Hydrocarbon Yield from Botryoccoccus Braunii Under Varied Growth Conditions and Extraction Methods Context Sensitive Links

Author(s): Pisutpaisal N, Boonyawanich S

Source: RESEARCH JOURNAL OF BIOTECHNOLOGY, Special Issue: Sp. Iss. SI, Pages: 296-300, Published: 2008

Times Cited: 0 References: 11

Abstract: The growth of microalga, Botrycoocus braunii, was examined tinder the cultivated temperature of 25o C and room temperature (33 +/- 3 oC) using two culture media, medium no 1 (Modified Chu13; Inoue et al., 1994) and medium no. 2 (Modified Chu13; Largeau et al., 1980) with the initial pH of 7. The alga was cultivated in 1-L reactors, under 1400 lux light intensity (24-h exposure period), and the alga suspension was mixed by the air mixtures containing 1% carbon dioxide with a flow rate of 3 L min-1. The results showed cultivated temperature of 25o C is more suitable to the growth of the algae than that of room temperature, and at the cultivated temperature of 25o C, cultivation of algae using medium no. 1 is better than using medium no. 1 due to higher algal growth percentage based on optical density measurement. The total hydrocarbon extracted from the algae after 0, 10, 20, 30 and 35 days of cultivation indicated that the yield of the hydrocarbon ranges from 20 to 40 percents in all cultivated conditions based on the grinding-hexane; and combined grinding and sonication-hexane extraction methods.

Document Type: Proceedings Paper

Author Keywords: Botryococcus braunii; microalgae; hydrocarbon; biodiesel; renewable energy

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Solar Energy Conversion Through Seaweed Photosynthesis and Zero Emissions Power Generation Context Sensitive Links

Author(s): Yantovski EI

Source: SURFACE ENGINEERING AND APPLIED ELECTROCHEMISTRY, Volume: 44, Issue: 2, Pages: 138-145,
Published: APR 2008

Times Cited: 0 References: 23

Abstract: The present paper is aimed at describing a "closed cycle" power plant scheme (Solar Oxygen Fuel Turbine (SOFT)) with macroalgae (seaweed) cultivation in a pond, combustion of its organic matter in a fluidized bed boiler using the Rankine cycle, and return of the combustion products to the pond to feed the algae. The oxygen used for combustion is released to the atmosphere during photosynthesis. It is further elaborated in a paper presented at ECOS2005 in

Trondheim. As a renewable fuel, the seaweed Ulva lactuca is selected. Its growth rate in many experiments (in the literature) is 0.1-0.2 per day, the heating value of its dry weight is 19 MJ/kg, and its optimal concentration in salt water is 1 : 1000. The energy efficiency is less than in photovoltaics, but the energy expenditures to construct the pond as a solar energy receiver are much less, so it gives some economic benefits. For a power unit of 100 kW, the pond surface is about 4 hectare. The cultivation of seaweed in sea-water ponds is well developed in Italy and Israel for water cleaning and chemical production. Construction in the future of a SOFT system near the Dead Sea in the Israeli desert would provide the country with needed power, chemicals, and fresh water using solar energy. The system is protected by United States Patten no. 6 477 841 B1 dated 12.11.2002 with priority in Israel dated 22.03.1999. Many more benefits to the customer than are in the patent text are highlighted in the paper, including fresh water by desalination. In view of the active work in Italy on water cleaning using Ulva and contaminants in the water as nutrients for an increase of the biomass productivity, an additional target of the SOFT cycle might be incineration. Some suppositions of the use of a desert surface for massive scale use of ponds are given.

