: Biomass and Bioenergy, Volume 111
Autores: Shijian Ge, Max Madill, Pascale Champagne

Abstract

Freshwater macroalgae has competitive advantages compared to microalgae and marine macroalgae, such as lower separation and drying cost requirements and an abundance of available freshwater media. Municipal wastewater containing large quantities of nutrients (particularly nitrogen and phosphorus) is a valuable and underutilized resource. In this study, the cultivation of the naturally isolated filamentous freshwater macroalgae Spirogyra sp. was investigated in three different types of municipal wastewater including primary (PW), secondary (SW) and centrate (CW) wastewaters. Two different types of reactors including closed column photobioreactors and open rectangular aquarium reactors were operated under no and low air flow rates of less than (18 ± 2) cm−3·min− 1, respectively. The SW, PW diluted with water to a 20 % volume fraction and CW diluted with water to a 2 % volume fraction appeared to promote ash-free biomass productivities of (2.17-6.68) g·m− 2·d− 1 and specific growth rates of (16.4–29.7) %·d− 1. Nitrogen and phosphorus removal efficiencies ranged from (50.6–90.6) % and (60.4–99.1) %, respectively. Based on ultimate analysis, the biomass produced a higher heating value of (12.4–17.1) MJ·kg−1, and also showed relatively consistent protein ((16.7–19.5) % of the dry mass fraction), carbohydrate ((41.5–55.0) %) and lipid ((2.8–10.0) %) contents. These results indicate the feasibility of using Spirogyra sp. to recover nutrients from multiple municipal wastewater sources with the simultaneous production of biomass that contains value-added biochemical components for bioenergy and biofuel applications.

Strategies to increase the potential use of oleaginous microalgae as biodiesel feedstocks: Nutrient starvations and cost-effective harvesting process.

Fecha de Publicación: July 2018
Fuente: Renewable Energy, Volume 122
Autores: Sirasit Srinuanpan, Benjamas Cheirsilp, Poonsuk Prasertsan, Yasuo Kato, Yasuhisa Asano

Abstract

Two locally isolated oleaginous microalgae from Songkhla Lake in Thailand were identified as Micractinium reisseri SIT04 and Scenedesmus obliquus SIT06. The effects of nutrient starvations on the responses of these two strains were intensively investigated in order to increase their lipid contents and manipulate their fatty acid compositions for suitable use as biodiesel feedstocks. Starvation of either phosphorus or ferrous less affected cell growth but did stimulate lipid accumulation of both strains by 1.2 folds. While nitrogen starvation severely limited cell growth but most effectively increased lipid content of both strains by 1.54 folds for M.

reisseri SIT04 (up to 36.6%) and by 1.6 folds for S. obliquus SIT06 (up to 56.8%). The lipid accumulated during nitrogen starvation contained higher saturated fatty acids which could make biodiesel with better fuel properties and higher oxidative stability. The harvesting process through bioflocculation was optimized by Response Surface Methodology. The maximum flocculation efficiency greater than 99.5% was achieved using minimum dosage of chitosan as bioflocculant. This study has revealed the strategies to increase the potential use of oleaginous microalgae as biodiesel feedstocks and the cost-effective process for the harvesting of microalgal biomass.

Seasonal performance of a full-scale wastewater treatment enhanced pond system.

Fecha de Publicación: 1 June 2018
Fuente: Water Research, Volume 136
Autores: Donna L. Sutherland, Stephan Heubeck, Jason Park, Matthew H. Turnbull, Rupert J. Craggs

Abstract

Enhanced pond systems (EPS) consist of a series of ponds that have been designed to work in synergy to provide both cost-effective enhanced wastewater treatment and resource recovery, in the form of algal biomass, for beneficial reuse. Due to the limited number of full-scale EPS systems worldwide, our understanding of factors governing both enhanced wastewater treatment and resource recovery is limited. This paper investigates the seasonal performance of a full-scale municipal wastewater EPS with respect to nutrient removal from the liquid fraction, microalgal biomass production and subsequent removal through the system. In the high rate algal pond both microalgal productivity (determined as organic matter and chlorophyll a biomass) and NH4-N removal varied seasonally, with significantly higher biomass and removal rates in summer than in spring (p < 0.05) or winter (p < 0.01). Microalgal biomass was not successfully harvested in the algal harvester pond (AHP), most likely due to poor flocc formation coupled with relatively short hydraulic residence time (HRT). High percentage removal rates, from sedimentation and zooplankton grazing, were achieved in the maturation pond (MP) series, particularly in winter and spring. However, in summer decreased efficiency of biomass removal and the growth of new microalgal species suggests that summer-time HRT in the MPs could be shortened. Further modifications to the operation of the AHP, seasonal changes in the HRT of the MPs and potential harvesting of zooplankton grazers are all potential strategies for improving resource recovery and producing a higher quality final discharge effluent.

Improving water quality using settleable microalga Ettlia sp. and the bacterial community in freshwater recirculating aquaculture system of Danio rerio.

Fecha de Publicación: 15 May 2018
Fuente: Water Research, Volume 135
Autores: Seong-Jun Chun, Yingshun Cui, Chi-Yong Ahn, Hee-Mock Oh

Abstract

A highly settleable microalga, Ettlia sp., was applied to a freshwater recirculating aquaculture system (RAS) of Danio rerio to improve the treatment of nitrogenous compounds. The growth characteristics of the microalgae, water quality parameters, and bacterial communities were monitored for 73 days. In the treatment RAS, the inoculated Ettlia sp. grew up to 1.26 g/L and dominated (>99%) throughout the experiment, whereas naturally occurring microalgae grew to 0.57 g/L in the control RAS. The nitrate, nitrite, and ammonium concentrations in the treatment RAS were reduced by 50.1%, 73.3%, and 24.2%, respectively, compared to the control RAS. A bacterial community analysis showed that Rhodospirillales, Phycisphaerae, Chlorobiales, and Burkholderiales were the major bacterial groups in the later phase of the treatment RAS. Meanwhile, a network analysis among the Ettlia sp., bacterial groups, and environmental parameters, revealed that the bacterial groups played key roles in both water quality improvement and Ettlia sp. growth. In conclusion, the inoculation and growth of the Ettlia sp. and its associated bacteria in the RAS produced beneficial effects on the water quality by reducing the nitrogenous compounds and providing a favorable environment for certain bacterial groups to further improve water quality.

Bioflocculants' production from a cellulase-free xylanase-producing Pseudomonas boreopolis G22 by degrading biomass and its application in cost-effective harvest of microalgae.

Fecha de Publicación: May 2018
Fuente: Bioresource Technology, Volume 255
Autores: Haipeng Guo, Chuntao Hong, Cheng Zhang, Bingsong Zheng, Dean Jiang, Wensheng Qin

Abstract

The major problem for industrial application of bioflocculants is its high production cost. Here, a novel bacterium Pseudomonas boreopolis G22, which can secret a cellulase-free xylanase and simultaneously produce bioflocculants (MBF-G22)

through directly converting untreated biomass, was isolated. The bioflocculants' production of G22 was closely related to its xylanase activity, hydrolysis ability of biomass and the hemicellulose loss caused by G22. The optimal fermentation conditions with the highest bioflocculants' yield (3.75 mg g−1 dry biomass) were obtained at the fermentation time of 96 h, incubation temperature of 30 °C, inoculum concentration of 1.0% and biomass concentration of 1.0% in an initial pH value of 7.0. MBF-G22 mainly consisted of polysaccharides (63.3%) with a molecular weight of 3.982 × 106 Da and showed the highest flocculating efficiency of 97.1% at a dosage of 3.5 mg L−1. In addition, MBF-G22 showed high flocculating efficiency of microalgae (95.7%) at a dosage of 80 mg L−1.

Techno-economic assessment of the sustainability of an integrated biorefinery from microalgae and Jatropha: A review and case study.

Fecha de Publicación: May 2018
Fuente: Renewable and Sustainable Energy Reviews, Volume 88
Autores: Adewale Giwa, Idowu Adeyemi, Abdallah Dindi, Celia García-Baños Lopez, Catia Giovanna Lopresto, Stefano Curcio, Sudip Chakraborty

Abstract

In this paper, a detailed review on the recent advances in the production of biofuels and biochemicals from microalgae and Jatropha is presented. This review includes critical elements of the sustainability of microalgae and Jatropha biorefineries such as technical analysis, socioeconomic considerations, and environmental impact assessments that are reported in recent studies. The integration of microalgae and Jatropha as viable feedstock for the production of biofuels and biochemicals which may serve as sustainable alternatives to fossils fuels and petrochemicals is also modeled using SuperPro designer. A technoeconomic assessment of the integrated biorefinery is carried out. United Arab Emirates (UAE) is considered as a geographical reference for the technoeconomic assessment. Three scenarios are examined. All scenarios involve the production of biodiesel and glycerol. In addition to these two products, the production of animal feed, organic fertilizer and biogas is considered in scenario 1. In scenario 2, the biorefinery products include bioethanol, organic fertilizer and biogas. Scenario 3 involves the production of hydrogen and animal feed. Scenario 1 is the base case, with which other scenarios are compared. Scenario 1 is profitable but scenarios 2 and 3 are not profitable. In addition, emissions from scenario 2 make it less attractive when it is compared to other scenarios. The integrated biorefinery with microalgae and Jatropha as feedstock is technically feasible and economically profitable in scenario 1, as modeled.

A pilot-scale bioprocess to produce amphidinols from the marine microalga Amphidinium carterae: Isolation of a novel analogue.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: A. Molina-Miras, A. Morales-Amador, C.R. de Vera, L. López-Rosales, A. Sánchez-Mirón, M.L. Souto, J.J. Fernández, M. Norte, F. García-Camacho, E. Molina-Grima

Abstract

Marine dinoflagellate microalgae belonging to the genus Amphidinium are a key source of an interesting group of polyketide metabolites with potent bioactivities, wide-ranging functional diversity and stereochemical complexity, but low natural availabilities. The feasibility of a microalgae dinoflagellate-based sustainable bioprocess for producing amphidinols (APDNs) by photoautotrophic culture of Amphidinium carterae in a pilot-scale LED-illuminated bubble column photobioreactor (PBR) was therefore investigated. A fed-batch culture mode with pulse feeding strategy provided a growth pattern strongly limited by the availability of phosphate content in the culture medium that stimulated the production of cellular APDNs. Since A. carterae was found to be much more shear-sensitive than other shear-tolerant non-dinoflagellate microalgae, the culture height and air flow rate were established to ensure the absence of damaging levels of hydrodynamic stress. The biomass capacity yielded by the PBR at the end of the culture (0.540 g d.w. L−1 equivalent to 1.70 × 106 cell mL−1) corresponded to that estimated stoichiometrically from the experimentally determined biomass P-molar formula (C329 O126 H732 N69 S3 P1) and the total phosphorus and nitrogen balances. The downstream processing section was initially conceived to recover APDNs excreted by cells into the supernatant. A dry APDN-enriched extract concentration of 49 mg per liter of supernatant was obtained. This purification process led to partitioning of the extract into several fractions and sub-fractions thereof. Only two sub-fractions were studied, yielding thereof highly pure (>95% pure) luteophanol D and lingshuiol A, and a new, roughly purified (>80% pure) APDN, namely amphidinol 20. The percentages of luteophanol D, lingshuiol A and amphidinol 20 by dry weight of the APDN-enriched extract obtained were 1%, 0.39% and 0.31%, respectively, thus representing a concentration in the culture supernatant of 490, 191 and 152 μg L−1, respectively.

Energy-efficient outdoor cultivation of oleaginous microalgae at northern latitudes using waste heat and flue gas from a pulp and paper mill.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Susanne Ekendahl, Mathias Bark, Johan Engelbrektsson, Carl-Anton Karlsson, Domitille Niyitegeka, Niklas Strömberg

Abstract

Energy efficient cultivation is the major bottleneck for microalgal biomass production on a large scale and considered very difficult to attain at northern latitudes. In this study an unconventional method for industrial microalgae cultivation for bio-oil production using pulp and paper mill waste resources while harvesting only once a year was performed, mainly in order to investigate the energy efficiency of the process. Algae were cultivated for three months in 2014 in covered pond systems with access to flue gas and waste heat from the industry, and the biomass was recovered as thick sediment sludge after dewatering. The cultivation systems, designed to manage the waste resources, reached a promising photosynthetic efficiency of at most 1.1%, a net energy ratio (NER) of 0.25, and a projected year-round energy biomass yield per area 5.2 times higher than corresponding rapeseed production at the location. Thus, microalgae cultivation was, for the first time, proven energy efficient in a cold continental climate. Energy-rich indigenous communities quickly out-competed the oleaginous monocultures used for inoculation. The recovered biomass had higher heating values of 20–23MJkg−1 and contained 14–19% oil dominated by C16 followed by C18 fatty acids. The cultivation season at 59°15'N, 14°18'E was projected to be efficient for 10months and waste heat drying of the biomass is suggested for two winter months. The technique is proposed for carbon sequestering and energy storage in the form of microalgal sludge or dry matter for later conversion into biochemicals.

Bacterial community changes in an industrial algae production system.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Scott P. Fulbright, Adam Robbins-Pianka, Donna Berg-Lyons, Rob Knight, Kenneth F. Reardon, Stephen T. Chisholm

Abstract

While microalgae are a promising feedstock for production of fuels and other chemicals, a challenge for the algal bioproducts industry is obtaining consistent,

robust algae growth. Algal cultures include complex bacterial communities and can be difficult to manage because specific bacteria can promote or reduce algae growth. To overcome bacterial contamination, algae growers may use closed photobioreactors designed to reduce the number of contaminant organisms. Even with closed systems, bacteria are known to enter and cohabitate, but little is known about these communities. Therefore, the richness, structure, and composition of bacterial communities were characterized in closed photobioreactor cultivations of Nannochloropsis salina in F/2 medium at different scales, across nine months spanning late summer – early spring, and during a sequence of serially inoculated cultivations. Using 16S rRNA sequence data from 275 samples, bacterial communities in small, medium, and large cultures were shown to be significantly different. Larger systems contained richer bacterial communities compared to smaller systems. Relationships between bacterial communities and algae growth were complex. On one hand, blooms of a specific bacterial type were observed in three abnormal, poorly performing replicate cultivations, while on the other, notable changes in the bacterial community structures were observed in a series of serial large-scale batch cultivations that had similar growth rates. Bacteria common to the majority of samples were identified, including a single OTU within the class Saprospirae that was found in all samples. This study contributes important information for crop protection in algae systems, and demonstrates the complex ecosystems that need to be understood for consistent, successful industrial algae cultivation. This is the first study to profile bacterial communities during the scale-up process of industrial algae systems.

