Unidad de Vigilancia Tecnológica e Inteligencia Competitiva

Microalgas

Julio 2016

Participan en Confección y Edición

Juan Ignacio Gori

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Contenido

Publicaciones

En esta sección del presente boletín se presentan publicaciones que se encuentran por fuera de las áreas temáticas del árbol de categorías, pero que aún pertenecen al cultivo de microalgas.

Isolation and characterization of a mutant defective in triacylglycerol accumulation in nitrogen-starved Chlamydomonas reinhardtii.

Fecha de Publicación: Disponible on line 7 Abril 2016

Fuente: Biochimica et Biophysica Acta (BBA) - Molecular and Cell Biology of Lipids

Autor(es): Chun-Hsien Hung, Kazue Kanehara, Yuki Nakamura

Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS1388198116300890%26_version%3D1%26md5%3Daee48c950ffa386209ed402a9ed7d558

Abstract

Triacylglycerol (TAG), a major source of biodiesel production, accumulates in nitrogen-starved Chlamydomonas reinhardtii. However, the metabolic pathway of starch-to-TAG conversion remains elusive because an enzyme that affects the starch degradation is unknown. Here, we isolated a new class of mutant bgal1, which expressed an overaccumulation of starch granules and defective photosynthetic growth. The bgal1 was a null mutant of a previously uncharacterized β-galactosidase-like gene (Cre02.g119700), which decreased total β-galactosidase activity 40% of wild type. Upon nitrogen starvation, the bgal1 mutant showed decreased TAG accumulation mainly due to the reduced flux of de novo TAG biosynthesis evidenced by increased unsaturation of fatty acid composition in TAG and reduced TAG accumulation by additional supplementation of acetate to the culture media. Metabolomic analysis of the bgal1 mutant showed significantly reduced levels of metabolites following the hydrolysis of starch and substrates for TAG accumulation, whereas metabolites in TCA cycle were unaffected. Upon nitrogen starvation, while levels of glucose 6-phosphate, fluctose 6-phosphate and acetyl-CoA remained lower, most of the other metabolites in glycolysis were increased but those in the TCA cycle were decreased, supporting TAG accumulation. We suggest that BGAL1 may be involved in the degradation of starch, which affects TAG accumulation in nitrogen-starved C. reinhardtii.

Solar Radiation Stress in Natural Acidophilic Biofilms of Euglena mutabilis Revealed by Metatranscriptomics and PAM Fluorometry

Fecha de Publicación: Febrero 2016

Fuente: Protist, Volume 167, Issue 1

Autor(es): Fernando Puente-Sánchez, Sanna Olsson, Manuel Gómez-Rodriguez, Virginia Souza-Egipsy, Maria Altamirano-Jeschke, Ricardo Amils, Victor Parro, Angeles Aguilera

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Abstract

The daily photosynthetic performance of a natural biofilm of the extreme acidophilic Euglena mutabilis from Río Tinto (SW, Spain) under full solar radiation was analyzed by means of pulse amplitude-modulated (PAM) fluorescence measurements and metatrascriptomic analysis. Natural E. mutabilis biofilms undergo large-scale transcriptomic reprogramming during midday due to a dynamic photoinhibition and solar radiation stress. Photoinhibition is due to UV radiation and not to light intensity, as revealed by PAM fluorometry analysis. In order to minimize the negative effects of solar radiation, our data supports the presence of a circadian rhythm in this euglenophyte that increases their opportunity to survive. Differential gene expression throughout the day (at 12:00, 20:00 and night) was monitored by massive Illumina parallel sequencing of metatranscriptomic libraries. The transcription pattern was altered in genes involved in Photosystem II stability and repair, UV damaged DNA repair, non-photochemical quenching and oxidative stress, supporting the photoinhibition detected by PAM fluorometry at midday.

An Empirical Study Investigating the Impact of Micro-algal Technologies and their Application within Intelligent Building Fabrics

Fecha de Publicación: 6 Enero 2016

Fuente: Procedia - Social and Behavioral Sciences, Volume 216

Autor(es): Amira Elnokaly, Ian Keeling

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Abstract

The potential for algal technologies to lead innovation in bio-mimetic design requires much further analysis. This paper investigates the potential of the use of algal technologies in the building sector as part of an on-going research study. This investigation restricted itself to the application of algal technologies as catalysts for architectural creativity in the design of intelligent building fabrics and the resulting influence on internal luminance. In its attempt, the research study integrated both quantitative and qualitative approaches and was thus based upon a mixed method research. The paper outlines the initial empirical study, the primary purpose of such being the investigation of algal growth mechanisms and the examination of any interdependence that exists between culture density and internal luminance. Through the construction of a highly controlled experimental chamber, the authors were able to successfully examine this relationship and thus develop a visual design tool that informs what action should be taken or strategy employed based on the clients shading requirements and specific technological framework. It was established that from such work that as culture density increased, the technological strategies light transmittance decreased proportionally.

Multi-Level Light Capture Control in Plants and Green Algae

Fecha de Publicación: Enero 2016

Fuente: Trends in Plant Science, Volume 21, Issue 1

Autor(es): Lutz Wobbe, Roberto Bassi, Olaf Kruse

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http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS1360138515002526%26_version%3D1%26md5%3D1266fa9b5345db91f9845051f62fd866

Abstract

Life on Earth relies on photosynthesis, and the ongoing depletion of fossil carbon fuels has renewed interest in phototrophic light-energy conversion processes as a blueprint for the conversion of atmospheric CO2 into various organic compounds. Light-harvesting systems have evolved in plants and green algae, which are adapted to the light intensity and spectral composition encountered in their habitats. These organisms are constantly challenged by a fluctuating light supply and other environmental cues affecting photosynthetic performance. Excess light can be especially harmful, but plants and microalgae are equipped with different acclimation mechanisms to control the processing of sunlight absorbed at both photosystems. We

summarize the current knowledge and discuss the potential for optimization of phototrophic light-energy conversion.

Genetic engineering and metabolite profiling for overproduction of polyhydroxybutyrate in cyanobacteria

Fecha de Publicación: Noviembre 2015

Fuente: Journal of Bioscience and Bioengineering, Volume 120, Issue 5

Autor(es): Sayaka Hondo, Masatoshi Takahashi, Takashi Osanai, Mami Matsuda, Tomohisa Hasunuma, Akio Tazuke, Yoichi Nakahira, Shigeru Chohnan, Morifumi Hasegawa, Munehiko Asayama

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Abstract

Genetic engineering and metabolite profiling for the overproduction of polyhydroxybutyrate (PHB), which is a carbon material in biodegradable plastics, were examined in the unicellular cyanobacterium Synechocystis sp. PCC 6803. Transconjugants harboring cyanobacterial expression vectors that carried the pha genes for PHB biosynthesis were constructed. The overproduction of PHB by the engineering cells was confirmed through microscopic observations using Nile red, transmission electron microscopy (TEM), or nuclear magnetic resonance (NMR). We successfully recovered PHB from transconjugants prepared from nitrogen-depleted medium without sugar supplementation in which PHB reached approximately 7% (w/w) of the dry cell weight, showing a value of 12-fold higher productivity in the transconjugant than that in the control strain. We also measured the intracellular levels of acetyl-CoA, acetoacetyl-CoA, and 3-hydroxybutyryl-CoA (3HB-CoA), which are intermediate products for PHB. The results obtained indicated that these products were absent or at markedly low levels when cells were subjected to the steady-state growth phase of cultivation under nitrogen depletion for the overproduction of bioplastics. Based on these results, efficient factors were discussed for the overproduction of PHB in recombinant cyanobacteria.