Document Type: Article

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Oil Feedstocks & The Environment Algae in the tank

Author(s): Torrey M

Source: TRIBOLOGY & LUBRICATION TECHNOLOGY, Volume: 64, Issue: 12, Pages: 26-32, Published: DEC 2008

Times Cited: 0 References: 5

Abstract: Not available online

Document Type: Article

KeyWords Plus: BIOFUEL PRODUCTION

* *

Culture of microalga Botryococcus in livestock wastewater

Author(s): Shen Y, Yuan W, Pei Z, Mao E

Source: TRANSACTIONS OF THE ASABE, Volume: 51, Issue: 4, Pages: 1395-1400, Published: JUL-AUG 2008

Times Cited: 0 References: 20
Abstract: Botryococcus has been one of the most frequently and extensively studied algae in the world. Its potentially high hydrocarbon content and applicability for wastewater treatment have attracted increasing attention in recent years. This study aimed to produce oil from Botryococcus braunii using livestock wastewater for dual purposes of biofuel production and animal waste nutrient removal. B. braunii was batch-wise cultivated in the laboratory in livestock wastewater containing various nutrient concentrations. Optimal growth of B. braunii occurred in 50% autoclaved wastewater Dry biomass concentration of up to 2.543 g L-1 was achieved with an oil content of 19.8%wt. The 30-day average biomass and oil productivities were 84.8 and 16.8 mg L-1 day(-1), respectively. Growing B. braunii in livestock wastewater also effectively removed nutrients. On average, 88% of total nitrogen and 98% of total phosphorous in wastewater were removed in 14 days. B. braunii was found to be able to co-exist with a wild green alga, Chlorella sp.; the presence of either alga did not negatively affect growth of the other Dry weights of B. braunii and Chlorella sp. were measured using a spectrophotometer by correlating dry weights of algae with their optical density values. Linear regression equations (R-2 > 99.7%) for dry weight versus optical density for both algae were developed. These equations can be used to determine the dry-weight concentration of B. braunii and Chlorella sp. using readily obtained optical density values, regardless of wastewater concentration.

Document Type: Article

Author Keywords: Algae; Biofuel; Biomass; Botryococcus braunii; Chlorella; Nutrient removal; Optical density; Wastewater

* *

Recent progress in biorenewable feedstocks

Author(s): Demirbas A

Source: ENERGY EDUCATION SCIENCE AND TECHNOLOGY, Vol.: 22, Issue: 1, Pg.: 69-95, Published: DEC 2008

Times Cited: 2 References: 133

Abstract: Bioenergy is one of the forms of renewable energy. Biorenewables contain all sustainable bioenergy feedstocks. Bioenergy can always be considered as a form of renewable energy. Biomass resources include wood and wood wastes; agricultural crops and their waste byproducts; municipal solid waste; animal wastes; waste from food processing; and aquatic plants and algae. Recently, the studies have been focused on developing new crops and cropping systems that can be used as dedicated bioenergy feedstock. Switchgrass, hybrid poplars, and hybrid willows are among these dedicated crops. Biomass is commonly recognized as an important renewable energy, which is considered to be such a resource that during the growth of

plants and trees solar energy is stored as chemical energy via photosynthesis, which can be released via direct or indirect combustion. There are three ways to use biomass. It can be burned to produce heat and electricity, changed to gas-like fuels such as methane, hydrogen and carbon monoxide or changed to a liquid fuel. In the last decade, there are rapid progresses in biofuel marketing trend: increasing production capacity, increasing international material flows, increased competition with conventional agriculture, increased competition with forest industries, increasing international trade flows, and strong international debate about the sustainability of biofuels production.

Document Type: Review

Author Keywords: biorenewables; biomass; biomass feedstocks; bioenergy; biofuels

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Solar-powered aeration and disinfection, anaerobic co-digestion, biological CO2 scrubbing and biofuel production: the energy and carbon management opportunities of waste stabilisation ponds

Author(s): Shilton AN, Mara DD, Craggs R, Powell N

Source: WATER SCIENCE AND TECHNOLOGY, Volume: 58, Issue: 1, Pages: 253-258, Published: 2008