Evaluation of an electro-flotation-oxidation process for harvesting bio-flocculated algal biomass and simultaneous treatment of residual pollutants in coke wastewater following an algal-bacterial process.

Fecha de Publicación: April 2018
Fuente: Algal Research, Volume 31
Autores: Byung-Gon Ryu, Jungmin Kim, Jong-In Han, Kyochan Kim, Donghyun Kim, Bum-Kyoung Seo, Chang-Min Kang, Ji-Won Yang

Abstract

This study investigated the feasibility of employing an electro-flotation-oxidation process that employs a pair of boron-doped diamond (BDD) and aluminum (Al) electrodes for electrochemical harvesting of green microalgae (Scenedesmus quadricauda) and treatment of residual pollutants in coke effluent, following an algal-bacterial process. Electro-coagulation-flotation with polarity exchange and with direct electro-flotation at 15mAcm−2 or more for 40min allowed almost complete harvesting of microalgae. Similar harvesting efficiencies were achieved using direct electro-flotation, without electro-coagulation, under different electrical densities

because algal biomass formed flocs with the other microorganisms in the activated sludge (AS). These results also indicate that the proposed approach of inducing bioaggregation via floc-forming microorganisms with microalgae is an efficient alternative to chemical flocculation, because it can minimize the release of toxic metal coagulants during electrochemical harvesting. During sequential electro-oxidation, anodic oxidation using the BDD electrode simultaneously mineralized residual soluble chemical oxygen demand (SCOD) and thiocyanate (SCN−), which are not degraded by algal-bacterial mixed cultures. Although the degradation rate of SCN− was much higher than that of SCOD under certain current densities, further investigation is needed to clarify the mechanism of SCN− mineralization during BDD-anodic oxidation. To satisfy the standard level of electrical power consumption for wastewater treatment, an electric current density below 15mAcm−2 must be supplied. The proposed electrochemical approach involving bioflocculation could be used as an efficient post treatment of microalgae-mediated process for treating coke wastewater.

Nutrients recovery and recycling in algae processing for biofuels production.

Fecha de Publicación: July 2018
Fuente: Renewable and Sustainable Energy Reviews, Volume 90
Autores: Elena Barbera, Alberto Bertucco, Sandeep Kumar

Abstract

The supply of nutrients is a great issue to a sustainable scale-up of microalgal biofuels production, as these photosynthetic microorganisms require large amounts of N, P and other micronutrients to grow, which turns into high fertilizers demand. Additionally, recovery and reuse of nutrients (particularly N & P) are a must to reduce the non-point pollution emanating from their release into water or air during the downstream processing steps to biofuels or bioproducts. In the recent years, strong research efforts have been paid for developing nutrient recovery and recycling techniques, in order to reduce the net amount of fertilizers required. One possibility is exploiting nutrients from waste streams, such as wastewaters, while others focus on the recovery of N and P from the non-fuel fraction of the produced microalgal biomass, which is then recycled to the cultivation system, in a closed-loop perspective. In both cases, the presence of possible contaminants as well as nutrients bioavailability can impact the biomass productivity compared to standard synthetic media. Although the nutrients recovery and reuse has been in the forefront for a few years, there are no review publications available yet. In this paper, state-of-the art studies on nutrients recovery and recycling methods in microalgae processing from the last decade are reviewed. The study focuses on the different N and P recovery methods and yields, as well as on their subsequent use in

algal cultivation and impact on algae productivity. Possible bioproducts exploitation is considered, and perspectives of closed-loop material balances on a large-scale are eventually provided.

Mathematical modeling of light energy flux balance in flat panel photobioreactor for Botryococcus braunii growth, CO2 biofixation and lipid production under varying light regimes.

Fecha de Publicación: 15 June 2018
Fuente: Biochemical Engineering Journal, Volume 134
Autores: Shailendra Singh Khichi, Afifa Anis, Sanjoy Ghosh

Abstract

Light is the most significant parameter for microalgal growth and light distribution inside the flat panel photobioreactor is critical to assess the photosynthetic productivity of Botryococcus braunii. In algal photobioreactors, self shading of the microalgal cells reduces the effective light penetration. The local light intensity inside the photobioreactor is essential for efficient designs. In this study B. braunii was grown in flat panel photobioreactor under varying light intensity. Maximum biomass concentration and maximum specific growth rate were 1.8 g L−1 and 1.344 d−1 respectively at light intensity of 800 µmol m−2 s−1. The maximum lipid content and lipid yield were 27.37% and 0.146 g mol photons−1 respectively at 450 µmol m−2 s−1 light intensity. The results reported in this study is used with the radiative transport equation (RTE) to accurately predict and optimize light transport in photobioreactors for biomass and lipid production. Finally, simulation of RTE in flat panel photobioreactor also suggests, at cell concentration (>0.41 g L−1) multiple scattering and diffusive reflections reduced the light penetration. Based on these results, optimal conditions for lipid production were found to be at mid level light intensity i.e. 450 µmol m−2 s−1 which allows maximizing the use of light energy by the cells to produce maximum lipid.

Effect of cultivation conditions on β-estradiol removal in laboratory and pilot-plant photobioreactors by an algal-bacterial consortium treating urban wastewater.

Fecha de Publicación: 15 June 2018
Fuente: Water Research, Volume 137
Autores: Eloi Parladé, Andrea Hom-Diaz, Paqui Blánquez, Maira Martínez-Alonso, Teresa Vicent, Nuria Gaju

Abstract

The use of microalgal consortia for urban wastewater treatment is an increasing trend, as it allows simultaneous nutrient removal and biomass production. Emerging contaminants proposed for the list of priority substances such as the hormone 17β-estradiol are commonly found in urban wastewater, and their removal using algal monocultures has been accomplished. Due to the inherent potential of algae-based systems, this study aimed to assess the capability of native photobioreactor biomass to remove 17β-estradiol under indoor and outdoor conditions. At the same time, the microbial community changes in regular and bioaugmented operations with Scenedesmus were assessed. The results show that almost complete removal (>93.75%) of the hormone 17β-estradiol can be attained in the system under favourable seasonal conditions, although these conditions greatly influence biomass concentrations and microbial diversity. Even under the harsh conditions of low temperatures and solar irradiation, the established consortium removed more than 50% of the pollutant in 24 h. While species from genus Chlorella were stable during the entire operation, the microbial diversity analysis revealed that assorted and evenly distributed populations stimulate the removal rates. Bioaugmentation assays proved that the input of additional biomass results in higher overall removal and decreases the yield per mg of biomass.

Isolation and characterization of microalgal strains for biomass production and wastewater reclamation in Northern Sweden.

Fecha de Publicación: June 2018
Fuente: Algal Research, Volume 32
Autores: Lorenza Ferro, Francesco G. Gentili, Christiane Funk

Abstract

Microalgal strains adapted to the harsh Nordic climate were isolated from Swedish fresh- and wastewater sources and tested for their ability to grow in municipal wastewater. The 62 strains able to grow in municipal wastewater belonged to 12 different genera, of those Desmodesmus, Scenedesmus and Chlorella were most representative. Eight axenic strains were further characterized, all of which could efficiently remove nitrogen (>90%) and phosphate (>99%) from the wastewater in less than two weeks. The microalga Coelastrella sp. had the highest performance in terms of both biomass concentration and total lipid content (1.46 g/L, 30.8%) after 13 days of cultivation. This is the first report of a Coelastrella strain isolated in Sweden. Even Chlorella vulgaris performed very well with a biomass concentration and total lipid content of 1.15 g/L and 34.2%, respectively. Finally, two Desmodesmus sp. strains showed desirable traits for biofuel-feedstock, due to their

fast growth rates (1.18 and 1.08 d−1) together with high oil content (29.8% and 36.7% of DW).

Effect of pretreatments on biogas production from microalgae biomass grown in pig manure treatment plants.

Fecha de Publicación: June 2018
Fuente: Bioresource Technology, Volume 257
Autores: Judit Martín Juárez, Elena Riol Pastor, José M. Fernández Sevilla, Raúl Muñoz Torre, Pedro A. García-Encina, Silvia Bolado Rodríguez

Abstract

Methane production from pretreated and raw mixed microalgae biomass grown in pig manure was evaluated. Acid and basic pretreatments provided the highest volatile solids solubilisation (up to 81%) followed by alkaline-peroxide and ultrasounds (23%). Bead milling and steam explosion remarkably increased the methane production rate, although the highest yield (377 mL CH4/g SV) was achieved by alkali pretreatment. Nevertheless, some pretreatments inhibited biogas production and resulted in lag phases of 7–9 days. Hence, experiments using only the pretreated solid phase were performed, which resulted in a decrease in the lag phase to 2–3 days for the alkali pretreatment and slightly increased biomass biodegradability of few samples. The limiting step during the BMP test (hydrolysis or microbial inhibition) for each pretreatment was elucidated using the goodness of fitting to a first order or a Gompertz model. Finally, the use of digestate as biofertilizer was evaluated applying a biorefinery concept.

Illumination wavelengths effect on Arthrospira platensis production and its process applications in River Yamuna water treatment.

Fecha de Publicación: June 2018
Fuente: Journal of Water Process Engineering, Volume 23
Autores: Luv Mehan, Ritu Verma, Rahul Kumar, Aradhana Srivastava

Abstract

Illumination triggers the metabolic activities in microalgae. Wavelength governs the energy fluxes and activates the photosystem I and II. Treating the river water is the prime project in India due to disposal of effluent discharge. Lack of well-defined illumination wavelength for microalgae cultivation aimed this study to find optimum wavelength for promoting growth of Arthrospira platensis and hence, treatment of Yamuna water enriched with effluent discharge. Seven experimental set-up each

comprising of an Erlynmeyer flask containing Zarrouk's medium supplied with sterile air and kept under different wavelengths, were used. Effects of different energy fluxes were investigated on the production of A. platensis. Optimum illumination wavelength selection was based on the comparison of maximum specific growth rate (µmax). Sunlight exhibited µmax of 0.45 day−1 and maximum biomass productivity of 16.77 mg/L/h, i.e. highest among others. Energy flux per unit power for the corresponding source of illumination was 6.05 × 10−21 s/m2. Optimum wavelength was further used for microalgae cultivation in Yamuna water. Culture was acclimatized to Yamuna water using sequential increased levels to maintain the µmax. Biomass productivity of 10 mg/L/h and removal efficiencies of 99.76% for nitrate, 99.22% for lead, 100% for nickel, 90.80% for cadmium and 68.57% for copper, were achieved. Biomass productivity was 40.3% lesser than that of Zarrouk's medium but lipid content of cells increased by 16.45%. Maximum productivity of value added by-products chlorophyll and phycocyanin was 2.93 and 7.34 mg/g cells/day respectively. A. platensis has great potential for wastewater treatment and production of valuable by-products.

Symbiosis optimization of building envelopes and micro-algae photobioreactors.

Fecha de Publicación: July 2018
Fuente: Journal of Building Engineering, Volume 18
Autores: Mohamad T. Araji, Iqbal Shahid

Abstract

This paper introduces a theoretical optimization method for utilizing micro-algae on building envelopes. Such concept opens various opportunities with mutual benefits for high performance built environments and cellular growth. Building form and its contextual determinants were analyzed with respect to algae's prototype, residence time and panel inclination. Parameters that were kept constant involved thermal regulation, mixing energy and photobioreactor (PBR) geometry. Three performance indicators were examined to derive energy production, CO2 biofixation and land resource preservation. Sensitivity analysis was further utilized to investigate microalgae dependence on intercepted light intensity and lethal temperatures. With Chlorella vulgaris prototype, the volumetric productivity (kWh/m3) was 34.5% above Dunaliella tertiolecta at low building energy consumption levels. The residence time of 1.3 days led to higher performance as compared to that of 4 days by a factor of 1.2. In terms of the capability of CO2 biofixation, the percentage by which a PBR inclination of 75° outperformed a value of 90° was 66%. For a given building footprint to land ratio b, the achievable height was approximated to be 22.5 b . At a higher energy consumption, the impact of building aspect ratio AR on net-zero target was increased by 40.31% with AR = 1:8 as compared to AR = 1:1.

Supercritical water gasification of microalgae over a two-component catalyst mixture.

Fecha de Publicación: 15 July 2018
Fuente: Science of The Total Environment, Volume 630
Autores: Pei-Gao Duan, Shi-Chang Li, Jia-Li Jiao, Feng Wang, Yu-Ping Xu

Abstract

Supercritical water gasification (SCWG) of the microalga Chlorella pyrenoidosa was examined with a catalyst mixture of Ru/C and Rh/C in a mass ratio of 1:1. The influences of temperature (380–600°C), water density (0–0.197g/cm3), and catalyst loading (0–20wt%) on the yields and composition of the gaseous products and the gasification efficiency were examined. The temperature and water density significantly affected the SCWG of the microalgae. The hydrogen gasification efficiency was more dependent on the temperature, while the carbon gasification efficiency was more dependent on the water density. The gaseous products mainly consisted of CH4, H2, CO, and CO2, with smaller amounts of C2-C3 hydrocarbons. CH4 made up half of the mole fraction of the gaseous products under most reaction conditions. A synergistic effect between Ru/C and Rh/C existed during the SCWG of the microalgae, and this effect favored the production of CH4. The role of the catalyst mixture became indistinct at higher temperatures. Hydrogen atoms from the water were transferred to the gaseous products during the SCWG, leading to hydrogen gasification efficiencies that exceeded 100%. The main components of the bio-oil were aromatics and nitrogen-containing compounds, and the main aromatics consisted of azulene and anthracene. The nitrogen-containing compounds are potential poisons to the catalyst mixture.

Supercritical transesterification of microalgae triglycerides for biodiesel production: Effect of alcohol type and co-solvent.

Fecha de Publicación: July 2018
Fuente: The Journal of Supercritical Fluids, Volume 137
Autores: Maira Tobar, Gonzalo A. Núñez

Abstract

In the present study, biodiesel produced by supercritical transesterification (non-catalytic) from Spirulina oil with alcohol (methanol and ethanol) was investigated. A factorial experimental design 22 with two central points for each alcohol was used. The effect of temperature (200 and 300 °C) and the amount of co-solvent (0.0005–0.003 g CO2/g methanol and 0.0003–0.001 g CO2/g ethanol) on the reaction yield was studied. Results showed that yield increased from 42% to 65% (at 200 °C) and

from 46% to 72% (at 300 °C) when the amount of CO2 increased from 0.0005 to 0.003 g CO2/g methanol. By using CO2 as a co-solvent, it is possible to reduce the critical point of the reaction mixture (oil + alcohol) and thereby increase the reaction yield. For ethanolysis, the effect of selected variables was not statistically significant in the range of studied reaction conditions.