Solar biofuels production with microalgae

Fecha de Publicación: 1 Octubre 2016

Fuente: Applied Energy, Volume 179

Autor(es): P.C. Hallenbeck, M. Grogger, M. Mraz, D. Veverka

Enlace:
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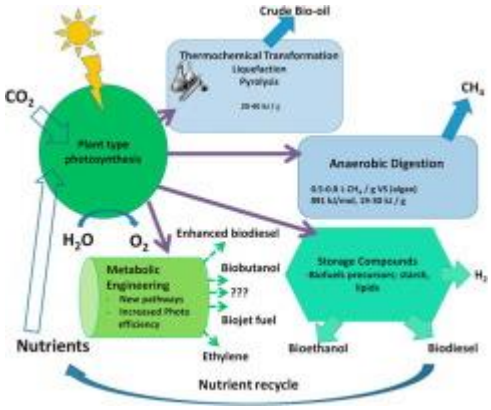
Abstract

With impending climate change and ever decreasing supplies of easily extractable fossil fuel, means to produce renewable and sustainable replacement fuels are being sought. Plants or algae appear ideal since they can use sunlight to fix CO2 into usable fuel or fuel feedstocks. However, as the world population approaches the 1010 (10 billion) mark, the use of agricultural land to produce fuel instead of food cannot be justified. Microalgal biofuel production is under intense investigation due to its promise as a sustainable, renewable biofuel that can be produced using non-arable land and brackish or non-potable water. Some species accumulate high levels of TAGs (triacylglycerols) that can be converted to fatty acid esters suitable as replacement diesel fuels. However, there are many technical barriers to the practical application of microalgae for biofuel production and thus a number of significant challenges need to be met before microalgal biodiesel production becomes a practical reality. These include developing cost-effective cultivation strategies, low energy requiring harvesting technologies, and energy efficient and sustainable lipid conversion technologies. The large culture volumes that will be necessary dictate that the necessary nutrients come from wastewaters, such as the effluents from secondary treatment of sewage. Economical and energy sparing harvesting will require the development of novel flocculation or floatation strategies and new methods of oil extraction/catalysis that avoid the extensive use of solvents. Recent advances in these critical areas are reviewed and some of the possible strategies for moving forward are outlined.

Graphical abstract



Synthesis and characterization of cryogel structures for isolation of EPSs from Botryococcus braunii

Fecha de Publicación: 5 Octubre 2016

Fuente: Carbohydrate Polymers, Volume 150

Autor(es): Irem Cemre Turu, Ceren Turkcan-Kayhan, Aslihan Kazan, Ece Yildiz-Ozturk, Sinan Akgol, Ozlem Yesil-Celiktas

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Abstract

In this study, the objective was to separate exopolysaccharides (EPSs) released in the broth subsequent to outdoor cultivation of Botryococcus braunii. For this, poly(2-hydroxyethyl methacrylate) (PHEMA) cryogels were synthesized. After that, the surface was modified by coupling Concanavalin A. Box-Behnken statistical design was used to evaluate the effect of freezing temperature, Con A concentration and flow rate on Con A binding capacity. Optimum synthesis conditions were elicited as −14.48°C freezing temperature, 1.00mg/ml Con A concentration and 0.30ml/min flow rate yielding 3.18mg Con A/g cryogel, whereas −16°C, 1.00mg/ml and 0.30ml/min yielded the highest (3.38mg) binding capacity in experimental cryogel preparation. The EPS adsorption capacity of the optimum cryogel column was found as 3.26mg EPS/g cryogel corresponding to adsorption yield of 80%. Besides; swelling test, elemental analysis, Micro-CT, SEM and FTIR analysis were carried out for characterization of the synthesized cryogels.

Graphical abstract

Ecotoxicological assessment of flocculant modified soil for lake restoration using an integrated biotic toxicity index

Fecha de Publicación: 15 Junio 2016

Fuente: Water Research, Volume 97

Autor(es): Zhibin Wang, Honggang Zhang, Gang Pan

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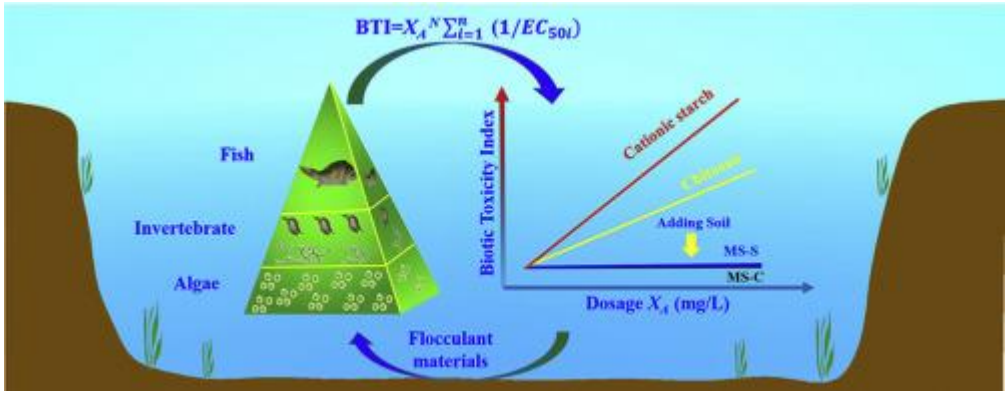
Abstract

Flocculant modified soils/clays are being increasingly studied as geo-engineering materials for lake restoration and harmful algal bloom control. However, the potential impacts of adding these materials in aquatic ecological systems remain unclear. This study investigated the potential effects of chitosan, cationic starch, chitosan modified soils (MS-C) and cationic starch modified soils (MS-S) on the aquatic organisms by using a bioassay battery. The toxicity potential of these four flocculants was quantitatively assessed using an integrated biotic toxicity index (BTI). The test system includes four aquatic species, namely Chlorella vulgaris, Daphnia magna, Cyprinus carpio and Limnodrilus hoffmeisteri, which represent four trophic levels in the freshwater ecosystem. Results showed that median effect concentrations (EC50) of the MS-C and MS-S were 31–124 times higher than chitosan and cationic starch, respectively. D. magna was the most sensitive species to the four flocculants. Histological examination of C. carpio showed that significant pathological changes were found in gills. Different from chitosan and cationic starch, MS-C and MS-S significantly alleviated the acute toxicities of chitosan and cationic starch. The toxicity order of the four flocculants based on BTI were cationic starch > chitosan > MS-S > MS-C. The results suggested that BTI can be used as a quantitative and comparable indicator to assess biotic

toxicity for aquatic geo-engineering materials. Chitosan or cationic starch modified soil/clay materials can be used at their optimal dosage without causing substantial adverse effects to the bioassay battery in aquatic ecosystem.