Abstract: Waste stabilisation pond (WSP) technology offers some important advantages and interesting possibilities when viewed in the light of sustainable energy and carbon management. Pond systems stand out as having significant advantages due to simple construction; low (or zero) operating energy requirements; and the potential for bio-energy generation. Conventional WSP requires little or no electrical energy for aerobic treatment as a result of algal photosynthesis. Sunlight enables WSP to disinfect wastewaters very effectively without the need for any chemicals or electricity consumption and their associated CO2 emissions. The energy and carbon emission savings gained over electromechanical treatment systems are immense. Furthermore, because algal photosynthesis consumes CO2, WSP can be utilised as CO2 scrubbers. The environmental and financial benefits of pond technology broaden further when considering the low-cost, energy production opportunities of anaerobic ponds and the potential of algae as a biofuel. As we assess future best practice in wastewater treatment technology, perhaps one of the greatest needs is an improved consideration of the carbon footprint and the implications of future increases in the cost of electricity and the value of biogas.

Document Type: Article

Author Keywords: aeration; anaerobic digestion; carbon management; disinfection; energy; high rate algal ponds; waste stabilisation ponds

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Aquatic phototrophs: efficient alternatives to land-based crops for biofuels

Author(s): Dismukes GC, Carrieri D, Bennette N, Ananyev GM, Posewitz MC

Source: CURRENT OPINION IN BIOTECHNOLOGY, Volume: 19, Issue: 3, Pages: 235-240, Published: JUN 2008

Times Cited: 2 References: 36

Abstract: To mitigate some of the potentially deleterious environmental and agricultural consequences associated with current land-based-biofuel feedstocks, we propose the use of biofuels derived from aquatic microbial oxygenic photoautotrophs (AMOPs), more commonly known as cyanobacteria, algae, and diatoms. Herein we review their demonstrated productivity in mass culturing and aspects of their physiology that are particularly attractive for integration into renewable biofuel applications. Compared with terrestrial crops, AIMOPs are inherently more efficient solar collectors, use less or no land, can be converted to liquid fuels using simpler technologies than cellulose, and offer secondary uses that fossil fuels do not provide. AMOPs pose a new set of technological challenges if they are to contribute as biofuel feedstocks.

Document Type: Review

KeyWords Plus: SPIRULINA-PLATENSIS; ARTHROSPIRA-FUSIFORMIS; SOLAR-ENERGY; LAKE-CHITU; WATER; BIOMASS; PHOTOSYNTHESIS; CHLAMYDOMONAS; PERFORMANCE; METABOLISM

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A perspective on the biotechnological potential of microalgae

Author(s): Raja R, Hemaiswarya S, Kumar NA, Sridhar S, Rengasamy R

Source: CRITICAL REVIEWS IN MICROBIOLOGY, Volume: 34, Issue: 2, Pages: 77-88, Published: JUN 2008

Times Cited: 0 References: 82 Citation MapCitation Map beta

Abstract: Microalgae are the untapped resource with more than 25,000 species of which only 15 are in use. In recent years, microalgal culture technology is a business oriented line owing to their different practical applications. Innovative processes and products have been introduced in microalgal biotechnology to produce vitamins, proteins, cosmetics, and health foods. For most of

these applications, the market is still developing and the biotechnological use of microalgae will extend into new areas. With the development of sophisticated culture and screening techniques, microalgal biotechnology can meet the challenging demands of both the food and pharmaceutical industries. Genetic improvement should also play an important role in the future development of algal industries. Based on the preliminary research, several therapeutic benefits have been claimed for commercially produced microalgae including AIDS, cancer, and Cerebro vascular diseases. In near future, algal biomass will serve as a renewable energy source through commercial production of hydrocarbon by Botryococcus throughout the world.