Immobilization of the green microalga Botryococcus braunii in polyester wadding: Effect on biomass, fatty acids, and exopolysaccharide production.

Fecha de Publicación: April 2018
Fuente: Biocatalysis and Agricultural Biotechnology, Volume 14
Autores: Néstor D. Giraldo Calderón, Kenny C. Díaz Bayona, Lucía Atehortúa Garcés

Abstract

Botryococcus braunii is a renowned source of biomass, lipids and hydrocarbons for biofuel production. However, this microalga also produces exopolysaccharides (EPS) which might be used industrially. The artificial immobilization of B. braunii has proven to influence its growth and metabolite yield. In this work, B. braunii was immobilized using 3 g/L of polyester wadding, a recyclable material no reported before as fixing matrix for this microalga. This inexpensive polymer was non-toxic to the cells and allowed their fixing during 2 months. After 24 days, the final biomass yield (g/L) was statistically higher (P < 0.05) in immobilized (1.05 ± 0.05) than in suspended cultures (0.734 ± 0.003). The final EPS yield (g/L) was also higher in immobilized (0.094 ± 0.008) than in the suspended cultures (0.077 ± 0.004). In both cases, the sugar composition of the EPS (mainly 71.73 mol% galactose) and the profile of fatty acids were the same.

Hydrothermal liquefaction of pretreated low-lipid microalgae for the production of bio-oil with low heteroatom content.

Fecha de Publicación: Available online 22 March 2018
Fuente: Process Biochemistry
Autores: Zhaodan Huang, Anaerguli Wufuer, Yuanyuan Wang, Liyi Dai

Abstract

The conversion of microalgae to bio-oil by hydrothermal liquefaction (HTL) is considered an effective method to obtain environmentally friendly energy. However, the heteroatomic organic species, mainly nitrogen and oxygen-containing chemicals, in bio-oil hamper its practical utilization. A low-temperature liquefaction

pretreatment process (150–225 °C, 10–50 min) was performed to improve the quality of bio-oil from low-lipid microalgae. After the pretreatment, 11–61% of the nitrogen content was removed from the microalgae. Then, the algae were converted via HTL at 340 °C for 120 min into bio-oil with lower heteroatom content and higher conversion yield compared to those obtained by direct HTL. Specifically, when algae were pretreated at 225 °C for 10–50 min, the yield and higher heating value of the bio-oil reached 26.5–34.3 wt% and 34.9–37.1 MJ/kg, respectively, while the nitrogen and oxygen contents were reduced by 37% and 36%, respectively. Furthermore, GC-MS, FT-IR and elemental analyses revealed that the bio-oil derived from pretreated algae contained a lower level of N-containing compounds and that the content of desired long-chain hydrocarbons had increased to 30%. These findings demonstrate that great improvements in the quality of bio-oil can be achieved by pretreatment of the algae.

Repeated batch fermentation for photo-hydrogen and lipid production from wastewater of a sugar manufacturing plant.

Fecha de Publicación: 15 February 2018
Fuente: International Journal of Hydrogen Energy, Volume 43, Issue 7
Autores: Thitirut Assawamongkholsiri, Alissara Reungsang, Pensri Plangkang, Sureewan Sittijunda

Abstract

Hydrogen and lipid production from sugar manufacturing plant wastewater (SMW) by Rhodobacter sp. KKU-PS1 were investigated. Aji-L (i.e., a waste from the process of crystallizing monosodium glutamate) was used as nitrogen source. Batch fermentation was conducted in 300 mL serum bottles with the working volume of 180 mL to investigate the optimal inoculum size by varying the initial inoculum concentration from 0.23 to 0.92 gCDW/L. The photo-fermentation was conducted at an initial pH 7.0 and 25.6 °C with continuously light illumination at 7500 lux. The optimal inoculum size of 0.77 gCDW/L gave the hydrogen production rate (Rm) and lipid production of 5.24 mL H2/L.h and 407 mg lipid/L, respectively. The hydrogen production from SMW was further examined in 1.7-L photo-bioreactor with the working volume of 1.2-L using the optimal condition from batch experiment. A photo-bioreactor yielded 1.73 times higher Rm than that obtained from the fermentation in serum bottles with a greater lipid production of 424 mg lipid/L. Hydrogen production from SMW in the repeated-batch fermentation was further studied by varying the medium replacement ratios of 25, 50–75%. A maximum biomass and lipid concentration of 2.83 gCDW/L and 685 mg lipid/L, respectively were achieved at a medium replacement ratio of 75%. C18:1 (51.2%), C18:0 (24.9%) and C16:0 (9.1%) were found as the major free fatty acid. Lactic acid followed by

propionic, acetic and butyric acids containing in SMW were the suitable carbon source for biomass production of KKU-PS1.

Bioremediation of textile wastewater and successive biodiesel production using microalgae.

Fecha de Publicación: February 2018
Fuente: Renewable and Sustainable Energy Reviews, Volume 82, Part 3
Autores: Tahir Fazal, Azeem Mushtaq, Fahad Rehman, Asad Ullah Khan, Naim Rashid, Wasif Farooq, Muhammad Saif Ur Rehman, Jian Xu

Abstract

Microalgal biodiesel has emerged as an environment friendly alternative to the existing fossil fuels. The commercial production of this biodiesel is still challenging due to several technical and economic issues, which span from mass cultivation of microalgae to the biodiesel production. Mass cultivation is the most critical step in terms of water and nutrient requirement. Industrial wastewater such as textile wastewater (TWW) is a cheap source for water, which additionally contains necessary nutrients (phosphate, nitrates, micronutrients etc.) and organic dyes (potential carbon source) for algae cultivation. The application of microalgae for biodiesel production employing single objective strategy is not sustainable. Microalgae can be effectively employed to bioremediate TWW (dyes and nutrients removal) and to produce biodiesel from grown microalgae. This process integration (bioremediation-biodiesel production) can potentially improve biodiesel production and wastewater treatment. However, this process coupling needs to be thoroughly investigated to identify and optimize critical process factors (algal species, cultivation and harvesting methods, bioremediation mechanism etc.). This study has reviewed the status of TWW as potential source of water and nutrients, role of different algal species in the bioremediation of TWW, different cultivation systems, harvesting and biodiesel production methods. This review also suggests future research and development challenges for coupled textile wastewater treatment and microalgal biodiesel production.

Polyhydroxybutyrate and phenolic compounds microalgae electrospun nanofibers: A novel nanomaterial with antibacterial activity.

Fecha de Publicación: 1 July 2018
Fuente: International Journal of Biological Macromolecules, Volume 113
Autores: Suelen Goettems Kuntzler, Ana Claudia Araujo de Almeida, Jorge Alberto Vieira Costa, Michele Greque de Morais

Abstract

Polymer nanofibers produced by electrospinning are promising for use in food packaging because of their nanometric diameter, which provides a barrier to external conditions above the possible incorporation of the active compounds. The microalga Spirulina sp. LEB 18 synthesizes bioproducts, such as polyhydroxybutyrate (PHB), which is biodegradable and has similar mechanical and thermal properties to polymers of petrochemical origin. Moreover, phenolic compounds of microalgae have antibacterial, antifungal, and antioxidant activities, which is a differential for the development of packaging. The objective of the study was to develop a nanomaterial with antibacterial action from bioproducts of microalgal origin. PHB nanofibers containing phenolic compounds presented average diameter of 810±85nm exhibited hydrophobicity, which gave protection to the food relative to the moisture outside the package. These nanofibers showed inhibition of the growth of Staphylococcus aureus ATCC 25923 with a zone of 7.5±0.4mm. Thermal and mechanical properties have confirmed the potential applicability of this material as food packaging. This new nanomaterial combines a packaging function to protect products and to be biodegradable with the antibacterial activity that prevents the proliferation of microorganisms and ensures the quality and preservation of food.

Docosahexaenoic acid production by a novel high yielding strain of Thraustochytrium sp. of Indian origin: Isolation and bioprocess optimization studies.

Fecha de Publicación: June 2018
Fuente: Algal Research, Volume 32
Autores: Kabilan Chandrasekaran, Rony K. Roy, Anju Chadha

Abstract

Docosahexaenoic acid [DHA], an important nutraceutical, generally isolated from fish can be derived from a marine heterotroph microalgae of the thraustochytrid family. In this study, strategic screening for a high yielding strain from the mangroves of South India for the production of DHA resulted in a strain which showed promising yields of biomass and DHA. Phylogenetic (18S rRNA) analysis of this strain revealed that the isolate belonged to Thraustochytrium sp. and was labeled T01. The total lipid of the wet cell volume was detected by Nile red fluorescence spectroscopy and the lipid content was estimated by gravimetric analysis, was found to be 50 ± 2% of dry cell weight. The maximum biomass and DHA obtained using optimized (central composite design) media composition after 108 h at 25 °C and 180 rpm were 31 ± 0.2 g L−1 and 6.9 ± 0.05 g L−1 respectively. Of the total fatty acid methyl ester content in the biomass, 45.3 ± 1.7% of DHA methyl ester was observed which was improved to 80% by the urea complexation method (3.3 M urea and

3.3 Urea/FAME). This strain thus could be an ideal candidate for commercial production of DHA.

Optimized co-production of lipids and carotenoids from Ettlia sp. by regulating stress conditions.

Fecha de Publicación: June 2018
Fuente: Bioresource Technology, Volume 258
Autores: Nakyeong Lee, So-Ra Ko, Chi-Yong Ahn, Hee-Mock Oh

Abstract

This study used a single strain Ettlia sp. YC001 and two stages to optimize the production of three materials: lipids, lutein, and β-carotene. In the cultivation stage for lutein production, different temperatures, light qualities, and intensities were applied. The highest biomass was obtained at 35 °C, but the maximum lutein productivity of 6.1 mg/L/d achieved at 25 °C. In the stress stage for lipids and β-carotene production, UV-A and nitrogen starvation were applied. While UV stress increased the chlorophyll-a and β-carotene content. The β-carotene, oleic acid, and lipids significantly increased under nitrogen starvation with a high light intensity of 1200 µmol/m2/s, plus the Ettlia sp. changed from green to red. The results showed that Ettlia sp. can be an effective microalga for the co-production of lutein, β-carotene, and biodiesel.

Enhancement of bioelectricity generation and algal productivity in microbial carbon-capture cell using low cost coconut shell as membrane separator.

Fecha de Publicación: 15 May 2018
Fuente: Biochemical Engineering Journal, Volume 133
Autores: B. Neethu, G.D. Bhowmick, M.M. Ghangrekar

Abstract

Proton exchange membranes (PEMs) are the most prominently used separator in microbial fuel cell (MFC) and microbial carbon capture cell (MCC). This study aims at evaluating the characteristics of coconut shell (CS) to explore its potential as a PEM. The CS exhibited superior water absorption (32%), which can stimulate the proton transmission through water molecules to the cathodic chamber. The proton conductivity of CS separator was comparable to Nafion 117; however, the oxygen mass transfer coefficient of CS separator was lower than Nafion 117, indicating it as superior separator. These separators were used in MCC with Chlorella sorokiniana

grown in cathodic chamber. The maximum power density (MPD) and coulombic efficiency (CE) of MCC with CS separator were 3.2 W/m3 and 16.53%, respectively, whereas the MCC with Nafion 117 membrane showed a MPD of 1.8 W/m3 and CE of 8.42%. Although the COD removal efficiency in the anodic chamber of Nafion-MCC (72.14 ± 0.15%) was superior to CS-MCC (65.97 ± 0.83%), the algal specific growth rate at cathode was found better in CS-MCC (2.64 day−1) than Nafion-MCC (2.16 day−1). This study reveals the feasibility of using CS as low cost as well as energy efficient membrane separator for the application in MCC.

Enhancing biomass and lipid productions of microalgae in palm oil mill effluent using carbon and nutrient supplementation.

Fecha de Publicación: 15 May 2018
Fuente: Energy Conversion and Management, Volume 164
Autores: Wai Yan Cheah, Pau Loke Show, Joon Ching Juan, Jo-Shu Chang, Tau Chuan Ling

Abstract

Microalgae are a promising feedstock for biofuel generation. Economical and effective mass cultivation is essential for greater feasibility in microalgal-based biofuel full applications. The present study reported on cultivation of Chlorella sorokiniana CY-1 in palm oil mill effluent (POME) under photoautotrophic and mixotrophic cultivation. Enhancement of biomass and lipid productions were carried out by using glucose, urea and glycerol supplementations. Mixotrophic cultivation was more effective than photoautotrophic condition. Glycerol addition exhibited greater microalgae growth performance compared to supplementing glucose or urea. Biomass (1.68 g L−1) and lipid (15.07%) production were highest in POME medium with combinations of 200 mg L−1 urea, glucose and glycerol supplementation. Chlorella sorokiniana CY-1 grown in POME with glucose and glycerol supplementation gave considerably comparable yields as in all supplements-added POME medium. Ideal fatty acids compositions shown in urea and glycerol supplemented-POME medium though lower biomass production obtained. The pollutant remediation efficiencies attained were 63.85% COD, 91.54% TN and 83.25% TP in all supplements-added medium. The estimated net energy ratio was 0.55 and nutrient cost could be reduced up to 76%. Cheap and effective carbon and nutrients supplementation is essential to minimize the economic impact and maximize yields in commercial scale microalgae cultivation for biofuel production and environmental sustainability.

Use of microalgae to recycle nutrients in aqueous phase derived from hydrothermal liquefaction process.

Fecha de Publicación: May 2018
Fuente: Bioresource Technology, Volume 256
Autores: Lijian Leng, Jun Li, Zhiyou Wen, Wenguang Zhou

Abstract

Hydrothermal liquefaction (HTL) of microalgae biomass generates an aqueous phase (AP) byproduct with limited energy value. Recycling the AP solution as a source of nutrients for microalgae cultivation provides an opportunity for a cost-effective production of HTL based biofuel and algal biomass feedstock for HTL, allowing a closed-loop biofuel production in microalgae HTL biofuel system. This paper aims to provide a comprehensive overview of characteristics of AP and its nutrients recycling for algae production. Inhibitory effects resulted from the toxic compounds in AP and alleviation strategies are discussed.

Use of mixed wastewaters from piggery and winery for nutrient removal and lipid production by Chlorella sp. MM3.