Graphical abstract



Conceptual design of sustainable integrated microalgae biorefineries: Parametric analysis of energy use, greenhouse gas emissions and techno-economics

Fecha de Publicación: Julio 2016

Fuente: Algal Research, Volume 17

Autor(es): John A. Posada, Laura B. Brentner, Andrea Ramirez, Martin K. Patel

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Abstract

This study covers four main aspects of the conceptual design of sustainable integrated microalgae-based biorefineries using flue gas from CO2-intensive industries (i.e. 100% CO2): i) screening of technologies (4 options for cultivation, 3 for culture dewatering, 3 for cell disruption, 4 for lipids extraction & purification, and 4 for fractions upgrading); ii) analysis of processing variables (parametric study of the main cultivation conditions affecting the global performance of the

biorefinery systems); iii) combination of final products (10 biorefinery configurations are generated from the combination of 9 final products); and iv) assessment of sustainability criteria (i.e., non-renewable energy use (NREU), greenhouse gas (GHG) emissions and economics). The used approach compares processing options and operation conditions to identify those combinations of production processes that minimize NREU and GHG emissions. In a second step, 10 integrated biorefinery concepts are selected and compared with respect to their environmental and economic performances. The impacts of choosing different microalgae species, locations, and nutrient sources were also studied as part of the scenario analysis. The results showed that the biorefinery systems with the best economic and environmental performances are those where microalgae oil-free cake is used as nutrient for substitution of animal feed and where lipids are used for substitution of vegetable oils. The worst economic and environmental performances of biorefineries were obtained when microalgae oil-free cake is anaerobically digested to biogas and lipids are converted to either biodiesel or green diesel. Regarding the cultivation technologies for the biorefinery systems with the best performance, favorable environmental results were obtained for flat panel photobioreactors (FPPBRs), followed by open ponds (OPs), vertical photobioreactors (VPBRs) and horizontal photobioreactors (HPBRs). In contrast, the best economic results were found for FPPBRs followed by VPBRs, HPBRs and OPs.

Applications of de-oiled microalgal biomass towards development of sustainable biorefinery

Fecha de Publicación: Disponible on line 26 Abril 2016

Fuente: Bioresource Technology

Autor(es): Rahulkumar Maurya, Chetan Paliwal, Tonmoy Ghosh, Imran Pancha, Kaumeel Chokshi, Madhusree Mitra, Arup Ghosh, Sandhya Mishra

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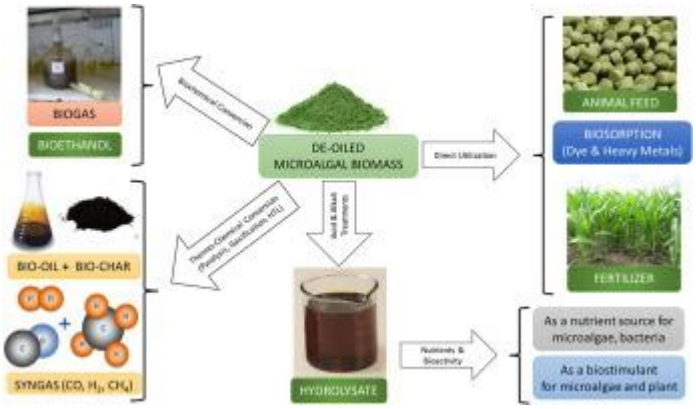
Abstract

In view of commercialization of microalgal biofuel, the de-oiled microalgal biomass (DMB) is a surplus by-product in the biorefinery process that needs to be exploited to make the process economically attractive and feasible. This DMB, rich in carbohydrates, proteins, and minerals, can be used as feed, fertilizer, and substrate for the production of bioethanol/bio-methane. Further, thermo-chemical conversion of DMB results into fuels and industrially important chemicals. Future prospects of DMB also lie with its conversion into novel biomaterials like nanoparticles and carbon-dot which has biomedical importance. The lowest valued application of DMB is to use it for adsorption of dyes and heavy metals from industrial effluents. This study reviews how DMB can be

utilized for different applications and in the generation of valuable co-products. The value addition of DMB would thereby improve the overall cost economics of the microalgal bio-refinery.

Graphical abstract



Multi-scenario energy-economic evaluation for a biorefinery based on microalgae biomass with application of anaerobic digestion

Fecha de Publicación: Junio 2016

Fuente: Algal Research, Volume 16

Autor(es): Cristián P. Bravo-Fritz, César A. Sáez-Navarrete, Leandro A. Herrera-Zeppelin, Felipe Varas-Concha

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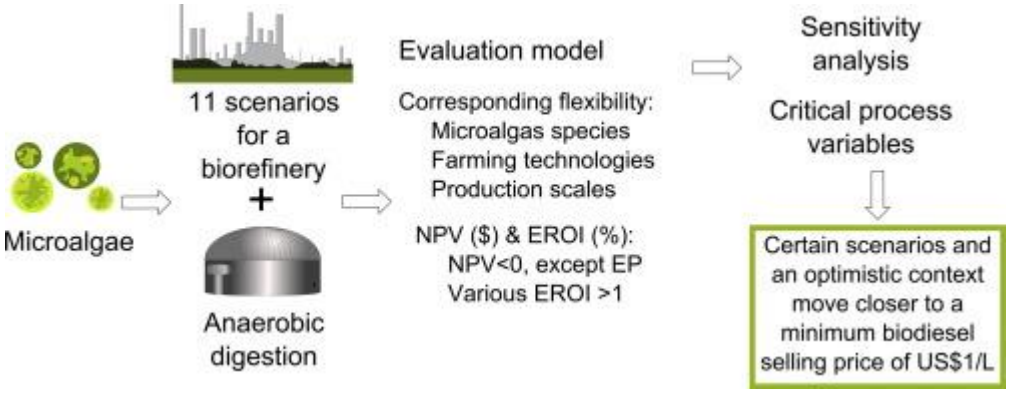
Abstract

Microalgae are a source of biomass that has aroused the interest of the bioenergy industry due to its sustainability potential and maximum use of different abundant natural resources. This research proposes an energy-economic evaluation model for 11 scenarios for a biorefinery based on microalgae biomass, including a final stage of anaerobic digestion. Furthermore, it allows for comparisons between different scales of production, farming technologies and microalgae species, in line with latest industry information. Results are displayed by means of economic (NPV) and

energy (EROI) indicators. Almost all the scenarios evaluated returned negative economic profitability, except for the extraction and commercialization of concentrated proteins (the PE scenario with protein sales of US$3/kg). In order to guide future research and investment in microalgae projects, a sensitivity analysis was conducted into the critical variables of the overall process. An optimistic context, led by the increase of the percentage of biomass lipids, allows a minimum biodiesel selling price to be reached which is close to the international value of fossil diesel (US$1/L) for scenarios in which this biofuel is commercialized.

Graphical abstract



Economic and policy issues in the production of algae-based biofuels: A review

Fecha de Publicación: Octubre 2016

Fuente: Renewable and Sustainable Energy Reviews, Volume 64

Autor(es): Amar Doshi, Sean Pascoe, Louisa Coglan, Thomas J. Rainey

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Abstract

Despite the initial environmental and supply benefits associated with conventional biofuels leading to substantial policy support, research has indicated that these benefits might have been overly optimistic. Negative externalities associated with food and resource allocation have also

resulted in an increasing scepticism about the long-term potential of transitioning to biofuels. This review presents the economic benefits and costs surrounding conventional biofuels and suggests the need for further development of a third-generation feedstock based on algae. The article provides guidance on the potential for a policy framework for supporting microalgae as a source of biofuels given the numerous associated positive externalities.