Document Type: Review

Author Keywords: astaxanthin; aquaculture; biofuel; beta-carotene; microalgae

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Microalgal triacylglycerols as feedstocks for biofuel production: perspectives and advances

Author(s): Hu Q, Sommerfeld M, Jarvis E, Ghirardi M, Posewitz M, Seibert M, Darzins A

Source: PLANT JOURNAL, Volume: 54, Issue: 4, Pages: 621-639, Published: MAY 2008

Times Cited: 7 References: 141 Citation MapCitation Map beta

Abstract: Microalgae represent an exceptionally diverse but highly specialized group of micro-organisms adapted to various ecological habitats. Many microalgae have the ability to produce substantial amounts (e.g. 20-50% dry cell weight) of triacylglycerols (TAG) as a storage lipid under photo-oxidative stress or other adverse environmental conditions. Fatty acids, the building blocks for TAGs and all other cellular lipids, are synthesized in the chloroplast using a single set of enzymes, of which acetyl CoA carboxylase (ACCase) is key in regulating fatty acid synthesis rates. However, the expression of genes involved in fatty acid synthesis is poorly understood in microalgae. Synthesis and sequestration of TAG into cytosolic lipid bodies appear to be a protective mechanism by which algal cells cope with stress conditions, but little is known about regulation of TAG formation at the molecular and cellular level. While the concept of using microalgae as an alternative and renewable source of lipid-rich biomass feedstock for biofuels has been explored over the past few decades, a scalable, commercially viable system has yet to emerge. Today, the production of algal oil is primarily confined to high-value specialty oils with nutritional value, rather than commodity oils for biofuel. This review provides a brief summary of the current knowledge on oleaginous algae and their fatty acid and TAG biosynthesis, algal model systems and genomic approaches to a better understanding of TAG production, and a historical perspective and path forward for microalgae-based biofuel research and commercialization.

Document Type: Review

Author Keywords: microalgae; lipids; triacylglycerol; fatty acids; biofuels; Chlamydomonas reinhardtii

* *

Transgenics are imperative for biofuel crops

Author(s): Gressel J

Source: PLANT SCIENCE, Volume: 174, Issue: 3, Pages: 246-263, Published: MAR 2008

Times Cited: 8 References: 153

Abstract: Petroleum dependency is a challenge that can potentially be partly offset by agricultural production of biofuels, while decreasing net, nonrenewable carbon dioxide output. Plants have not been domesticated for modern biofuel production, and the quickest, most efficient, and often, the only way to convert plants to biofuel feedstocks is biotechnologically. First generation biofuel feedstock sources: sugarcane and cereal grains to produce bioethanol and biobutanol and oilseeds to produce biodiesel compete directly with needs for world food security. The heavy use of oilseed rape releases quantities of methyl bromide to the atmosphere, which can be prevented by gene suppression. Second generation bioethanolic/biobutanolic biofuels will come from cultivated lignocellulosic crops or straw wastes. These presently require heat and acid to remove lignin, which could be partially replaced by transgenically reducing or modifying lignin content and upregulating cellulose biosynthesis. Non-precipitable silicon emissions from burning could be reduced by transgenically modulating silicon content. The shrubby Jatropha and castor beans should have highly toxic protein components transgenically removed from their meal, cancer potentiating diterpenes removed from the oils, and allergens from the pollen, before extensive cultivation. Algae and cyanobacteria for third generation biodiesel need transgenic manipulation to deal with "weeds", light penetration, photoinhibition, carbon assimilation, etc. The possibilities of producing fourth generation biohydrogen and bioelectricity using photosynthetic mechanisms are being explored. There seem to be no health or environmental impact study requirements when the undomesticated biofuel crops are grown, yet there are illogically stringent requirements should they transgenically be rendered less toxic and more efficient as biofuel crops.