Fecha de Publicación: May 2018
Fuente: Bioresource Technology, Volume 256
Autores: Vimalkumar Ganeshkumar, Suresh R. Subashchandrabose, Rajarathnam Dharmarajan, Kadiyala Venkateswarlu, Ravi Naidu, Mallavarapu Megharaj

Abstract

The larger-scale generation of piggery and winery wastewaters and consequent eutrophication are quite alarming, necessitating the use of a cost-effective treatment. This study attempted to remediate wastewaters from piggery and winery mixed in the ratios of 20:80, 50:50, 80:20, 100:0 and 0:100, in terms of nutrient removal and subsequent lipid accumulation by soil microalga, Chlorella sp. MM3. The per cent removal of total nitrogen and phosphates by the alga from mixed wastewaters within 10-days ranged between 51 and 89 and 26–49, respectively. As determined by FTIR spectroscopy, the lipid accumulation in the microalgal cells grown in wastewater mixtures ranged between 29 and 51%. Our results suggest that Chlorella sp. MM3 could be a potential candidate for bioremediation of wastewaters derived from piggery farm and winery industry, and that mixing of these wastewaters in 20:80 ratio would be an efficient approach for phycoremediation of mineral-rich effluents and subsequent yield of fairly good amounts of biofuel.

Enhanced single cell oil production by mixed culture of Chlorella pyrenoidosa and Rhodotorula glutinis using cassava bagasse hydrolysate as carbon source.

Fecha de Publicación: May 2018
Fuente: Bioresource Technology, Volume 255
Autores: Lu Liu, Junhui Chen, Phaik-Eem Lim, Dong Wei

Abstract

The single cell oil (SCO) production by the mono and mixed culture of microalgae Chlorella pyrenoidosa and red yeast Rhodotorula glutinis was investigated using non-detoxified cassava bagasse hydrolysate (CBH) as carbon source. The results suggested that the two strains were able to tolerate and even degrade some byproducts presented in the CBH, and the mixed culture approach enhanced the degradation of certain byproducts. Biomass (20.37 ± 0.38 g/L) and lipid yield (10.42 ± 1.21 g/L) of the mixed culture achieved in the batch culture were significantly higher than that of the mono-cultures (p < 0.05). The fed-batch culture further raised the biomass and lipid yield to 31.45 ± 4.93 g/L and 18.47 ± 3.25 g/L, respectively. The lipids mainly composed of oleic acid and palmitic acid, suggesting the potential applications such as biofuel feedstock, cosmetics, food additives and lubricant. This study provided new insights for the integration of the economical SCO production with agro-industrial waste disposal.

Approaches to convert Mucor circinelloides lipid into biodiesel by enzymatic synthesis assisted by microwave irradiations.

Fecha de Publicación: September 2018
Fuente: Renewable Energy, Volume 125
Autores: Ana Karine F. Carvalho, Heitor B.S. Bento, Hélcio J. Izário Filho, Heizir F. de Castro

Abstract

This work aimed to study the enzymatic production of biodiesel from lipids produced by Mucor circinelloides URM 4182 using Novozym 435® as catalyst under different conditions, in which microwave irradiations were used to perform both the lipids extraction and transesterification heating. Sequential or simultaneous approaches were also investigated. In direct transesterification, ethanol serves as a solvent for lipid extraction and a reactant for the reaction, simultaneously. Cell growth and the lipids accumulation were carried out in a bioreactor containing glucose and corn steep liquor as carbon and nutrients sources, respectively. Corn steep liquor (CSL)

can be a good replacement for synthetic nutrients allowing higher volumetric biomass production (3.1 ± 0.01 gL−1day−1). M. circinelloides oil revealed as main fatty acids: palmitic acid C16:0 (18.9%), oleic C18:1 (25.3%), linoleic C18:2 (19.3%) and linoleic acid C18:3 (18.3%). With regards to biodiesel synthesis, the two steps technology, which combined the lipids extraction from microbial biomass followed by enzymatic transesterification reaction both carried out under microwave irradiation, allowing for the attainment of 98.5% ethyl esters in 10 h, compared to 30 h under conventional heating. The simultaneous extraction and transesterification also shows promising results, although the ester content was slight lower (90.1%).

A genset and mini-photobioreactor association for CO2 capturing, enhanced microalgae growth and multigeneration.

Fecha de Publicación: September 2018
Fuente: Renewable Energy, Volume 125
Autores: E.C. Telles, S. Yang, J.V.C. Vargas, F.G. Dias, J.C. Ordonez, A.B. Mariano, M.B. Chagas, T. Davis

Abstract

A multigeneration system is proposed to recover waste heat from a genset driven by a diesel engine, and capture CO2 in its emissions for microalgae growth. Scenedesmus sp. and an algae mixture were separately cultivated in 20-L jugs by supplying two CO2 sources: air and diesel engine emissions. Microalgae growth rates were determined from absorbances and analyzed to construe whether emissions in lieu of air enhanced the microalgae growth. Also, a mini-photobioreactor (mPBR) was employed to grow local algae mixture with air and emissions as CO2 sources. The experimental results demonstrated that diesel engine emissions increased the growth of both Scenedesmus sp. and local algae mixture. The multigeneration system thermal efficiency was defined as the sum of the total electrical power produced for cultivation in PBR, biomass harvesting, flocculation, separation, drying and oil extraction, followed by biodiesel production via transesterification reaction, plus the waste heat recovery and the heat generation rate potential of the produced biodiesel, divided by the heat input rate due to the combustion of consumed diesel fuel. In the absence of waste heat recovery, maximum thermodynamic efficiency of the system was 26%, while it increased to 36.2% with waste heat recovery and microalgae biodiesel, i.e., by 39.2%.

Optimization of enzymatic hydrolysis for effective lipid extraction from microalgae Scenedesmus sp.

Fecha de Publicación: September 2018
Fuente: Renewable Energy, Volume 125
Autores: Yi Zhang, Xiaoying Kong, Zhongming Wang, Yongming Sun, Shunni Zhu, Lianhua Li, Pengmei Lv

Abstract

Cell wall disruption is an essential downstream processing step for improving the efficiency of lipid extraction from microalgae. Enzyme-assisted extraction of lipid from microalga Scenedesmus sp. with cellulase, xylanase and pectinase, using various parameters, such as enzyme concentration, temperature, pH and incubation time, was optimized by central composite design (CCD) coupled with response surface methodology (RSM). Both the lipid extraction from microalgae and the fatty acid methyl esters (FAMEs) production under optimal conditions showed a ~twofold in the yields compared to the control group with no enzymatic treatment. SEM images, FTIR measurement, XPS and HPLC analysis showed that the enzymatic pretreatment caused significant alterations in the cell wall structure of microalgae. And the disruption of microalgal cell walls was primarily attributed to the breakage of β-glucosidic linkages in cellulose and hemicellulose. The study showed a promising approach can lead to an improvement in the lipid extraction yield from microalgae and further provide valuable information for the use of enzymes in microalgal processes.

Antialgal compounds with antialgal activity against the common red tide microalgae from a green algae Ulva pertusa.

Fecha de Publicación: 15 August 2018
Fuente: Ecotoxicology and Environmental Safety, Volume 157
Autores: Ying-ying Sun, Wen-jing Zhou, Hui Wang, Gan-lin Guo, Zhen-xia Su, Yin-fang Pu

Abstract

Nine antialgal active compounds, (i.e. trehalose (1), twenty-two methyl carbonate (2), (-)-dihydromenisdaurilide (3), 3,7,11,15-tetramethyl-2-hexadecen-1-ol (4), isophytol (5), 8-hexadecenol (6), 17-hydroxyheptadecanoic acid (7), trans-asarone (8) and 2-amino-3-mercaptopropanoic acid (9)) were isolated from Ulva pertusa for the first time by sephadex LH-20 column chromatography, silica gel column chromatography and repeated preparative TLC. Except for compound 4, all compounds represented novel isolated molecules from marine macroalgae. Further,

antialgal activities of these compounds against Amphidinium carterae, Heterosigma akashiwo, Karenia mikimitoi, Phaeocystis globosa, Prorocentrum donghaiense and Skeletonema costatum were investigated for the first time. Results showed these nine compounds have selectivity antialgal effects on all test red tide microalgae, and antialgal activities against red tide microalgae obviously enhanced with the increase of concentration of antialgal compounds. Based on this, EC50–96 h values of these nine compounds for six red tide microalgae were obtained for the first time. By analyzing and comparing EC50–96 h values, it has been determined that seven compounds (1, 3, 4, 6, 7, 8 and 9) showed the superior application potential than potassium dichromate or gossonorol and other six compounds as a characteristic antialgal agent against Heterosigma akashiwo, Karenia mikimitoi and Prorocentrum donghaiense. Overall this study has suggested that green algae Ulva pertusa is a new source of bioactive compounds with antialgal activity.

Tolerance of Ulothrix sp. LAFIC 010 (Chlorophyta) against high concentration of metals from acid mine drainage.

Fecha de Publicación: 15 August 2018
Fuente: Ecotoxicology and Environmental Safety, Volume 157
Autores: T.F. Massocato, J.C. Ramos, V.L.F. Bascuñan, C. Simioni, L.R. Rörig, J. Bonomi Barufi

Abstract

The production of acid mine drainage of (AMD) is one of the main phenomena responsible for much of the degradation of water and soil resources. Organisms present at sites contaminated by AMD can have the potential to bioaccumulate heavy metals, stimulating their application in bioremediation processes. Ulothrix sp. LAFIC 010 was identified among the species of algae isolated from water contaminated by AMD in the region of Sideropólis (Brazil). The present study evaluated its tolerance and bioaccumulation potential related to zinc, manganese and nickel. Experiments were performed to see the effects of different concentrations of Zn, Mn and Ni (individually and in combination) on the physiological performance of the alga. The results showed that only the cultures submitted to concentrations above 0.55 mM Zn showed a decrease in growth rate and damage to physiological processes. There was no observed effect of Mn and Ni on Ulothrix sp. LAFIC 010 physiology, even with an 8-fold increase in concentrations of these metals in the medium. In cultures with combined metals, only the treatments with the highest concentrations of Zn presented reduced growth, regardless of the presence of other metals. Additionally, we observed that Mn and Ni did not decrease the toxic effect of Zn. Mn accumulation was indicated in the cell wall and Ni in the vacuole. Our results suggest that the distribution of this alga in contaminated medium is not affected by the concentration of Ni and Mn, at least

under the pH that was evaluated. We conclude that Ulothrix sp. LAFIC 010 tolerates and grows under conditions with higher metal concentrations than previously reported for AMD.

Microalgae-mediated bioremediation and valorization of cattle wastewater previously digested in a hybrid anaerobic reactor using a photobioreactor: Comparison between batch and continuous operation.

Fecha de Publicación: 15 August 2018
Fuente: Science of The Total Environment, Volume 633
Autores: Henrique Vieira de Mendonça, Jean Pierre Henry Balbaud Ometto, Marcelo Henrique Otenio, Isabel Paula Ramos Marques, Alberto José Delgado dos Reis

Abstract

Scenedesmus obliquus (ACOI 204/07) microalgae were cultivated in cattle wastewater in vertical alveolar flat panel photobioreactors, operated in batch and continuous mode, after previous digestion in a hybrid anaerobic reactor. In batch operation, removal efficiencies ranges of 65 to 70% of COD, 98 to 99% of NH4 + and 69 to 77.5% of PO4 −3 after 12days were recorded. The corresponding figures for continuous flow were from 57 to 61% of COD, 94 to 96% of NH4 + and 65 to 70% of PO4 −3 with mean hidraulic retention time of 12days. Higher rates of CO2 fixation (327–547mgL−1 d−1) and higher biomass volumetric productivity (213–358mgL−1 d−1) were obtained in batch mode. This microalgae-mediated process can be considered promising for bioremediation and valorization of effluents produced by cattle breeding yielding a protein-rich microalgal biomass that could be eventually used as cattle feed.

Determining how polymer-bubble interactions impact algal separation using the novel “Posi”-dissolved air flotation process.

Fecha de Publicación: 7 August 2018
Fuente: Separation and Purification Technology, Volume 201
Autores: Narasinga Rao Hanumanth Rao, Anthony M. Granville, Christine I. Browne, Raymond R. Dagastine, Russell Yap, Bruce Jefferson, Rita K. Henderson

Abstract

The novel dissolved air flotation (DAF) process that uses hydrophobically-modified polymers (HMPs) to generate positively charged bubbles (PosiDAF) has been shown

to separate negatively charged algal cells without the need for coagulation-flocculation. Previous research has been limited to HMPs of poly(N,N-dimethylaminoethyl methacrylate) (PDMAEMA) and, while they were effective at bench-scale, performance at pilot-scale was better using commercial poly(N,N-diallyl-N,N-dimethylammonium chloride) (PDADMAC). Hence, the aim of this research was to compare the effectiveness of PDADMAC modified with aliphatic and aromatic moieties in comparison to previously tested PDMAEMA HMPs in respect to algal cell separation and minimisation of effluent polymer concentration, as well as defining the underlying polymer-bubble interaction mechanisms. Polymer-bubble adhesion properties were measured using atomic force microscopy (AFM) while polymer concentration was monitored via zeta potential and, where possible, assays using fluorescence spectroscopy. Both PDADMAC functionalised with a fluorinated aromatic group (PDADMAC-BCF) and PDMAEMA modified with 1-bromodecane respectively, gave effective cell separation, while the treated effluent zeta potential values at maximum cell removal were lower than the other polymers trialled. The effluent polymer concentration when using PDADMAC-BCF was four times lower in comparison to another aromatically modified PDADMAC polymer. AFM studies indicated that, in contrast to the PDMAEMA-based polymers, the PDADMAC-based polymers did not adsorb closely to the bubble surface. The different polymer-bubble interactions indicate that separation mechanisms will also vary, potentially leading to differences in process effectiveness when explored at pilot scale.

Removal of pharmaceuticals in urban wastewater: High rate algae pond (HRAP) based technologies as an alternative to activated sludge based processes.