Waste biorefinery models towards sustainable circular bioeconomy: Critical review and future perspectives

Fecha de Publicación: Septiembre 2016

Fuente: Bioresource Technology, Volume 215

Autor(es): S. Venkata Mohan, G.N. Nikhil, P. Chiranjeevi, C. Nagendranatha Reddy, M.V. Rohit, A. Naresh Kumar, Omprakash Sarkar

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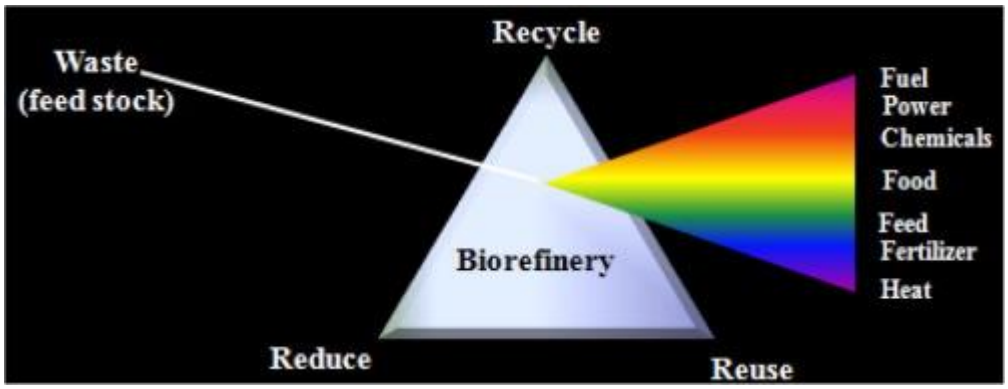
Abstract

Increased urbanization worldwide has resulted in a substantial increase in energy and material consumption as well as anthropogenic waste generation. The main source for our current needs is petroleum refinery, which have grave impact over energy-environment nexus. Therefore, production of bioenergy and biomaterials have significant potential to contribute and need to meet the ever increasing demand. In this perspective, a biorefinery concept visualizes negative-valued waste as a potential renewable feedstock. This review illustrates different bioprocess based technological models that will pave sustainable avenues for the development of biobased society. The proposed models hypothesize closed loop approach wherein waste is valorised through a cascade of various biotechnological processes addressing circular economy. Biorefinery offers a sustainable green option to utilize waste and to produce a gamut of marketable bioproducts and bioenergy on par to petro-chemical refinery.

Graphical abstract



Metabolomics analysis of phytohormone gibberellin improving lipid and DHA accumulation in Aurantiochytrium sp.

Fecha de Publicación: 15 Agosto 2016

Fuente: Biochemical Engineering Journal, Volume 112

Autor(es): Xin-Jun Yu, Jie Sun, Ya-Qi Sun, Jian-Yong Zheng, Zhao Wang

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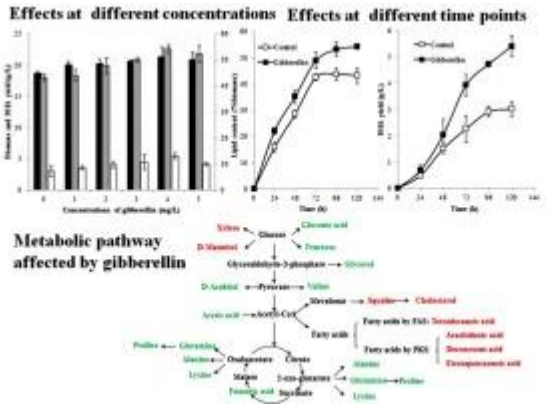
Abstract

In this study, the phytohormone gibberellin was evaluated for its effect on lipid and docosahexaenoic acid (DHA) accumulation in Aurantiochytrium sp.YLH70. It was found that 4mg/mL of gibberellin increased biomass, lipid and DHA yield of Aurantiochytrium sp.YLH70 by 14.4%, 43.6% and 79.1%, respectively. Moreover, a GC–MS metabolomics method combined with a multivariate analysis was applied to reveal the metabolic mechanisms responsible for the increased lipid and DHA accumulation. The principal component analysis (PCA) revealed that metabolomics profiles from all groups were discriminated. 38 metabolites identified by the partial least-squares-discriminant analysis (PLS-DA) were responsible for responding to gibberellin treatment. Metabolic pathway analysis showed that gibberellin accelerated the rate of utilization of glucose, and metabolites in fatty acids biosynthesis and mevalonate pathway were increased, while metabolites in glycolysis and TCA cycle were decreased in Aurantiochytrium sp.YLH70. Moreover, the anti-stress mechanism in Aurantiochytrium sp.YLH70 might be induced by gibberellin.

Graphical abstract



Biodegradation of crude oil by Anabaena oryzae, Chlorella kessleri and its consortium under mixotrophic conditions

Fecha de Publicación: Agosto 2016

Fuente: International Biodeterioration & Biodegradation, Volume 112

Autor(es): Ragaa Abd El Fatah Hamouda, Noha Mohamed Sorour, Dalia Said Yeheia

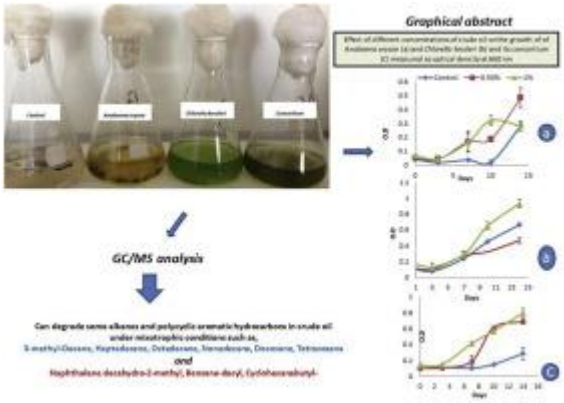
Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS0964830516301494%26_version%3D1%26md5%3D612c30fe6bf88d356e70521753ca2bfd

Abstract

Oil spill occurs frequently all around the world which certainly impacts adversely the environment. Thus a low cost and environmentally friendly bioremediation could be an alternative way to solve the oil pollution problem. The present study presents a bioremediation attempt using the microalgae/cyanobacterium consortium of Anabaena oryzae and Chlorella kessleri. Each of A. oryzae and C. kessleri as well as its consortium could grow at different concentrations of crude oil (0.5, 1, and 1.5%) under mixotrophic conditions. However, 1% of crude oil was the optimum concentration for their maximum growth. Chlorophyll-a content of C. kessleri, A. oryzae and its consortium increased from the first day of incubation with 0.5 and 1% crude oil concentration up to 14 days. While, chlorophyll-b content of the consortium decreased at different concentration of crude oil after 14 days. The carotenoids content of A. oryzae and C. kessleri increased with increasing the oil concentration from 0.5 to 1% with increasing the incubation time until day

seven. GC/MS analysis showed that some aliphatic compounds such as, 3-methyl-decane, heptadecane, octadecane, nonadecane, docosane and tetracosane completely disappeared when A. oryzae or C. kessleri was incubated mixotrophically with 1% crude oil. Aromatic compounds such as, naphthalene decahydro-2-methyl, benzene-decyl, cyclohexanebutyl- completely disappeared when the consortium was incubated mixotrophically with 1% crude oil for 30 days. Overall, our results indicate that C. kessleri, A. oryzae and its consortium can grow mixotrophically, and enhance the crude oil biodegradation.