Document Type: Review

Author Keywords: biofuels; lignocellulosics; Jatropha; switchgrass; straw

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Production of electricity from the treatment of urban waste water using a microbial fuel cell

Author(s): Rodrigo MA, Canizares P, Lobato J, Paz R, Saez C, Linares JJ

Source: JOURNAL OF POWER SOURCES, Vol.: 169, Issue: 1, Special Issue: Sp. Iss. SI, Pg.: 198-204,
Published: JUN 10 2007

Times Cited: 8 References: 25
Abstract: In this work, is studied the oxidation of the pollutants contained in an actual urban wastewater using a two-chamber microbial fuel cell (MFC). By using an anaerobic pre-treatment of the activated sludge of an urban wastewater treatment plant, the electricity generation in a WC was obtained after a short acclimatization period of less than 10 days. The power density generated was found to depend mainly on the organic matter contain (COD) but not on the wastewater flow-rate. Maximum power densities of 25 mW m(-2) (at a cell potential of 0.23 V) were obtained. The rate of consumption of oxygen in the cathodic chamber was very low. As the oxygen reduction is coupled with the COD oxidation in the anodic chamber, the COD removed by the electricity-generating process is very small. Thus, taking into account the oxygen consumption, it was concluded that only 0.25% of the removed COD was used for the electricity-generation processes. The remaining COD should be removed by anaerobic processes. The presence of oxygen in the anodic chamber leads to a deterioration of the MFC performance. This deterioration of the MFC process occurs rapidly after the appearance of non-negligible concentrations of oxygen. Hence, to assure a good performance of this type of MFC, the growth of algae should be avoided. (C) 2007 Elsevier B.V. All rights reserved.

Document Type: Proceedings Paper

Author Keywords: waste water treatment; microbial fuel cell; electricity generation

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Micromachined microbial and photosynthetic fuel cells

Author(s): Chiao M, Lam KB, Lin LW

Source: JOURNAL OF MICROMECHANICS AND MICROENGINEERING, Vol.: 16, Issue: 12, Pg.: 2547-2553,
Published: DEC 2006

Times Cited: 7 References: 24
Abstract: This paper presents two types of fuel cells: a miniature microbial fuel cell (mu MFC) and a miniature photosynthetic electrochemical cell (mu PEC). A bulk micromachining process is used to fabricate the fuel cells, and the prototype has an active proton exchange membrane area of 1 cm(2). Two different micro-organisms are used as biocatalysts in the anode: (1) Saccharomyces cerevisiae (baker's yeast) is used to catalyze glucose and (2) Phylum Cyanophyta (blue-green algae) is used to produce electrons by a photosynthetic reaction under light. In the

dark, the mu PEC continues to generate power using the glucose produced under light. In the cathode, potassium ferricyanide is used to accept electrons and electric power is produced by the overall redox reactions. The bio-electrical responses of mu MFCs and mu PECs are characterized with the open-circuit potential measured at an average value of 300-500 mV. Under a 10 ohm load, the power density is measured as 2.3 nW cm(-2) and 0.04 nW cm(-2) for mu MFCs and mu PECs, respectively.

Document Type: Article

KeyWords Plus: ELECTRICITY-GENERATION; BIOFUEL CELLS; OUTPUT; LIGHT

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A review on microbial synthesis of hydrocarbons

Author(s): Ladygina N, Dedyukhina EG, Vainshtein MB

Source: PROCESS BIOCHEMISTRY, Vol.: 41, Issue: 5, Pg.: 1001-1014, Published: MAY 2006

Times Cited: 10 References: 145

Abstract: Review summarizes comparative data on the intracellular hydrocarbons of different microorganisms (cyanobacteria, aerobic and anaerobic bacteria, yeasts, and mycelial fungi). Certain systematic groups of microorganisms are characterized by specific composition of intracellular hydrocarbons, in particular, cyanobacteria are unique in their ability to produce 7- and 8-methylheptadecanes; photosynthetic bacteria are distinguished by the synthesis of cyclic hydrocarbons (pristane and phytane), whereas in fungi, long-chain hydrocarbons are predominant. The synthesis of hydrocarbons by microorganisms depends considerably on the growth conditions that provides a way for its physiological regulation. The processes for microbiological production of extracellular aliphatic and volatile non-methane hydrocarbons are exemplified. Pathways for the biosynthesis of straight chain-, branched-, volatile non-methane hydrocarbons, and isoprenoids are described. Mechanisms of the hydrocarbon synthesis appear to be different in various microorganisms. The role of hydrocarbons in microorganisms is discussed. (c) 2005 Elsevier Ltd. All rights reserved.