Fecha de Publicación: 1 August 2018
Fuente: Water Research, Volume 139
Autores: Elena Villar-Navarro, Rosa M. Baena-Nogueras, Maria Paniw, José A. Perales, Pablo A. Lara-Martín

Abstract

Microalgae biotechnology is a promising tool for many applications, including the elimination of nutrients and other contaminants from wastewater. In this work, we measured the removal efficiency of two wastewater treatment processes: an activated-sludge based conventional process and another based on microalgae biotechnology using high-rate algae ponds (HRAPs). The latter was tested using two different configurations. In the first one, HRAPs were placed after an UASB reactor and used as a tertiary treatment to remove nutrients. In the second, the UASB reactor was disconnected so the HRAPs were directly fed with pretreated wastewater. Additional treatment was performed using dissolved air flotation (DAF). The performances of both configurations (UASB-HRAP and HRAP-DAF) were

compared to that of the conventional line including primary and secondary biological treatments and operating in parallel within the same wastewater treatment plant (WWTP). Sixty-four out of 81 target PhACs were detected in the influent of the WWTP, at an average concentration of 223 µg L−1, whereas 55 and 54 were measured in the conventional (14 µg L−1) and non-conventional (17 µg L−1) effluents. Average removal efficiencies were similar (94 vs. 92%) for both treatment lines when comparing total PhACs concentrations. The compositional patterns of the resulting effluents, however, were not, suggesting the occurrence of differential removal mechanisms depending on the chemicals and wastewater treatments considered. Highly consumed compounds such as ibuprofen and acetaminophen were predominant in the non-conventional effluent (>1 µg L−1), denoting lower removal than in the conventional line. On the other hand, elimination of diclofenac and some specific antibiotics and diuretics (e.g., hydrochlorothiazide) was between 15 and 50% higher using HRAPs. Overall, the efficiency of the microalgae technology removing PhACs was found to be comparable to that used in conventional WWTPs. This, combined with a higher efficiency removing nutrients, shows the potential of HRAP technology for wastewater treatment as an alternative (or addition as tertiary treatment) to more conventional approaches based on activated sludge.

Environmental concentrations of pharmaceuticals directly affect phytoplankton and effects propagate through trophic interactions.

Fecha de Publicación: 30 July 2018
Fuente: Ecotoxicology and Environmental Safety, Volume 156
Autores: Malgorzata Grzesiuk, Elly Spijkerman, Sabrina C. Lachmann, Alexander Wacker

Abstract

Pharmaceuticals are found in freshwater ecosystems where even low concentrations in the range of ng L−1 may affect aquatic organisms. In the current study, we investigated the effects of chronic exposure to three pharmaceuticals on two microalgae, a potential modulation of the effects by additional inorganic phosphorus (Pi) limitation, and a potential propagation of the pharmaceuticals' effect across a trophic interaction. The latter considers that pharmaceuticals are bioaccumulated by algae, potentially metabolized into more (or less) toxic derivates and consequently consumed by zooplankton. We cultured Acutodesmus obliquus and Nannochloropsis limnetica in Pi-replete and Pi-limited medium contaminated with one of three commonly human used pharmaceuticals: fluoxetine, ibuprofen, and propranolol. Secondly, we tested to what extent first level consumers (Daphnia magna) were affected when fed with pharmaceutical-grown algae. Chronic exposure, covering 30 generations, led to (i) decreased cell numbers of A. obliquus in the presence of fluoxetine (under Pi-replete conditions) (ii) increased carotenoid to chlorophyll ratios

in N. limnetica (under Pi-limited conditions), and (iii) increased photosynthetic yields in A. obliquus (in both Pi-conditions). In addition, ibuprofen affected both algae and their consumer: Feeding ibuprofen-contaminated algae to Pi-stressed D. magna improved their survival. We demonstrate, that even very low concentrations of pharmaceuticals present in freshwater ecosystems can significantly affect aquatic organisms when chronically exposed. Our study indicates that pharmaceutical effects can cross trophic levels and travel up the food chain.

A novel symbiotic system combining algae and sludge membrane bioreactor technology for wastewater treatment and membrane fouling mitigation: Performance and mechanism.

Fecha de Publicación: 15 July 2018
Fuente: Chemical Engineering Journal, Volume 344
Autores: Li Sun, Yu Tian, Jun Zhang, Hao Cui, Wei Zuo, Jianzheng Li

Abstract

A novel Algal-Sludge Bacterial-Membrane bioreactor (ASB-MBR) system, which combined a sludge membrane bioreactor and an algal system in a single tank, was developed in this study. The combined system exhibited excellent wastewater treatment performance, sludge flocs properties and membrane permeability. Compared with conventional MBR (C-MBR), ASB-MBR showed 25% faster growth rate. Meantime, the removal efficiencies of chemical oxygen demand (COD), ammonia nitrogen (NH4 +-N), total nitrogen (TN) and phosphate (PO4 3−-P) in ASB-MBR were increased by 4.6%, 6.7%, 10.1% and 8.2%, respectively. Amelioration of microbial activity and the increase of dissolved oxygen (DO) concentration were identified as the main reasons for better COD and nitrogen removal, while algal great assimilation and “luxury” uptake of phosphorus and high mixed liquor suspended solids (MLSS) removal contributed to higher PO4 3−-P removal in ASB-MBR. Moreover, the membrane fouling was mitigated by 50% after inoculating algae. Further mechanism investigation demonstrated that algae has a positive influence on the inhibition of the filamentous bacteria overgrowth and the decrease of zeta potential absolute value, thus improved the flocs flocculability and stability in ASB-MBR. ASB-MBR exhibited higher SMPpr/SMPps ratio, lower bound extracellular polymeric substances (bound EPS) concentrations and smaller Pr/Ps ratio in bound EPS, which contributed to improve the flocs filterability and decrease the fouling layer accumulation. Deposited by this modified sludge, the flocs morphology of the bio-cake in ASB-MBR was more regular and less easy to accumulate on membrane surface resulted in higher membrane permeability.

Cultivation of microalgal biomass using swine manure for biohydrogen production: Impact of dilution ratio and pretreatment.

Fecha de Publicación: July 2018
Fuente: Bioresource Technology, Volume 260
Autores: Gopalakrishnan Kumar, Dinh Duc Nguyen, Periyasamy Sivagurunathan, Takuro Kobayashi, Kaiqin Xu, Soon Woong Chang

Abstract

This study assessed the impact of swine manure (SM) dilution ratio on the microalgal biomass cultivation and further tested for biohydrogen production efficiency from the mixed microalgal biomass. At first, various solid/liquid (S/L) ratio of the SM ranged from 2.5 to 10 g/L was prepared as a nutrient medium for the algal biomass cultivation without addition of the external nutrient sources over a period of 18 d. The peak biomass concentration of 2.57 ± 0.03 g/L was obtained under the initial S/L loading rates of 5 g/L. Further, the cultivated biomass was subjected to two-step (ultrasonication + enzymatic) pretreatment and evaluated for biohydrogen production potential. Results showed that the variable amount of hydrogen production was observed with different S/L ratio of the SM. The peak hydrogen yield of 116 ± 6 mL/g TSadded was observed at the 5 g/L grown SM mixed algal biomass.

Conversion of stranded waste-stream carbon and nutrients into value-added products via metabolically coupled binary heterotroph-photoautotroph system.

Fecha de Publicación: July 2018
Fuente: Bioresource Technology, Volume 260
Autores: Pavlo Bohutskyi, Leo A. Kucek, Eric Hill, Grigoriy E. Pinchuk, Sagadevan G. Mundree, Alexander S. Beliaev

Abstract

Growth of heterotrophic bacterium Bacillus subtilis was metabolically coupled with the photosynthetic activity of an astaxanthin-producing alga Haematococcus pluvialis for conversion of starch-containing waste stream into carotenoid-enriched biomass. The H. pluvialis accounted for 63% of the produced co-culture biomass of 2.2 g/L. Importantly, the binary system requires neither exogenous supply of gaseous substrates nor application of energy-intensive mass transfer technologies due to in-situ exchange in CO2 and O2. The maximum reduction in COD, total nitrogen and phosphorus reached 65%, 55% and 30%, respectively. Conducted techno-economic assessment suggested that the astaxanthin-rich biomass may

potentially offset the costs of waste treatment, and, with specific productivity enhancements (induction of astaxanthin to 2% and increase H. pluvialis fraction to 80%), provide and additional revenue stream. The outcome of this study demonstrates a successful proof-of-principle for conversion of waste carbon and nutrients into value-added products through metabolic coupling of heterotrophic and phototrophic metabolisms.

PATENTES

MICROALGAE-BASED COMPOSITION, AND METHODS OF ITS PREPARATION AND APPLICATION TO PLANTS09:00 21/12/2017, SHINDE SANDIP [US]; CARNEY LAURA [US] (9)

Page bookmark	WO2017218896 (A1) - MICROALGAE-BASED COMPOSITION, AND METHODS OF ITS PREPARATION AND APPLICATION TO PLANTS
Inventor(s):	SHINDE SANDIP [US]; CARNEY LAURA [US]; TABERNA ENEKO GANUZA [US]; CIZEK LUKE [US]; HANSEN JON [US]; CHELLAPPAN GANAPATHY [US]; BENNETT BRADEN [US]; SORENSEN KRISTINE [US]; VENTRE STEPHEN [US]; DONOWITZ NICHOLAS ADAM [US]; ROHLFSEN MICHAEL CLINT [US] + (SHINDE, Sandip, ; CARNEY, Laura, ; TABERNA, Eneko Ganuza, ; CIZEK, Luke, ; HANSEN, Jon, ; CHELLAPPAN, Ganapathy, ; BENNETT, Braden, ; SORENSEN, Kristine, ; VENTRE, Stephen, ; DONOWITZ, Nicholas Adam, ; ROHLFSEN, Michael Clint)
Applicant(s):	HELIAE DEV LLC [US] + (HELIAE DEVELOPMENT, LLC)
Application number:	WO2017US37878 20170616 Global Dossier
Priority number(s):	US201662350929P 20160616 ; US201662376440P 20160818

A liquid phototrophic, mixotrophic, or heterotropic microalgae-based composition and methods preparing a liquid microalgae-based composition that can include pasteurization and stabilization of a low concentration of microalgae whole cells that have not been subjected to a drying process are disclosed. The liquid composition can be used to enhance the emergence and growth of plants in low concentration and low frequency soil and foliar applications.

Apparatus for harvesting microalgae09:00 27/11/2017, JEONG SANG HYEON [KR]; SHIM SUNG HOON [KR],

Page bookmark	KR101801534 (B1) - Apparatus for harvesting microalgae
Inventor(s):	JEONG SANG HYEON [KR]; SHIM SUNG HOON [KR] + (정상현, ; 심성훈)
Applicant(s):	KOREA INST MACH & MATERIALS [KR] + (한국기계연구원)
Application number:	KR20160149178 20161110 Global Dossier
Priority number(s):	KR20160149178 20161110

The present invention relates to a microalgae collecting device. The device comprises: a cathodic electrode formed into a tube shape of which both ends are closed, and including an algal water inlet taking water containing microalgae, an algal aggregate outlet discharging algal aggregates, and a purified water outlet discharging purified water after the removal of the microalgae; an anodic electrode having both sides combined with the cathodic electrode to be rotatable, and installed in the cathodic electrode at a distance from the cathodic electrode; a screw combined with the outer surface of the anodic electrode at a distance from the inner surface of the cathodic electrode, and formed as a nonconductor; and a filter combined with the cathodic electrode by being located between the algal aggregate outlet and the purified water outlet, and made of a porous material to filter the algal aggregates while letting the water go. As such, the present invention is capable of effectively condensing and floating microalgae in algal water and effectively collecting the condensed and floated microalgae, thereby achieving high efficiency of microalgae collection through the consecutive processes.

Heterotrophic culture method for microalgae by utilizing starch and immobilized microorganism co-culture09:00 17/10/2017, WANG SHIKAI; WANG XU (3),

Page bookmark	CN107254413 (A) - Heterotrophic culture method for microalgae by utilizing starch and immobilized microorganism co-culture
Inventor(s):	WANG SHIKAI; WANG XU; TAO HUIHUI; SUN XIANGSHENG; TIAN YONGTING + (王仕楷, ; 汪旭, ; 陶慧慧, ; 孙祥圣, ; 田永婷)
Applicant(s):	UNIV YANGZHOU + (扬州大学)
Application number:	CN20171702856 20170816 Global Dossier

Priority number(s):	CN20171702856 20170816

The invention belongs to the biotechnology field and in particular relates to a heterotrophic culture method for microalgae by utilizing starch and immobilized microorganism co-culture. The method comprises the following steps: preparing a culture medium, inoculating, immobilizing microorganism cells, culturing, and collecting cells. The method provided by the invention has the main characteristics that co-culture is carried out on the microalgae and immobilized microorganisms with starch hydrolysis capability, the problem that the microalgae is difficult to be subjected to heterotrophic culture by utilizing a low-cost starch type raw material is solved, a new approach is provided for reducing carbon source cost of the heterotrophic culture of the microalgae, pure culture of the microalgae is realized by immobilizing co-culture microorganisms, and compared with the conventional co-culture technology, algae-bacteria separation is realized by virtue of simple filtration and purely cultured microalgae cells can be obtained finally, so that the method provided by the invention can be widely applicable to a production process of various algae-based biological products.

Method using pulsed electric field to assist extraction of oil from microalgae09:00 13/10/2017, JIN WENBIAO; HAN SONGFANG (2),

Page bookmark	CN107245371 (A) - Method using pulsed electric field to assist extraction of oil from microalgae
Inventor(s):	JIN WENBIAO; HAN SONGFANG; YANG QIAN; TU RENJIE + (金文标, ; 韩松芳, ; 杨倩, ; 涂仁杰)
Applicant(s):	HARBIN INST TECHNOLOGY SHENZHEN GRADUATE SCHOOL + (哈尔滨工业大学深圳研究生院)
Application number:	CN20171358924 20170519 Global Dossier
Priority number(s):	CN20171358924 20170519

The invention relates to a method using a pulsed electric field to assist the extraction of oil from microalgae. The method comprises the following steps: 1, breaking walls: pumping a certain concentration of a microalga solution into the pulsed electric field, and carrying out wall breaking treatment; 2, centrifuging: centrifuging the wall-broken microalga solution obtained in step 1; 3, extracting: taking alga mud obtained in step 2, adding an extraction solvent to the alga mud, and carrying out an

extraction reaction for 0.5-30 h; and 4, leaching: adding distilled water to a product obtained in step 3, taking an oil-containing organic phase, completely volatilizing the organic component, and drying the obtained organic phase to obtain crude oil. Microalga cells with the walls being broken by the pulsed electric field have the advantages of high broken wall efficiency, low cost and industrialization realization; and the low toxicity solvent substitutes traditional high toxicity chloroform/methanol, so the extraction efficiency is guaranteed, the extraction process is environmentally-friendly, and the method has a good industrial prospect in the extraction of the microalga oil.