Graphical abstract



Microalgae growth kinetic model based on the PSII quantum yield and its utilization in the operational curves construction

Fecha de Publicación: Julio 2016

Fuente: Algal Research, Volume 17

Autor(es): Daniel Undurraga, Paola Poirrier, Rolando Chamy

Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS221192641630176X%26_version%3D1%26md5%3Db65bb48efa5b052dfed1d5f7939be059

Abstract

In this study, a microalgae growth kinetic model based on its PSII quantum yield was built. It was used to simulate the following operational curves: microalgae concentration – dilution rate (X-D) and volumetric cell productivity – dilution rate (Q-D) in a continuous culture. The model considers

8 parameters particular for the microalgae species and its condition and 2 operational parameters (irradiance and flat plate photo-bioreactor (FPB) light path). The model was tested in a Scenedesmus obliquus continuous culture in FPB at a constant irradiance of 300μmol·m−2 s−1 and a dilution rate range of (0.16 to 2.7d−1), with CO2-enriched air at 2%. The microalgae kinetic parameters were determined independently by means of simple methodologies, which were used to simulate the X-D and Qx-D operational curves. A very good correlation with the experimental results was found (correlation coefficient of 0.993 for the X-D curve). The optimal operating point to maximize the experimentally determined cell volumetric productivity was D=0.84d−1, while the model determined a value of D=1d−1.

Comprehensive Techno-economic Analysis of Wastewater-Based Algal Biofuel Production: A Case Study

Fecha de Publicación: Disponible online 22 Marzo 2016

Fuente: Bioresource Technology

Autor(es): Chunhua Xin, Min M. Addy, Jinyu Zhao, Yanling Cheng, Sibo Cheng, Dongyan Mu, Yuhuan Liu, Rijia Ding, Paul Chen, Roger Ruan

Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS0960852416304059%26_version%3D1%26md5%3Da52e304c2032c62c54d57c8f59f42dda

Abstract

Combining algae cultivation and wastewater treatment for biofuel production is considered the feasible way for resource utilization. An updated comprehensive techno-economic analysis method that integrates resources availability into techno-economic analysis was employed to evaluate the wastewater-based algal biofuel production with the consideration of wastewater treatment improvement, greenhouse gases emissions, biofuel production costs, and coproduct utilization. An innovative approach consisting of microalgae cultivation on centrate wastewater, microalgae harvest through flocculation, solar drying of biomass, pyrolysis of biomass to bio-oil, and utilization of co-products, was analyzed and shown to yield profound positive results in comparison with others. The estimated break even selling price of biofuel ($2.23/gallon) is very close to the acceptable level. The approach would have better overall benefits and the internal rate of return would increase up to 18.7% if three critical components, namely cultivation, harvest, and downstream conversion could achieve breakthroughs.

Cultivation of Spirulina maxima in medium supplemented with sugarcane vinasse

Fecha de Publicación: Marzo 2016

Fuente: Bioresource Technology, Volume 204

Autor(es): Raquel Rezende dos Santos, Ofélia de Queiroz Fernandes Araújo, José Luiz de Medeiros, Ricardo Moreira Chaloub

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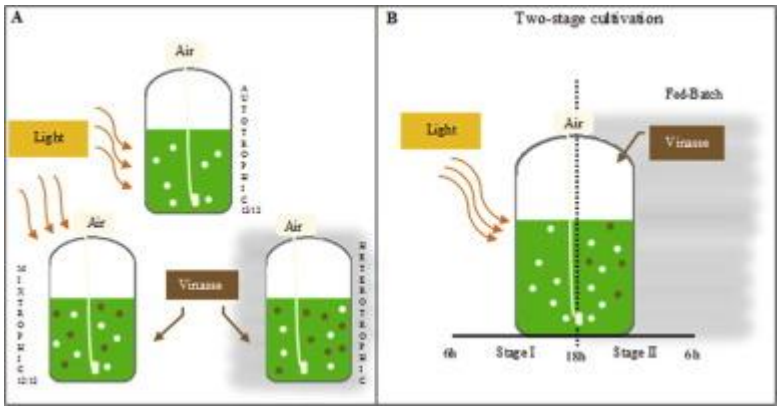
Abstract

The feasibility of sugarcane vinasse as supplement in growth medium of Spirulina maxima was investigated. The cell was cultivated under autotrophic (no vinasse, 70µmolphotonsm−2 s−1), heterotrophic (no light, culture medium supplemented with vinasse at 0.1% v/v and 1.0% v/v) and mixotrophic conditions (70µmolphotonsm−2 s−1, vinasse at 0.1% v/v and 1.0% v/v). These preliminary results suggested a cyclic two-stage cultivation – CTSC, with autotrophic condition during light phase of the photoperiod (12h, 70–200µmolphotonsm−2 s−1) and heterotrophic condition during dark phase (12h, 3.0% v/v vinasse). The adopted CTSC strategy consisted in three cycles with 75% withdrawal of suspension and reposition of medium containing 3.0% v/v vinasse, separated by autotrophic rest periods of few days between cycles. Results show an increase of biomass concentration between 0.495gL−1 and 0.609gL−1 at the 7th day of each cycle and high protein content (between 74.3% and 77.3% w/w).

Graphical abstract



Waste biorefinery in arid/semi-arid regions

Fecha de Publicación: Septiembre 2016

Fuente: Bioresource Technology, Volume 215

Autor(es): Juan-Rodrigo Bastidas-Oyanedel, Chuanji Fang, Saleha Almardeai, Usama Javid, Ahasa Yousuf, Jens Ejbye Schmidt

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Abstract

The utilization of waste biorefineries in arid/semi-arid regions is advisable due to the reduced sustainable resources in arid/semi-arid regions, e.g. fresh water and biomass. This review focuses on biomass residues available in arid/semi-arid regions, palm trees residues, seawater biomass based residues (coastal arid/semi-arid regions), and the organic fraction of municipal solid waste. The present review aims to describe and discuss the availability of these waste biomasses, their conversion to value chemicals by waste biorefinery processes. For the case of seawater biomass based residues it was reviewed and advise the use of seawater in the biorefinery processes, in order to decrease the use of fresh water.

Biorefineries of carbon dioxide: From carbon capture and storage (CCS) to bioenergies production

Fecha de Publicación: Septiembre 2016

Fuente: Bioresource Technology, Volume 215

Autor(es): Wai Yan Cheah, Tau Chuan Ling, Joon Ching Juan, Duu-Jong Lee, Jo-Shu Chang, Pau Loke Show

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http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS0960852416305065%26_version%3D1%26md5%3D355998586a497e1688741fbebf90e2ad

Abstract

Greenhouse gas emissions have several adverse environmental effects, like pollution and climate change. Currently applied carbon capture and storage (CCS) methods are not cost effective and have not been proven safe for long term sequestration. Another attractive approach is CO2 valorization, whereby CO2 can be captured in the form of biomass via photosynthesis and is subsequently converted into various form of bioenergy. This article summarizes the current carbon sequestration and utilization technologies, while emphasizing the value of bioconversion of CO2. In particular, CO2 sequestration by terrestrial plants, microalgae and other microorganisms are discussed. Prospects and challenges for CO2 conversion are addressed. The aim of this review is to provide comprehensive knowledge and updated information on the current advances in biological CO2 sequestration and valorization, which are essential if this approach is to achieve environmental sustainability and economic feasibility.