Document Type: Review

Author Keywords: microbial hydrocarbons; intracellular hydrocarbons; extracellular hydrocarbons; volatile hydrocarbons; biosynthesis; biofuel

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Utilization of macro-algae for enhanced CO2 fixation and biofuels production: Development of a computing software for an LCA study

Author(s): Aresta M, Dibenedetto A, Barberio G

Source: FUEL PROCESSING TECHNOLOGY, Volume: 86, Issue: 14-15, Pages: 1679-1693, Published: OCT 2005

Times Cited: 4 References: 49

Abstract: A Life Cycle Assessment study was carried out for evaluating the potential of utilizing marine biomass for energy production. Macro-algae obtained from the Adriatic and Jonian seas have been selected and tested for our initial case. Different techniques (supercritical CO2, organic solvents, and pyrolysis) were utilized in this study for the extraction of biofuel. Supercritical CO2 appears to be the most effective. A computing software has been developed which allows to evaluate various options and can be used with either aquatic or terrestrial biomass. It has been used in our studies to make an energetic evaluation of selected marine macro-algae. The results of the energetic assessment are presented here. (c) 2005 Elsevier B.V. All rights reserved.

Document Type: Proceedings Paper

Author Keywords: macro-algae; CO2 fixation; fuel production; life cycle assessment (LCA)

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Growth of microalgae with increased calorific values in a tubular bioreactor

Author(s): Scragg AH, Illman AM, Carden A, Shales SW

Source: BIOMASS & BIOENERGY, Volume: 23, Issue: 1, Pages: 67-73, Published: 2002

Times Cited: 10 References: 39

Abstract: In order to use microalgae as a fuel the algae should be of high calorific value and must be capable of growth in large volumes. Chlorella vulgaris and C emersonii have been shown to grow in a 2301 pumped tubular photobioreactor in Watanabe's medium and a low nitrogen medium. The low nitrogen medium induces higher lipid accumulation in both algae, which increased their calorific Value. The highest calorific value was obtained with C. vulgaris (28 kJ g(-1)) grown in low nitrogen medium. However. the biomass productivity was 24 mg dry wt 1(-1) d(-1) in the low nitrogen medium which was lower than in Watanabe's medium (40 mg dry wt 1(-1) d(-1)) and represents a reduced energy recovery. (C) 2002 Elsevier Science Ltd. All rights reserved.

Document Type: Article

Author Keywords: biofuel; Chlorella vulgaris; Chlorella emersonii; low nitrogen medium; pumped tubular photobioreactor

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Increase in Chlorella strains calorific values when grown in low nitrogen medium

Author(s): Illman AM, Scragg AH, Shales SW

Source: ENZYME AND MICROBIAL TECHNOLOGY, Volume: 27, Issue: 8, Pages: 631-635, Published: NOV 2000

Times Cited: 13 References: 23
Abstract: The calorific Value of five strains of Chlorella grown in Watanabe and low-nitrogen medium was determined. The algae were grown in small (2L) stirred tank bioreactors and the best growth was obtained with Chlorella vulgaris with a growth rate of 0.99 d(-1) and the highest calorific value (29 KJ/g) was obtained with C. emersonii. The cellular components were assayed at the end of the growth period and the calorific value appears to be linked to the lipid content rather than any other component. (C) 2000 Elsevier Science Inc. All rights reserved.

Document Type: Article

Author Keywords: microalgae; calorific value; lipid; biofuel; bioreactor

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Effects of light, CO2 and inhibitors on the current output of biofuel cells containing the photosynthetic organism Synechococcus sp.