Method for avoiding microalgae photoinhibition and improving astaxanthin yield09:00 22/09/2017, LI YUANGUANG; WAN MINXI (4),

Page bookmark	CN107189946 (A) - Method for avoiding microalgae photoinhibition and improving astaxanthin yield
Inventor(s):	LI YUANGUANG; WAN MINXI; ZHANG ZHEN; HUANG JIANKE; FAN FEI; WANG JUN + (李元广, ; 万民熙, ; 章真, ; 黄建科, ; 樊飞, ; 王军)
Applicant(s):	YUNNAN SHANGRI-LA ZEYUAN ALGAE INDUSTRY HEALTH TECH CO LTD; JIAXING ZEYUAN BIOLOGICAL PRODUCTS CO LTD + (云南香格里拉泽元藻业健康科技有限公司, ; 嘉兴泽元生物制品有限责任公司)
Application number:	CN20161147296 20160315 Global Dossier
Priority number(s):	CN20161147296 20160315

The invention relates to a new method for avoiding microalgae photoinhibition and improving astaxanthin yield in the culture process of microalgae. In general, a two-stage method is adopted to cultivate the microalgae to produce astaxanthin, wherein on the first stage, massive reproduction of cells and accumulation of biomass are achieved in a heterotrophic, autotrophic or mixotrophic culture mode, and on the second stage, accumulation of the astaxanthin in the cells are achieved in methods, such as light stress assisted with nutrition stress. However, when the microalgae is transformed from the firsts stage to the second stage, phenomenons, such as light stress usually occur, and accordingly the astaxanthin yield is seriously influenced. Therefore, multiple methods are adopted to control culture conditions in a transformation process, such as medium components controlling, sunshading, weak light transition, initial inoculated density improving, gradual dilution and outdoor inoculated time adjusting so that cell conditions can be adjusted and the cells can improve the ability to resist a strong light; therefore, thelight stress problem of the microalgae under the strong light is solved completely, the efficiency of the microalgae for producing the astaxanthin is improved greatly, and low cost,

high efficiency and large-scale cultivation of the microalgae for producing the astaxanthin are achieved.

Collaborative pyrolysis process method of oily sludge and microalgae biomass09:00 01/09/2017, GONG ZHIQIANG; DU AIXUN (6),

Page bookmark	CN107117787 (A) - Collaborative pyrolysis process method of oily sludge and microalgae biomass
Inventor(s):	GONG ZHIQIANG; DU AIXUN; WANG ZHENBO; SUN ZHIQIAN; JIANG WENCHUN; LI QIANG; LIU ZHAOZENG; ZHU LIYUN + (巩志强, ; 杜爱勋, ; 王振波, ; 孙治谦, ; 蒋文春, ; 李强, ; 刘兆增, ; 朱丽云)
Applicant(s):	UNIV CHINA PETROLEUM + (中国石油大学（华东）)
Application number:	CN20171549840 20170707 Global Dossier
Priority number(s):	CN20171549840 20170707

The invention discloses a collaborative pyrolysis process method of oily sludge and microalgae biomass and belongs to the technical field of oily sludge recycling. The process method comprises the steps as follows: 1) oily sludge is dehydrated preliminarily and the moisture content is reduced to 20%-40%; 2) the oily sludge and microalgae biomass are uniformly mixed in an agitator in a certain mass ratio; 3) the mixed oily sludge is sent to a dryer to be dried and dehydrated preliminarily for 6 h; 4) the dried oily sludge is sent into a pyrolysis reactor for a pyrolysis reaction, a product is pyrolysis gas, pyrolysis oil and pyrolysis coke; 5) the pyrolysis gas is sent to a condensing device through a thermal insulation pipeline, and an oil product and combustible gas are collected. Compared with the prior art, the process method has the advantages that collaborative pyrolysis is performed on the oily sludge and the microalgae biomass, the granular shape of the oily sludge is improved, the resource recovery rate is increased under the collaborative effect, the pyrolysis reaction resistance is reduced, and the reduction, recycling and harmless treatment purposes are achieved.

DUNALIELLA SP BIOMASS PRODUCTION METHOD FOR OBTAINING FOOD WITH ANTIOXIDANT PROPERTIES.09:00 08/03/2017, JOSE ANTONIO LOPEZ ELIAS [MX],

Page bookmark	MX2015013954 (A) - DUNALIELLA SP BIOMASS PRODUCTION METHOD FOR OBTAINING FOOD WITH ANTIOXIDANT PROPERTIES.
Inventor(s):	JOSE ANTONIO LOPEZ ELIAS [MX] + (JOSE ANTONIO LOPEZ ELIAS)
Applicant(s):	UNIV DE SONORA [MX] + (UNIVERSIDAD DE SONORA)
Application number:	MX20150013954 20150909
Priority number(s):	MX20150013954 20150909

The invention consists of Dunaliella sp biomass producing method to obtain antioxidant and immunostimulating food properties for different marine organisms, mainly shrimps. The method comprises the massive production of microalgae, which particularly in this case consist of culturing this organism in 20 L jars under controlled conditions in a laboratory. It is a key process to decrease the nutrient concentration, thereby increasing the production of carotenoids (antioxidant compound). Subsequently, the biomass is concentrated by applying a chemical compound for its flocculation, adding sea water, eliminating salts, and packing and freezing the biomass (in this process, cryo-preservatives can be added to increase shelf life). Finally, a drying process is carried out by lyophilization of the microalgae paste and the preparation of a feed composition for shrimps, including the microalgae paste.

Method for performing heterotrophic cultivation on microalgae by chicken excrement degradation liquid09:00 22/02/2017, LIANG GUOBIN; WANG BIN (1),

Page bookmark	CN106434355 (A) - Method for performing heterotrophic cultivation on microalgae by chicken excrement degradation liquid
Inventor(s):	LIANG GUOBIN; WANG BIN; LIU WEIPING + (梁国斌, ; 汪斌, ; 刘维平)
Applicant(s):	UNIV JIANGSU TECHNOLOGY + (江苏理工学院)
Application number:	CN201611136286 20140730 Global Dossier
Priority number(s):	CN201611136286 20140730 ; CN20141366807 20140730
Also published	CN104152356 (A) CN104152356 (B)

as:

The invention discloses a method for performing heterotrophic cultivation on microalgae by chicken excrement degradation liquid. The method comprises the following steps: degrading a chicken excrement diluent at a rotating speed of 40 rpm to 60 rpm to obtain low-nitrogen degradation liquid and degrading another chicken excrement diluent at a rotating speed of 240 rpm to 260 rpm to obtain high-nitrogen degradation liquid; and inoculating microalgae liquid which is cultivated on a shaker into a cultivation tank, performing heterotrophic cultivation on the microalgae for 180 to 220 hours to finish heterotrophic cultivation of the microalgae, wherein in the heterotrophic cultivation process, the high-nitrogen degradation liquid is added into a cultivation system at the earlier stage and the low-nitrogen degradation liquid is added in the cultivation system at the later stage. In the whole microalgae cultivation process, the chicken excrement high-nitrogen degradation liquid and the chicken excrement low-nitrogen degradation liquid are directly added into the cultivation liquid and an additional nitrogen source is not needed, so the whole process is high in efficiency, energy sources are saved and the cost is lowered.

Hyphae pellet mediated fast microalga harvesting method09:00 25/01/2017, ZHOU WENGUANG; LI JINGJING (2),

Page bookmark	CN106350455 (A) - Hyphae pellet mediated fast microalga harvesting method
Inventor(s):	ZHOU WENGUANG; LI JINGJING; LI JUN; CHEN JIE + (周文广, ; 李晶晶, ; 黎俊, ; 陈杰)
Applicant(s):	UNIV NANCHANG + (南昌大学)
Application number:	CN20161827066 20160918 Global Dossier
Priority number(s):	CN20161827066 20160918

The invention discloses a hyphae pellet mediated fast microalga harvesting method, including steps of (1) transferring microalgae; (2) culturing the microalgae under high density; (3) culturing balling fungal spore; (4) forming and culturing mycelium pellets; (5) transferring the mycelium pellets to microalga culture solution; (6) culturing the mycelium pellets during the microalga absorbing process; (7) harvesting the mycelium pellets of the microalgae by filtering. Through introducing the balling hyphae pellets into the microalga culture solution to be harvested and mixing and culturing, rapidly absorbing microalgae by mycelium pellets can be realized; finally, the mycelium pellets of microalgae can be harvested through simple filtering method.

Preparation method for edible fungus/selenium-rich microalgae complex09:00 25/05/2016, RUAN RONGSHENG; LUO SHANSHAN (1),

Page bookmark	CN105602858 (A) - Preparation method for edible fungus/selenium-rich microalgae complex
Inventor(s):	RUAN RONGSHENG; LUO SHANSHAN; LIU YUHUAN + (RUAN RONGSHENG, ; LUO SHANSHAN, ; LIU YUHUAN)
Applicant(s):	UNIV NANCHANG + (NANCHANG UNIVERSITY)
Application number:	CN2016111845 20160111 Global Dossier
Priority number(s):	CN2016111845 20160111

A preparation method for an edible fungus/selenium-rich microalgae complex comprises the steps that edible fungi are cultured into fungus balls with the diameter of 2-60 mm; 5-100 mg of sodium selenite is added into each liter of microalgae solution; distilled water is added into the microalgae solution, the concentration of microalgae is regulated to 0.1-5 g/L; diluted hydrochloric acid is added into the microalgae solution, and the pH value is regulated to 1-6; the edible fungus balls are added into the microalgae solution after being simply broken and then stirred for 30 minutes to form the edible fungus/microalgae complex; the formed edible fungus/selenium-rich microalgae complex is filtered through a simple screen, harvested, frozen and dried. The edible fungus/selenium-rich microalgae complex has the advantages that microalgae is fully absorbed; follow-up filtering and harvesting are simple and easy to operate; in the harvesting process, environment friendliness is achieved, and cost is moderate; external ions are not introduced, so that deep value-added processing is facilitated; the strain range is wide, the harvesting speed is high, operation is convenient and easy, and cost is low; the purpose of adjusting nutritional ingredients can be achieved conveniently by adjusting the ratio of the fungi to the microalgae.

HARVESTING ALGAE FROM WATER09:00 08/10/2015, LANGER TIMOTHY J [US]; MATSUMOTO SHINSYU [US] (1),

Page bookmark	US2015284673 (A1) - HARVESTING ALGAE FROM WATER
Inventor(s):	LANGER TIMOTHY J [US]; MATSUMOTO SHINSYU [US]; ARAVANIS ALEX M [US] + (LANGER TIMOTHY J, ; MATSUMOTO SHINSYU, ; ARAVANIS ALEX M)
Applicant(s):	SAPPHIRE ENERGY INC [US] + (SAPPHIRE ENERGY, INC)
Application number:	US201314649524 20131125 Global Dossier

Priority number(s): US201314649524 20131125 ; US201261736939P 20121213 ; WO2013US71633 20131125

Also published as: WO2014092993 (A1)

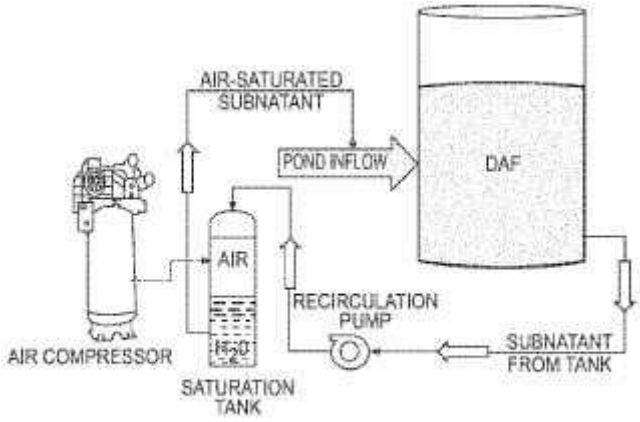


FIG. 1

The present application includes methods to harvest a non-vascular photosynthetic organism (NVPO) such as microalgae from an aqueous culture comprising brackish, non-brackish, marine, sea or saline water using polymer flocculants. The methods are suitable for harvesting NVPO from aqueous culture with total dissovled solids (TDS) of at least 1500 mg/L. Methods are also provided to harvest a NVPO using flocculation with or without a Dissolved Air Flotation (DAF) process. Methods are further provided to flocculate and harvest a NVPO directly in a pond. The present application further provides NVPO-containing intermediates, compositions, or products produced by the methods provided herein.

AQUATIC BASED MICROALGAE PRODUCTION APPARATUS09:00 17/07/2015, REDFORD DANIEL S [US],

Page bookmark IN2524MUN2014 (A) - AQUATIC BASED MICROALGAE PRODUCTION APPARATUS

Inventor(s): REDFORD DANIEL S [US] + (REDFORD DANIEL S)

Applicant(s): REDFORD DANIEL S [US] + (REDFORD DANIEL S)

Application number: IN2014MUMNP2524 20141211

Priority number(s): US201213473886 20120517 ; WO2012US42313 20120613

Also published as: JP2015521042 (A)

An aquatic based algae production apparatus employing a microalgae production support assembly and a cluster of six floating closed loop flatbed C02/02 gas permeable photobioreactors for microalgae industrial production are disclosed. The apparatus s bioreactors are submerged in the proximity of the water surface mark for maximum light exposure and for C02/02 continual diffusion. A microalgae processing and control assembly monitors the algae growth for each photo bioreactor in the cluster and cyclically harvests the microalgae. The microalgae are transferred into a submerged variable volume storage tank. Solar photovoltaic panels supply the energy required for the operation of the apparatus. Swivel electrical propellers attached to the bottom of the apparatus protective outer barrier control the apparatus s water deployment.

Method and culture device for coupling biogas fermentation with microalgae culture09:00 08/07/2015, JIA QIKUN; XIANG WENZHOU (2),

Page bookmark	CN104762331 (A) - Method and culture device for coupling biogas fermentation with microalgae culture
Inventor(s):	JIA QIKUN; XIANG WENZHOU; LI TAO; WU HUALIAN + (JIA QIKUN, ; XIANG WENZHOU, ; LI TAO, ; WU HUALIAN)
Applicant(s):	SOUTH CHINA SEA INST OCEANOLOG + (SOUTH CHINA SEA INSTITUTE OF OCEANOLOGY, CHINESE ACADEMY OF SCIENCES)
Application number:	CN20151148577 20150331 Global Dossier
Priority number(s):	CN20151148577 20150331

The invention discloses a method and a culture device for coupling biogas fermentation with microalgae culture. The method comprises the following steps: carrying out biogas fermentation to obtain biogas and biogas slurry; filtering the biogas slurry to remove solid granules, diluting the biogas slurry to serve as a microalgae culture medium, filling the diluted biogas slurry in a microalgae culture reactor to serve as the microalgae culture medium, filling the bottom of the microalgae culture solution in the microalgae culture reactor with biogas to serve as a carbon source, culturing under a light condition, and drying and removing water vapor from the biogas flowing out from the microalgae culture reactor for use; when harvesting the microalgae, dewatering to obtain microalgae sludge and culture solution, extracting biolipid, phycocyanin and other products with high added values from the microalgae sludge, and carrying out biogas fermentation on the residual microalgae residues and the culture solution in a biogas digester as biogas fermentation materials. The entire process of the method disclosed by the invention is driven by the solar energy, and carbon, nitrogen, phosphorus and other

microelements are recycled, thereby satisfying the requirements of green energy source and sustainable development.