Microencapsulation of H. pluvialis oleoresins with different fatty acid composition: Kinetic stability of astaxanthin and alpha-tocopherol

Fecha de Publicación: 1 Enero 2016

Fuente: Food Chemistry, Volume 190

Autor(es): Andrés Bustamante , Lilia Masson , Joaquín Velasco , José Manuel del Valle , Paz Robert

Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS0308814615009541%26_version%3D1%26md5%3D0a0ef9985ed2497569045e1769142845

Abstract

Haematococcus pluvialis is a natural source of astaxanthin (AX). However, AX loses its natural protection when extracted from this microalga. In this study, a supercritical fluid extract (SFE) of H. pluvialis was obtained and added to oils with different fatty acid compositions (sunflower oil (SO) or high oleic sunflower oil (HOSO)). The oleoresins of H. pluvialis ((SO+SFE) and (HOSO+SFE)) were encapsulated with Capsul by spray drying. The stability of the oleoresins and powders were

studied at 40, 50 and 70°C. AX and alpha-tocopherol (AT) degradation followed a zero-order and first-order kinetic model, respectively, for all systems. The encapsulation of oleoresins improved the stability of AX and AT to a greater extent in oleoresins with a monounsaturated fatty acid profile, as shown by the significantly lowest degradation rate constants and longest half-lives. Therefore, the encapsulation of H. pluvialis oleoresins is an alternative to developing a functional ingredient for healthy food design.

NPK-10:26:26 complex fertilizer assisted optimal cultivation of Dunaliella tertiolecta using response surface methodology and genetic algorithm

Fecha de Publicación: Octubre 2015

Fuente: Bioresource Technology, Volume 194

Autor(es): Anup Kumar, Akhilendra K. Pathak, Chandan Guria

Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS0960852415008731%26_version%3D1%26md5%3D91661b328795deab4f8fd35bbfffdf69

Abstract

A culture medium based on NPK-10:26:26 fertilizer was formulated for enhanced biomass and lipid production of Dunaliella tertiolecta by selecting appropriate nutrients and environmental parameters. Five-level-five-factor central composite design assisted response surface methodology was adopted for optimal cultivation of D. tertiolecta and results were compared with simple genetic algorithm (GA). Significant improvement in biomass and lipid production was obtained using newly formulated fertilizer medium over f/2 medium. Following optimal parameters [i.e., NaHCO3, (mM), NPK-10:26:26 (gL−1), NaCl (M), light intensity (μmolm−2 s−1) and temperature (°C)] were obtained for maximum biomass (1.98gL−1) and lipid production (0.76gL−1): (42.50, 0.33, 1.09, 125, 25.13) and (38.44, 0.40, 1.25, 125, 24.5), respectively using GA. A multi-objective optimization was solved using non-dominated sorting GA to find best operating variables to maximize biomass and lipid production simultaneously. Effects of operating parameters and their interactions on algae and lipid productivity were successfully revealed.

Effect of chromium oxide (III) nanoparticles on the production of reactive oxygen species and photosystem II activity in the green alga Chlamydomonas reinhardtii

Fecha de Publicación: 15 Septiembre 2016

Fuente: Science of The Total Environment, Volume 565

Autor(es): Cristina Henning da Costa, François Perreault, Abdallah Oukarroum, Sílvia Pedroso Melegari, Radovan Popovic, William Gerson Matias

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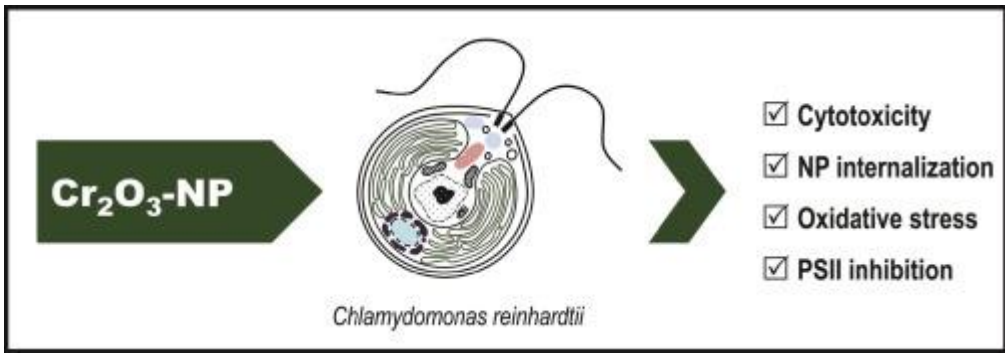
Abstract

With the growth of nanotechnology and widespread use of nanomaterials, there is an increasing risk of environmental contamination by nanomaterials. However, the potential implications of such environmental contamination are hard to evaluate since the toxicity of nanomaterials if often not well characterized. The objective of this study was to evaluate the toxicity of a chromium-based nanoparticle, Cr2O3-NP, used in a wide diversity of industrial processes and commercial products, on the unicellular green alga Chlamydomonas reinhardtii. The deleterious impacts of Cr2O3-NP were characterized using cell density measurements, production of reactive oxygen species (ROS), esterase enzymes activity, and photosystem II electron transport as indicators of toxicity. Cr2O3-NP exposure inhibited culture growth and significantly lowered cellular Chlorophyll a content. From cell density measurements, EC50 values of 2.05±0.20 and 1.35±0.06gL−1 Cr2O3-NP were obtained after 24 and 72h of exposure, respectively. In addition, ROS levels were increased to 160.24±2.47% and 59.91±0.15% of the control value after 24 and 72h of exposition to 10gL−1 Cr2O3-NP. At 24h of exposure, the esterase activity increased to 160.24% of control value, revealing a modification of the short-term metabolic response of algae to Cr2O3-NP exposure. In conclusion, the metabolism of C. reinhardtii was the most sensitive to Cr2O3-NP after 24h of treatment.

Graphical abstract



Knowledge management in a waste based biorefinery in the QbD paradigm

Fecha de Publicación: Septiembre 2016

Fuente: Bioresource Technology, Volume 215

Autor(es): Anurag S. Rathore, Viki R. Chopda, James Gomes

Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS0960852416304710%26_version%3D1%26md5%3De6ef01f86e8b4a76eec2247a1ccd2327

Abstract

Shifting resource base from fossil feedstock to renewable raw materials for production of chemical products has opened up an area of novel applications of industrial biotechnology-based process tools. This review aims to provide a concise and focused discussion on recent advances in knowledge management to facilitate efficient and optimal operation of a biorefinery. Application of quality by design (QbD) and process analytical technology (PAT) as tools for knowledge creation and management at different levels has been highlighted. Role of process integration, government policies, knowledge exchange through collaboration, and use of databases and computational tools have also been touched upon.

A biorefinery concept using the green macroalgae Chaetomorpha linum for the coproduction of bioethanol and biogas

Fecha de Publicación: 1 Julio 2016

Fuente: Energy Conversion and Management, Volume 119

Autor(es): Nesrine Ben Yahmed, Mohamed Amine Jmel, Monia Ben Alaya, Hassib Bouallagui, M. Nejib Marzouki, Issam Smaali

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Abstract

An innovative integrated biorefinery approach using the green macroalgae Chaetomorpha linum was investigated in the present study for the co-production of bioethanol and biogas. Among three pretreatments of C. linum biomass, consisting of acidic, neutral and alkali ones, 3% NaOH pretreatment gave the best result in terms of thallus disintegration, biomass recovery and enzymatic digestibility as demonstrated by scanning electron microscopy and saccharification tests. The hydrolysis of C. linum feedstock with a crude specific enzyme preparation, locally produced from fermentation of Aspergillus awamori, at 45°C, pH 5 for 30h gave the maximum yield of fermentable sugar of 0.22±0.02g/g dry substrate. An ethanol yield of 0.41g/g reducing sugar corresponding to about 0.093g/g pretreated algae was obtained after alcoholic fermentation by Saccharomyces cerevisiae. In the integrated proposed process, mycelium issued from the fungal fermentation, liquid issued from alkali pretreatment, residual from the non-hydrolysable biomass and all effluents and co-products represent a heterogeneous substrate that feed an anaerobic digester for biogas production. GC-analysis of this later showed that the biomethane yield reached 0.26±0.045L/gVS. This study presents therefore an eco-friendly biorefining process, which efficiently coproduce bioethanol and biomethane and generate only a single waste (0.3±0.01g/g) allowing an almost complete conversion of the algal biomass.