Author(s): YAGISHITA T, HORIGOME T, TANAKA K

Source: JOURNAL OF CHEMICAL TECHNOLOGY AND BIOTECHNOLOGY, Volume: 56, Issue: 4, Pages: 393-399,
Published: 1993

Times Cited: 16 References: 23

Abstract: The current output of the biofuel cells containing a marine alga, Synechococcus sp. and an electron transport mediator, 2-hydroxy-1,4-naphthoquinone (HNQ) was increased under illumination and in the presence of CO2. The inhibitory effects of carbonyl cyanide m-chlorophenylhydrazone (CCCP), 3-(3,4-dichlorophenyl)-1,1-dimethylurea (DCMU),

2,5-dibromomethylisopropyl-p-benzoquinone (DBMIB), phenylmercury acetate (PMA) and N,N'-dicyclohexylcarbodiimide (DCCD) on the output current of fuel cells run in the light suggested that HNQ accepts electrons mainly at the site of ferredoxin-NADP+ reductase (FNR) in the electron transfer chain. The inhibition of light-induced generation of current output by CCCP indicates that the current is derived from photosynthetic oxidation of water. Endogenous glycogen in algae is required to sustain a steady current output from the fuel cells.

Document Type: Article

Author Keywords: FUEL CELLS; BIOFUEL CELLS; CYANOBACTERIUM; ELECTRON TRANSPORT MEDIATOR; SYNECHOCOCCUS SP

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Renewable sustainable biocatalyzed electricity production in a photosynthetic algal microbial fuel cell (PAMFC)

Author(s): Strik DPBTB, Terlouw H, Hamelers HVM, Buisman CJN

Source: APPLIED MICROBIOLOGY AND BIOTECHNOLOGY, Vol.: 81, Issue: 4, Pg.: 659-668, Published: DEC 2008

Times Cited: 1 References: 37
Abstract: Electricity production via solar energy capturing by living higher plants and microalgae in combination with microbial fuel cells are attractive because these systems promise to generate useful energy in a renewable, sustainable, and efficient manner. This study describes the proof of principle of a photosynthetic algal microbial fuel cell (PAMFC) based on naturally selected algae and electrochemically active microorganisms in an open system and without addition of instable or toxic mediators. The developed solar-powered PAMFC produced continuously over 100 days renewable biocatalyzed electricity. The sustainable performance of the PAMFC resulted in a maximum current density of 539 mA/m(2) projected anode surface area and a maximum power production of 110 mW/m(2) surface area photobioreactor. The energy recovery of the PAMFC can be increased by optimization of the photobioreactor, by reducing the competition from non-electrochemically active microorganisms, by increasing the electrode surface and establishment of a further-enriched biofilm. Since the objective is to produce net renewable energy with algae, future research should also focus on the development of low energy input PAMFCs. This is because current algae production systems have energy inputs similar to the energy present in the outcoming valuable products.

Document Type: Article

Author Keywords: Alga; Bioenergy; Electricity; Microbial fuel cell; Photobioreactor; Renewable

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Perspectives of microbial oils for biodiesel production

Author(s): Li Q, Du W, Liu DH

Source: APPLIED MICROBIOLOGY AND BIOTECHNOLOGY, Vol.: 80, Issue: 5, Pg.: 749-756, Published: OCT 2008

Times Cited: 1 References: 51
Abstract: Biodiesel has become more attractive recently because of its environmental benefits, and the fact that it is made from renewable resources. Generally speaking, biodiesel is prepared through transesterification of vegetable oils or animal fats with short chain alcohols. However, the lack of oil feedstocks limits the large-scale development of biodiesel to some extent. Recently, much attention has been paid to the development of microbial, oils and it has been found that many microorganisms, such as algae, yeast, bacteria, and fungi, have the ability to accumulate oils under some special cultivation conditions. Compared to other plant oils, microbial oils have many advantages, such as short life cycle, less labor required, less affection by venue, season and climate, and easier to scale up. With the rapid expansion of biodiesel, microbial oils might become one of potential oil feedstocks for biodiesel production in the future, though there are many works associated with microorganisms producing oils need to be carried out further. This review is covering the related research about different oleaginous microorganisms producing oils, and the prospects of such microbial oils used for biodiesel production are also discussed.