AUTOMATIC SYSTEM FOR HARVESTING AND DRYING MICROALGAE09:00 15/06/2015, SONG JOON YONG [KR],

Page bookmark	KR20150065286 (A) - AUTOMATIC SYSTEM FOR HARVESTING AND DRYING MICROALGAE
Inventor(s):	SONG JOON YONG [KR] + (SONG, JOON YONG)
Applicant(s):	HYUNDAI MOTOR CO LTD [KR] + (HYUNDAI MOTOR COMPANY)
Application number:	KR20130150420 20131205 Global Dossier
Priority number(s):	KR20130150420 20131205
Also published as:	KR101550992 (B1)

The present invention relates to a system for producing microalgae in a dried biomass form by using hollow fiber membranes and near infrared ray, which is allowed to decrease moisture retention with use of membrane filter methods and maximizes effects of decreasing moisture retention by using near infrared ray while consecutively performing a microalgae collecting process and a microalgae drying process, thereby consecutively mass-producing good quality of dried biomass quickly.

PROCESS FOR CONTINUOUSLY GROWING MICROALGAE IN AUTOTROPHIC - MIXOTROPHIC CYCLE, WITH WATER AND NUTRIENT RECYCLING09:00 29/05/2015, OANCEA FLORIN [RO]; VELEA SANDA [RO] (2),

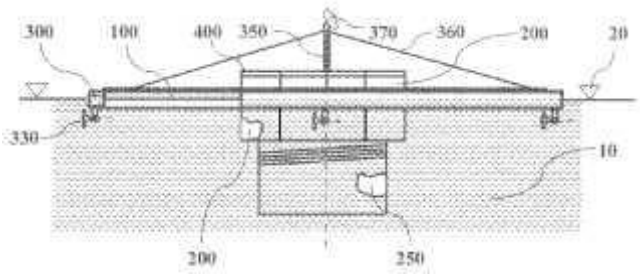
Page bookmark	RO130238 (A0) - PROCESS FOR CONTINUOUSLY GROWING MICROALGAE IN AUTOTROPHIC - MIXOTROPHIC CYCLE, WITH WATER AND NUTRIENT RECYCLING
Inventor(s):	OANCEA FLORIN [RO]; VELEA SANDA [RO]; STEPAN EMIL [RO]; ILIE LUCIA [RO] + (OANCEA FLORIN, ; VELEA SANDA, ; STEPAN EMIL, ; ILIE LUCIA)
Applicant(s):	INST NAŢIONAL DE CERCETARE DEZVOLTARE PENTRU CHIMIE ŞI PETROCHIMIE ICECHIM [RO] + (INSTITUTUL NAŢIONAL DE CERCETARE-DEZVOLTARE PENTRU CHIMIE ŞI PETROCHIMIE - ICECHIM)

Application number:	RO20140000330 20140430
Priority number(s):	RO20140000330 20140430

The invention relates to a process for continuously growing algae while obtaining a biofuel, biocarbon and an algal extract with complex effects on crop plants. According to the invention, the process consists in continuously growing microalgae in a system comprising two cascade-operating photo-bio-reactors, in autotrophic - mixotrophic cycle, separating the grown algal biomass from the growth media by electro-flocculation and flotation, extraction of lipids which are further subjected to transesterification into biofuel, the recovered liquid medium being then mixed with the recovered raw glycerine and the autotrophic biomass hydrolysates, resulting in a mixture to be used in the mixotrophic culture of algae, wherefrom the enzymatic hydrolysis-resistant biomass is converted into biocarbon to be used in the purification of the recovered liquid medium which is further completed with mineral nutrients and used in the process, in the end, an enzymatic extract with complex effects on crop plants being obtained from the mixotrophic biomass.

Aquatic-based microalgae production apparatus09:00 04/02/2015, REDFORD DANIEL S,

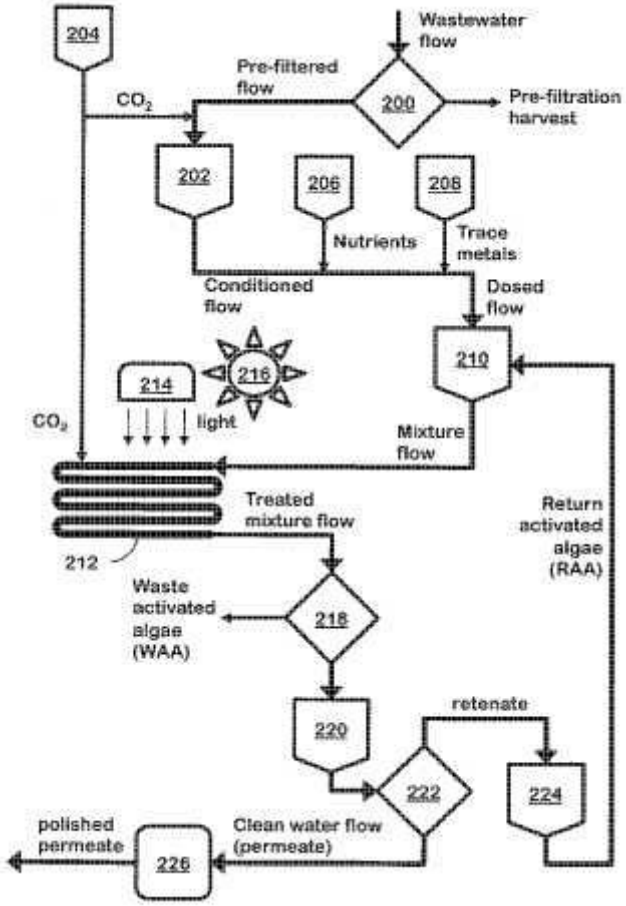
Page bookmark	CN104334715 (A) - Aquatic-based microalgae production apparatus
Inventor(s):	REDFORD DANIEL S + (REDFORD DANIEL S)
Applicant(s):	REDFORD DANIEL S + (REDFORD DANIEL S)
Application number:	CN2012873499 20120613 Global Dossier
Priority number(s):	WO2012US42313 20120613 ; US201213473886 20120517 ; US201161571107P 20110621
Also published as:	KR20150013783 (A) RU2014145084 (A) RU2610672 (C2) US2012329147 (A1) US8409852 (B2) more



An aquatic-based algae production apparatus employing a microalgae production support assembly (30) and a cluster of six floating, closed loop, flatbed, CO2/O2 gas-permeable, photo- bioreactors, offering an economical solution for microalgae industrial production. The apparatus's bioreactors are submerged in the proximity of the water surface mark (20) for maximum light exposure and for CO2/O2 continue diffusion. A microalgae processing and control assembly (200) is monitoring the algae growth for each photo-bioreactor in the cluster, and is cyclically harvesting the microalgae. After harvesting the microalgae are transferred into a submerged variable-volume microalgae storage tank (250). Solar photovoltaic panels (400) and (500) are supplying the energy required for the operation of the apparatus. Swivel electrical propellers (330) attached to the bottom of the apparatus protective outer barrier (300) are controlling the apparatus's water deployment.

Advanced Biologic Water Treatment Using Algae09:00 23/05/2013, MCGOWAN MICHAEL W [US]; JOHNSON RICKY L [US] (4),

Page bookmark	US2013126425 (A1) - Advanced Biologic Water Treatment Using Algae
Inventor(s):	MCGOWAN MICHAEL W [US]; JOHNSON RICKY L [US]; ROBINSON TERRY S [US]; MCGRAW KEVIN S [US]; SYLVESTER JARED W [US]; WEIDOW JESSE D [US] + (MCGOWAN MICHAEL W, ; JOHNSON RICKY L, ; ROBINSON TERRY S, ; MCGRAW KEVIN S, ; SYLVESTER JARED W, ; WEIDOW JESSE D)
Applicant(s):	ALGEVOLVE LLC [US] + (ALGEVOLVE, LLC)
Application number:	US201213726085 20121222 Global Dossier
Priority number(s):	US201213726085 20121222 ; WO2011US01113 20110622 ; US20100398350P 20100623
Also published as:	CA2800982 (A1) CA2800982 (C) EP2585407 (A2) EP2585407 (A4) US2011266215 (A1) more



An advanced water treatment method processes a continuous flow of water in a sequence of stages including pre-filtering [200] to remove solids, conditioning [202] to adjust pH, blending [210] with a recycled dense microalgae culture, and passing the resulting mixture through an enclosed, environmentally-controlled photobioreactor [212] where nutrients, PCB's, trace metals and other pollutants and regulated compounds are taken up by the algae. The flow from the PBR is separated using cross-flow filtration [222] to produce a treated water flow and a dense microalgae flow that is recycled to the blending stage [210] upstream. Thus, whereas the algae is recycled, the water entering the system is treated by flowing sequentially through the stages of the system, without any recycling or repetition of treatment stages.

Method for processing oilfield wastewater and fixing CO2 (carbon dioxide) by using microalgae09:00 22/05/2013, ZHANG JIAN; WANG HAIFENG (4),

Page bookmark CN103112993 (A) - Method for processing oilfield wastewater and fixing CO2 (carbon dioxide) by using microalgae

Inventor(s): ZHANG JIAN; WANG HAIFENG; DING HUI; SUN GUANGLING; JIA

	JIANCHANG; ZHANG LEI + (ZHANG JIAN, ; WANG HAIFENG, ; DING HUI, ; SUN GUANGLING, ; JIA JIANCHANG, ; ZHANG LEI)
Applicant(s):	SHENGLI OILFIELD SHENGLI EXPLORATION & DESIGN RES INST CO LTD; SHANDONG SAIRUI PETROLEUM TECHNOLOGY DEV CO LTD + (SHENGLI OILFIELD SHENGLI EEXPLORATION & DESIGN RESEARCH INSTITUTE CO., LTD, ; SHANDONG SAIRUI PETROLEUM TECHNOLOGY DEVELOPMENT CO., LTD)
Application number:	CN2013137965 20130131 Global Dossier
Priority number(s):	CN2013137965 20130131
Also published as:	CN103112993 (B)

The invention provides a method for processing oilfield wastewater and fixing CO2 (carbon dioxide) by using microalgae; the method comprises the following steps of: using oilfield wastewater in which the crude oil content is lower than 10mg/L, the TOC (total organic carbon) is lower than 40mg/L and the COD (chemical oxygen demand) is lower than 100mg/L for microalgae cultivation and carbon fixing, introducing CO2 directly into the wastewater, selecting the microalgae with high stress resistance, high oil content and high function in degrading petroleum hydrocarbon according to the water quality of the oilfield wastewater introduced with the CO2, combining the large-scale cultivation of the microalgae with the wastewater treatment, building a large-scale cultivation system by using five stepped microalgae processing ponds which are connected with each other, and then adjusting the water temperature to be 20 DEG C to 35 DEG C; a silicon carbide micro-filtration membrane is used for harvesting, and 10-20% of the harvested microalgae is used as algae seed for the algae liquid cultivation of the next batch and 70-90% of the harvested microalgae is used for preparing biodiesel. The wastewater temperature which is the most proper for the growth of the algae is controlled by controlling the content of fresh wastewater, and the full-year stable and continuous running of the oilfield wastewater processing and CO2 fixing system is achieved.

Method for microcystis algae bloom treatment in earth pond cultivation process09:00 06/02/2013, ZHANG JIASONG; LI ZHUOJIA (3),

Page bookmark	CN102910743 (A) - Method for microcystis algae bloom treatment in earth pond cultivation process
Inventor(s):	ZHANG JIASONG; LI ZHUOJIA; ZHANG XIAOYANG; YANG YINGYING; WEN GUOLIANG + (ZHANG JIASONG, ; LI ZHUOJIA, ; ZHANG XIAOYANG, ; YANG YINGYING, ; WEN GUOLIANG)
Applicant(s):	SOUTH CHINA SEA FISHERIES RES + (SOUTH CHINA SEA FISHERIES

	RESEARCH INSTITUTE, CHINESE ACADEMY OF FISHERY SCIENCES)
Application number:	CN20121412182 20121025 Global Dossier
Priority number(s):	CN20121412182 20121025

The invention discloses a method for microcystis algae bloom treatment in an earth pond cultivation process. The method includes the steps: 1) when algae bloom happens, closing an automatic aerator, blowing the microcystis algae bloom to downwind positions by the aid of wind force, and using a screen to fish microcystis algae bloom frond floating on the water surface; 2) mixing bacillus inoculant with brown sugar by adding water, soaking the bacillus inoculant and the brown sugar into water for one night, then splashing the mixture into the whole pond for once a day and continuing for 2-3days; and 3) adding inoculant of photosynthetic bacteria into the mixture, splashing the mixture into the whole pond for once a day and continuing for 2-3days. Probiotics are used for absorbing and converting eutrophic substances in water and competing nutrients with microalgae so as to inhibit reproduction of microcystis algae; and bacteria in waters lyse the microcystis algae and decompose and convert microcystin timely, so that cultivation water quality stability is maintained, shrimp diseases can be effectively prevented, survival rate and yield of culture species are increased, and economic benefit is increased.