Microalgae biorefinery alternatives and hazard evaluation

Fecha de Publicación: Marzo 2016

Fuente: Chemical Engineering Research and Design, Volume 107

Autor(es): J. Pinedo, C.V. García Prieto, A.A. D'Alessandro, R. Ibáñez, S. Tonelli, M.S. Díaz, Á. Irabien

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Abstract

Biodiesel production based on microalgae and using carbon dioxide as feedstock constitutes an attractive biofuel alternative. Technology development and process optimization are necessary to minimize the overall production cost. Moreover, in the framework of process sustainability, social and environmental impacts should include process safety aspects. In this context, the objective of this work is to develop a biodiesel production process based on microalgae and the subsequent estimation of the associated risks, thus contributing to more sustainable and safe processes. The biodiesel biorefinery is optimized, taking into account alternative configurations for algae cultivation and lipid extraction. Algae cultivation options are open ponds and tubular photobioreactors. Regarding lipid extraction, dewatering and subsequent n-hexane extraction, and combined ethanol/n-hexane extraction are the studied alternatives. Numerical results showed that open ponds and n-hexane extraction provide maximum net present value. However, n-hexane consumption dramatically rises, and industrial hazards have not been considered in the optimization process. To overcome this issue, a preliminary hazard analysis is carried out to identify hazardous materials and operations. Event trees are formulated to derive the frequencies of different accident scenarios, further determining the consequences. The major consequences of accidents involve toxic releases of high quantities of n-hexane. By comparing the proposed alternatives, this work aims to highlight the need to consider not only economic but also safety and environmental objectives in the development of a biodiesel production project.

Quantifying environmental performance of biomass energy

Fecha de Publicación: Junio 2016

Fuente: Renewable and Sustainable Energy Reviews, Volume 59

Autor(es): G.M. Joselin Herbert, A. Unni Krishnan

Enlace:
http://rss.sciencedirect.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%3F_ob%3DGatewayURL%26_origin%3DIRSSSEARCH%26_method%3DcitationSearch%26_piikey%3DS1364032115016378%26_version%3D1%26md5%3Da887314bdaa41308cb299068f76b4e52

Abstract

The world needs an enormous amount of energy to maintain the future economic developments. India has facile ways to overcome the immediate demand on energy supply by renewable energy resources. It has a huge potential of biomass resources to reduce the dependence on fossil fuels and to produce electrical and heat energy. The biomass energy can contributes to social and economic development. It has been identified as an alternative for the future energy demand in India. As part of furthering the development of biomass technology, it is essential to understand the environmental merits and demerits of biomass. It also aims to increase the use of biomass energy for domestic purposes. The interest behind the review is boosted by the rapid development of biomass conversion techniques and continual increase of biomass energy generation. It has motivated the authors to collect the quintessential literature of environmental aspects of biomass energy. The objective of the research work is to quantify and focuses the environmental performance of biomass energy. It also deals with the environment monitoring and control, pricing, standard and regulations of the bio-energy for the future development.

Biodegradation of carbamazepine using freshwater microalgae Chlamydomonas mexicana and Scenedesmus obliquus and the determination of its metabolic fate

Fecha de Publicación: Abril 2016

Fuente: Bioresource Technology, Volume 205

Autor(es): Jiu-Qiang Xiong, Mayur B. Kurade, Reda A.I. Abou-Shanab, Min-Kyu Ji, Jaeyoung Choi, Jong Oh Kim, Byong-Hun Jeon

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Abstract

This study evaluated the toxicity and cellular stresses of carbamazepine (CBZ) on Chlamydomonas mexicana and Scenedesmus obliquus, and its biodegradation by both microalgal species. The growth of both microalgal species decreased with increase of CBZ concentration. The growth of S. obliquus was significantly inhibited (97%) at 200 mg CBZ L−1, as compared to the control after 10days; whereas, C. mexicana showed 30% inhibition at the same experimental conditions. Biochemical characteristics including total chlorophyll, carotenoid contents and enzyme activities (SOD and CAT) for both species were affected by CBZ at relatively high concentration. C. mexicana and S. obliquus could achieve a maximum of 35% and 28% biodegradation of CBZ, respectively. Two metabolites (10,11-dihydro-10,11-expoxycarbamazepine and n-hydroxy-CBZ) were identified

by UPLC-MS, as a result of CBZ biodegradation by C. mexicana. This study demonstrated that C. mexicana was more tolerant to CBZ and could be used for treatment of CBZ contaminated wastewater.

Study on bioaccumulation and biosorption of mercury by living marine macroalgae: Prospecting for a new remediation biotechnology applied to saline waters

Fecha de Publicación: 1 Diciembre 2015

Fuente: Chemical Engineering Journal, Volume 281

Autor(es): Bruno Henriques, Luciana S. Rocha, Cláudia B. Lopes, Paula Figueira, Rui J.R. Monteiro, A.C. Duarte, M.A. Pardal, E. Pereira

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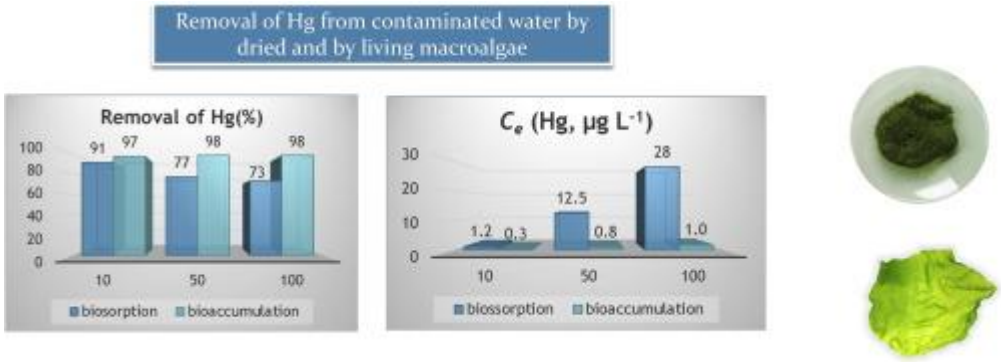
Abstract

This study aimed to assess and explore the bioaccumulation capabilities of three different macroalgae species, Ulva lactuca (green), Gracilaria gracilis (red) and Fucus vesiculosus (brown), very common on temperate coasts and estuaries, for the removal of mercury (Hg) from contaminated waters (with high salinity), using environmentally realistic concentrations of metal (10–100μgL−1). Levels of Hg accumulated by all seaweeds ranged between 20.8 and 208μgg−1, corresponding to bioconcentration factors of c.a. 2000. A comparative evaluation of bioaccumulation (living biomass) and biosorption (dried biomass) was performed for U. lactuca, which had displayed the best performance in accumulating Hg. The removal conducted by the living seaweed (m macroalgae/V solution ≈500mgL−1), although slower, was more promising since all Hg levels were reduced by about 99%, fulfilling the European criteria for drinking water quality. Pseudo-second-order and Elovich models described quite well the experimental data, assuming a process essentially of chemical nature. Determination of total Hg content in algal biomass over time, allowed to confirm and to follow the uptake of this metal by the living organism. Volatilization of Hg or its conversion to organo-metallic forms (0.02–0.05%) was negligible during the decontamination process. Overall, the results are a contribution for the development of an efficient and cost-effective water remediation biotechnology, based on the use of living macroalgae to promote the removal of Hg.

Graphical abstract



A microalga, Euglena tuba induces apoptosis and suppresses metastasis in human lung and breast carcinoma cells through ROS-mediated regulation of MAPKs

Fecha de Publicación: 10 Marzo 2016

Fuente: Cancer Cell International

Autor(es): Panja, S.; Ghate, N.B.; Mandal, N.

Enlace:
http://syndic8.scopus.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.scopus.com%2Finward%2Frecord.url%3Feid%3D2-s2.0-84976492719%26rel%3DR4.0.0%26partnerID%3D35%26md5%3D075f6b5ffcef82582de96befaf2ee89a

Abstract
Euglena tuba, a microalga, is known for its excellent antioxidant and iron-chelation activities; however its anticancer efficacies have not been reported yet. This study investigates the antitumor and antimetastatic activities of 70 % methanolic extract of Euglena tuba (ETME) against human lung (A549) and breast cancer (MCF-7) cells in vitro. Moreover, we had examined ETME's role in inducing intracellular ROS with the regulation of antioxidants and MAPK pathway.

Impact of microalgae-bacteria interactions on the production of algal biomass and associated compounds

Fecha de Publicación: 20 Febrero 2016

Fuente: Marine Drugs

Autor(es): Fuentes, J.L.; Garbayo, I.; Cuaresma, M.; Montero, Z.; González-Del-Valle, M.; Vílchez, C.

Enlace:
http://syndic8.scopus.com/action/redirectFile?&zone=main&currentActivity=feed&usageType=outward&url=http%3A%2F%2Fwww.scopus.com%2Finward%2Frecord.url%3Feid%3D2-s2.0-84971238279%26rel%3DR4.0.0%26partnerID%3D35%26md5%3D6c3a4732af85fdb64c6c2fb6766edb1e

Abstract

A greater insight on the control of the interactions between microalgae and other microorganisms, particularly bacteria, should be useful for enhancing the efficiency of microalgal biomass production and associated valuable compounds. Little attention has been paid to the controlled utilization of microalgae-bacteria consortia. However, the studies of microalgal-bacterial interactions have revealed a significant impact of the mutualistic or parasitic relationships on algal growth. The algal growth, for instance, has been shown to be enhanced by growth promoting factors produced by bacteria, such as indole-3-acetic acid. Vitamin B12 produced by bacteria in algal cultures and bacterial siderophores are also known to be involved in promoting faster microalgal growth. More interestingly, enhancement in the intracellular levels of carbohydrates, lipids and pigments of microalgae coupled with algal growth stimulation has also been reported. In this sense, massive algal production might occur in the presence of bacteria, and microalgae-bacteria interactions can be beneficial to the massive production of microalgae and algal products. This manuscript reviews the recent knowledge on the impact of the microalgae-bacteria interactions on the production of microalgae and accumulation of valuable compounds, with an emphasis on algal species having application in aquaculture.

Eventos y Cursos

Congresos

Euro Global Summit and Expo on Biomass.
August 08-09. Birmingham, UK.
http://biomass.global-summit.com/europe/

2nd International Congress and Expo on Biofuels & Bioenergy.
August 29-31. Sao Paulo, Brazil.
http://biofuels-bioenergy.conferenceseries.com/call-for-abstracts.php

Algae Biomass Summit.
October 23 - 26. Phoenix, Arizona. EEUU.
http://www.algaebiomasssummit.org/?page=Agenda

The 9th Asia-Pacific Conference on Algal Biotechnology. Algae for food, feed, fuel and beyond.
November 15-18. Bankhok, Thailand.
http://www.apcab2016.com/overview.asp

ALGAEUROPE
December 06 - 08 2016, UK.
http://algaecongress.com/

Workshop/ Talleres y cursos

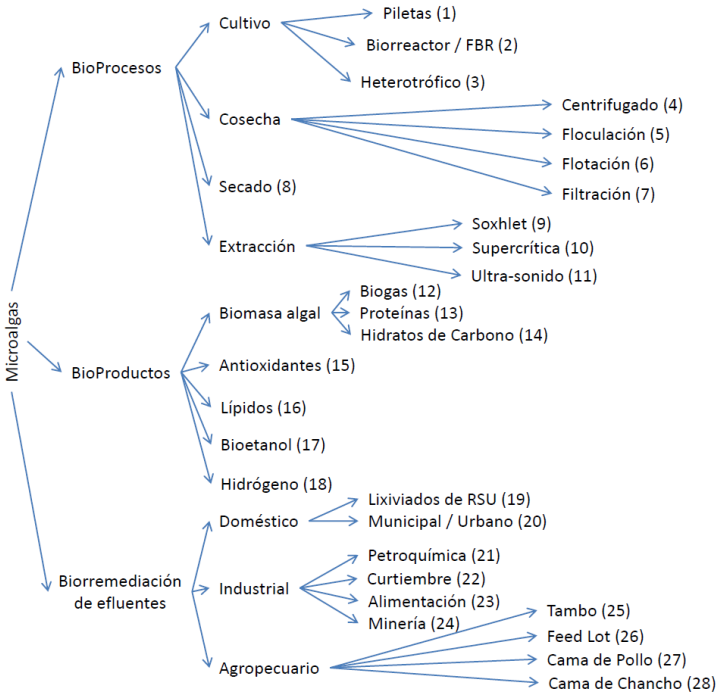
Aug 22-26: Summer ATP3 Workshop, UTEX - Microalgal Culture Management & Strain Selection.
This workshop will provide an introduction to the major classifications of microalgae, including their diversity, nutrition, ecology, and biochemical content. Topics are designed for advanced students, instructors and trainees who are interested in obtaining a broad survey of the microalgae and the field of applied phycology.

Workshop are hosted at AzCATI, a nationally-recognized algae testbed facility, where participants can explore every aspect of growing microalgae at the production scale. The summer workshop will take place at the UTEX Culture Collection of Algae located at the University of Texas at Austin.
http://utex.org/blogs/training-workshops
http://www.psaalgae.org/workshops-and-courses/
National Center for Marine Alage and Microbiota

Biología y Taxonomía de Diatomeas Continentales. UBA.
Maidana Nora Irene, nim@bg.fcen.uba.ar; postgrado.bbe@bg.fcen.uba.ar.
http://www.dbbe.fcen.uba.ar/objetos/biologia-y-taxonomia-de-diatomeas-continentales-P174.html
Taller de identificación de Diatomeas Continentales, UBA.
Este curso teórico y práctico brinda actualización de los conocimientos sobre la biología, taxonomía y ecología de las diatomeas (Bacillariophyceae), con énfasis en los géneros que habitan las aguas continentales. Se estudian las Bacillariophyceae actuales y fósiles, tanto en los aspectos de su biodiversidad como en los limnológicos y micropaleontológicos, así como sus aplicaciones en diversos campos de la ciencia y la industria.
Carga horaria: 60 hs.
Duración: quincenal.
Frecuencia de dictado: anual.
Maidana Nora Irene, nim@bg.fcen.uba.ar; postgrado.bbe@bg.fcen.uba.ar.
http://www.dbbe.fcen.uba.ar/objetos/taller-de-identificacion-de-diatomeas-continentales-P193.html.

Árbol de categorías

Español



Inglés