SUSTAINABLE DOUBLE-PURPOSE PROCESSES FOR TREATING AGROINDUSTRIAL WASTEWATERS AND FOR THE OBTENTION OF MICROALGAE AND PLANTS.09:00 27/01/2012, PALACIOS EUGENIA JUDITH OLGUIN [MX],

Page bookmark	MX2011006030 (A) - SUSTAINABLE DOUBLE-PURPOSE PROCESSES FOR TREATING AGROINDUSTRIAL WASTEWATERS AND FOR THE OBTENTION OF MICROALGAE AND PLANTS.
Inventor(s):	PALACIOS EUGENIA JUDITH OLGUIN [MX] + (EUGENIA JUDITH OLGUIN PALACIOS, ; EUGENIA JUDITH OLGUÍN PALACIOS)
Applicant(s):	INST DE ECOLOGIA A C [MX] + (INSTITUTO DE ECOLOGIA, A.C, ; INSTITUTO DE ECOLOGÍA, A.C.*)
Application number:	MX20110006030 20110607
Priority number(s):	MX20110006030 20110607
Also published as:	MX349967 (B)

This invention integrates sustainable double-purpose processes for treating agroindustrial wastewaters, which consists in: (a) cleaning the areas of agroindustrial production; (b) one or more devices for filtrating macrosolids; (c) one or more devices for degrading biodegradable material in the absence of oxygen, which are of horizontal flow and present: (1) one or more biogas outlets; and (2) at least one outlet for anaerobic effluents; (d) one or more devices for separating the methane and carbon dioxide contained in the biogas; (e) one or more devices for storing methane; (f) one or more conduits for incorporating carbon dioxide to the elliptic crop lagoons. (g) one or more tanks for storing and dispensing the anaerobic effluents; (h) one or more elliptic crop lagoons for producing microalgae; (i) one or more systems for recovering biomass; (j) one or more conduits for distributing the recycled water; (k) one or more lagoons packed with supports for supporting ornate aquatic emergi ng plants; and, optionally, at least a device for using the methane energy and/or at least a device for treating the wastewater of elliptic lagoon for crops and/or at least a device for extracting products of a high added value resulting from microalgae.

Photoautotrophic growth of microalgae for omega-3 fatty acid production09:00 10/07/2008, THOMAS SWATI SEBASTIAN [IN]; KUMARAVEL SWAMINATHAN [IN],

Page bookmark	US2008166779 (A1) - Photoautotrophic growth of microalgae for omega-3 fatty acid production
Inventor(s):	THOMAS SWATI SEBASTIAN [IN]; KUMARAVEL SWAMINATHAN [IN] + (THOMAS SWATI SEBASTIAN, ; KUMARAVEL SWAMINATHAN)
Applicant(s):	PARRY NUTRACEUTICALS LTD [IN] + (PARRY NUTRACEUTICALS LTD, ; PARRY NUTRACEUTICALS, DIVISION OF E.I.D. PARRY (INDIA) LTD)
Application number:	US20070651790 20070110 Global Dossier
Priority number(s):	US20070651790 20070110
Also published as:	US2012088011 (A1) US8030037 (B2) US8603488 (B2)

The invention provides methods of cultivating microalgae photoautotrophically outdoors to prepare concentrated microalgae products containing eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) docosahexaenoic acid, two long-chain polyunsaturated fatty acids found in fish oil that are very important for human and animal health. It also provides concentrated microalgae products containing EPA and DHA and purified lipid products containing EPA and DHA purified from microalgae. One embodiment provides a concentrated microalgae composition prepared by a

process comprising: (a) cultivating microalgae photoautotrophically outdoors in open ponds under filtered sunlight in continuous or batch mode at a dilution rate of less than 35% per day; (b) harvesting the microalgae in exponential phase when cell number is increasing at a rate of at least 20% of maximal rate; and (c) concentrating the microalgae; wherein at least 40% by weight of lipids in the microalgae are in the form of glycodiacylglycerides, phosphodiacylglycerides, or a combination thereof and at least 5% by weight of fatty acids are DHA, EPA, or a combination thereof.

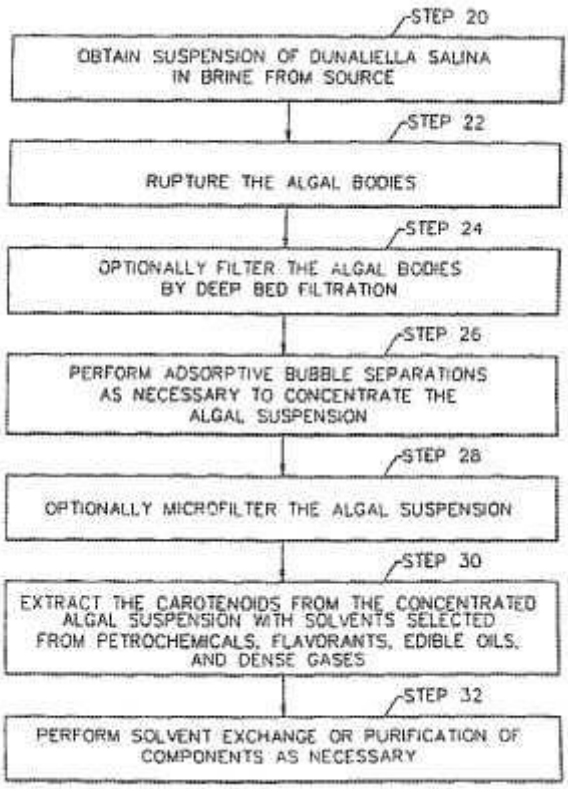
Pipeline gas raising magnetic treatment optical biological reactor microalgae breeding appts.09:00 19/05/1999, LI ZHIYONG [CN]; GUO JIYUAN [CN] (1),

Page bookmark	CN2319413 (Y) - Pipeline gas raising magnetic treatment optical biological reactor microalgae breeding appts.
Inventor(s):	LI ZHIYONG [CN]; GUO JIYUAN [CN]; LI LIN [CN] + (ZHIYONG LI, ; JIYUAN GUO, ; LIN LI)
Applicant(s):	HUANAN SCIENCE & ENGINEERING [CN] + (HUANAN SCIENCE AND ENGINEERING UNIV)
Application number:	CN1998211228U 19980119
Priority number(s):	CN1998211228U 19980119

The utility model relates to a pipeline gas raising type microalgae breeding device for a magnetic treatment photobiological reactor. The utility model is formed by jointly connecting an air pump, an air valve, an air inlet pipe, an exhaust pipe, a liquid taking pipe, a liquid draining pipe, an air filter, a gas flowmeter, a CO2 cylinder, a gas raising chamber, a magnetic processor, a liquid storing tank, a peristaltic pump, a harvesting tank, a deaerating chamber, a flux valve, a temperature sensor, a pH electrode, an O2 electrode, a charge pipe, a turbidity sensor, a partition board, a heat-exchanging device, a gas flowmeter, a fluorescent lamp, a photometric probe head, a gas descending chamber and a bubble distribution device through corresponding pipelines, the air valve, the flux valve, or connection conducting wires. The utility model has the advantages of simple structure, easy manufacture, low energy consumption and low cost, the growth velocity of the microalgae can be obviously enhanced, a content of some biochemical compositions is favorable for the high-efficiency pure culture of the microalgae, output is increased, and pollution is decreased.

FLOTATION SEPARATION METHODS AND SYSTEMS FOR DEWATERING SUSPENSIONS OF MICROALGAE AND EXTRACTING COMPONENTS THEREFROM09:00 02/07/1998, KANEL JEFFREY SCOTT; GUELCHER SCOTT ARTHUR,

Page bookmark	WO9828082 (A1) - FLOTATION SEPARATION METHODS AND SYSTEMS FOR DEWATERING SUSPENSIONS OF MICROALGAE AND EXTRACTING COMPONENTS THEREFROM
Inventor(s):	KANEL JEFFREY SCOTT; GUELCHER SCOTT ARTHUR + (KANEL, JEFFREY, SCOTT, ; GUELCHER, SCOTT, ARTHUR)
Applicant(s):	EASTMAN CHEM CO [US] + (EASTMAN CHEMICAL COMPANY)
Application number:	WO1997US22754 19971210 Global Dossier
Priority number(s):	US19960771754 19961220
Also published as:	AU6012598 (A) AU717340 (B2) IL130026 (A) JP2001509011 (A) US5951875 (A)



A process and system are disclosed for recovering mixed carotenoids from the alga Dunaliella salina. The harvested cells are ruptured, typically by circulating the algal

suspension at high pressure through a pump loop. The cells can then be dewatered by absorptive bubble separation techniques, including a froth flotation circuit that has a roughing zone and a concentrating zone. If further concentration is desired, the algal concentrate can be mechanically filtered in a cross flow microfiltration unit in the absence of flocculating agents with substantially no loss of carotenoids in the permeate. Various methods for extracting mixed carotenoids and other components from the algae are disclosed, including dense gas extraction, and extractions with natural and synthetic flavorants, and edible oils.

NOTICIAS

The Algae Agriculture Act of 2018

Legislation that would help put algae cultivation on even footing with other types of agriculture was introduced in Congress by a bipartisan group of lawmakers this month. Make sure your Congressional delegation signs on as sponsors to this important bill!

http://r20.rs6.net/tn.jsp?f=001_DGyCb6WrsTFyblLjLBoZGe2QgllJu9SyafpCv3U1P6GotiDc1vLECPUbIreBYqzKbqsATgwns5H-rAXhS9Apkpfw-M1-DZH7ui00iRocE8XmmH-woRCXgtDI2QLdxj9MA27YPhH8Ei0sX6KKUbUJThsP4PF5VNMb-8mqDEYkd4NvN6VRnsO5MEDiRfaV9sah38iT1Rw7Xo=&c=KDHVO8DtZXgFYI8RujfYvlVqwu28It2pINQIs84UQ4zjb6WQieNtTw==&ch=MZctwjfEK-GZxbsNququCupyWi9Z3sg7vFpWi_JWBWEIpCBHxu0anQ==

Spending Bill Includes Millions for Algae R&D

In yet another big legislative victory for algae, the spending bill passed by Congress and signed by the President this month includes strong support for advanced algae research, development and commercialization projects.

http://r20.rs6.net/tn.jsp?f=001_DGyCb6WrsTFyblLjLBoZGe2QgllJu9SyafpCv3U1P6GotiDc1vLECPUbIreBYqz4sM3MYq9HNp45cbPsX2n_t_fRg0EeJh4xD2FGhX9eobjutEMbVRoLd809JC0-uBJ98jBFeCNjDA620NrvMJD6yopntMJaokuCc8jqBZeHHZ_k8Uzp8nNPo0VfIX8lwQl8m37ge8ZYdTlKO05R6fXlDLAaRNirs32&c=KDHVO8DtZXgFYI8RujfYvlVqwu28It2pINQIs84UQ4zjb6WQieNtTw==&ch=MZctwjfEK-GZxbsNququCupyWi9Z3sg7vFpWi_JWBWEIpCBHxu0anQ==

EVENTOS

SILICAMICS 2 conference at the University of Victoria in Victoria, B.C. (Canada) from June 6 to June 8, 2018.

8° Conferencia Internacional sobre Biomasa de Algas, Biocombustibles y Bioproductos (AlgalBBB 2018). Seatle, Washington, USA
Junio 11-13, 2018

XIII Reunión Ibérica de Algas tóxicas y biotoxinas marinas 2018 (REDIBAL) Vigo, España.
20 al 22 de junio de 2018

1st Seaweed for Health Conference
Galway, Ireland
June 24-27, 2018

25° International Diatom Symposium
Berlín, Alemania
Junio 25-30, 2018

18° Conferencia Internacional sobre algas nocivas (ICHA 2018)
Nantes, Francia
Octubre 21-26, 2018

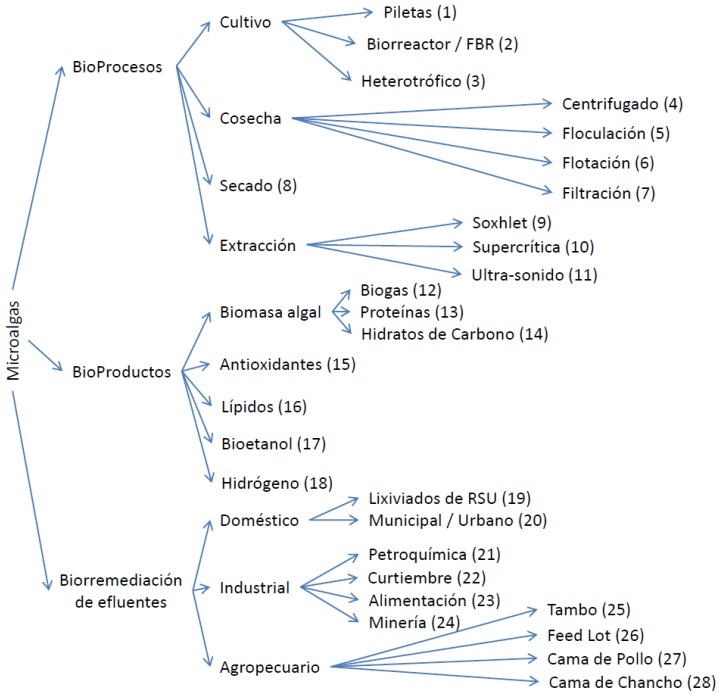
Algae Biomass Summit.
October 14 - October 17, 2018
The Woodlands Waterway Marriott Hotel & Convention Center
The Woodlands (Greater Houston), Texas

XI Congreso de Ciencias del Mar MarCuba'2018.
15-19 de octubre. La Habana, Cuba

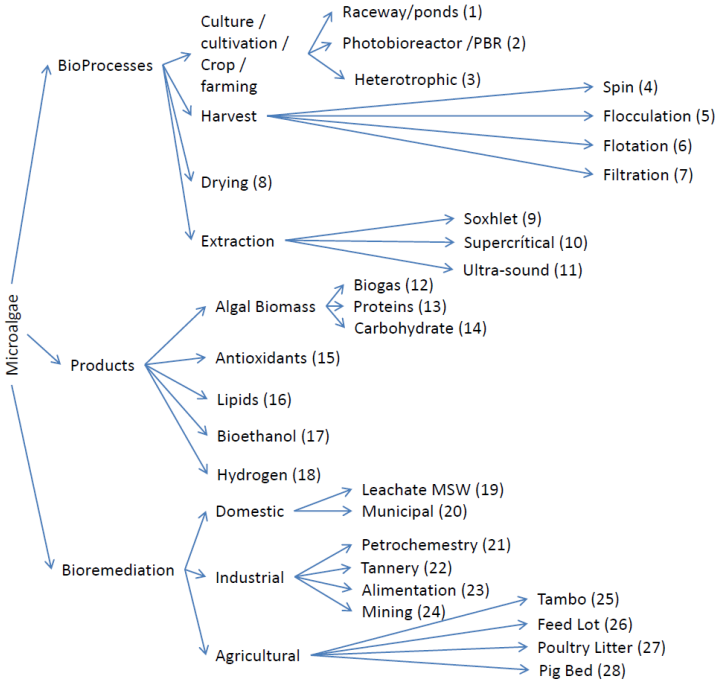
ALGAE EUROPE Conference
December 4-6, 2018
Amsterdam, the Netherlands.

Árbol de categorías

Español



Inglés



TITULO

SUBTITULO