Document Type: Review

Author Keywords: biodiesel; oleaginous microorganisms; microbial oil; sustainability

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Livestock waste-to-bioenergy generation opportunities

Author(s): Cantrell KB, Ducey T, Ro KS, Hunt PG

Source: BIORESOURCE TECHNOLOGY, Volume: 99, Issue: 17, Pages: 7941-7953, Published: NOV 2008

Times Cited: 1 References: 156
Abstract: The use of biological and thermochemical conversion (TCC) technologies in livestock waste-to-bioenergy treatments can provide livestock operators with multiple value-added, renewable energy products. These products can meet heating and power needs or serve as transportation fuels. The primary objective of this work is to present established and emerging

energy conversion opportunities that can transform the treatment of livestock waste from a liability to a profit center. While biological production of methanol and hydrogen are in early research stages, anaerobic digestion is an established method of generating between 0.1 to 1.3 m(3) m(-3) d(-1) of methane-rich biogas. The TCC processes of pyrolysis, direct liquefaction, and gasification can convert waste into gaseous fuels, combustible oils, and charcoal. Integration of biological and thermal-based conversion technologies in a farm-scale hybrid design by combining an algal CO2-fixation treatment requiring less than 27,000 m(2) of treatment area with the energy recovery component of wet gasification can drastically reduce CO2 emissions and efficiently recycle nutrients. These designs have the potential to make future large scale confined animal feeding operations sustainable and environmentally benign while generating on-farm renewable energy. Published by Elsevier Ltd.

Document Type: Review

Author Keywords: animal manure; thermochemical conversion; anaerobic digestion; gasification; algal treatment

* *

Evaluation of marine algae as a source of biogas in a two-stage anaerobic reactor system

Author(s): Vergara-Fernandez A, Vargas G, Alarcon N, Velasco A

Source: BIOMASS & BIOENERGY, Volume: 32, Issue: 4, Pages: 338-344, Published: APR 2008

Times Cited: 1 References: 21

Abstract: The marine algae are considered an important biomass source; however, their utilization as energy source is still low around the world. The technical feasibility of marine algae utilization as a source of renewable energy was studied to laboratory scale. The anaerobic digestion of Macrocystis pyrifera, Durvillea antarctica and their blend 1:1 (w/w) was evaluated in a two-phase anaerobic digestion system, which consisted of an anaerobic sequencing batch reactor (ASBR) and an upflow anaerobic filter (UAF). The results show that 70% of the total biogas produced in the system was generated in the UAF, and both algae species have similar biogas productions of 180.4(+/- 1.5) mL g(-1) dry algae d(-1), with a methane concentration around 65%. The same methane content was observed in biogas yield of algae blend; however, a lower biogas yield was obtained. In conclusion, either algae species or their blend can be utilized to produce methane gas in a two-phase digestion system.

Document Type: Article

Author Keywords: two-phase anaerobic digestion; ASBR; UAF; methane; renewable energy; Macrocystis pyrifera; Durvillea antarctica

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Opportunities for renewable bioenergy using microorganisms

Author(s): Rittmann BE

Source: BIOTECHNOLOGY AND BIOENGINEERING, Volume: 100, Issue: 2, Pages: 203-212, Published: JUN 1 2008

Times Cited: 5 References: 45

Abstract: Global warming can be slowed, and perhaps reversed, only when society replaces fossil fuels with renewable, carbon-neutral alternatives. The best option is bioenergy: the sun's energy is captured in biomass and converted to energy forms useful to modern society. To make a dent in global warming, bioenergy must be generated at a very high rate, since the world today uses similar to 10 TW of fossil-fuel energy. And, it must do so without inflicting serious damage on the environment or disrupting our food supply. While most bioenergy options fail on both counts, several microorganism-based options have the potential to produce large amounts of renewable energy without disruptions. In one approach, microbial communities convert the energy value of various biomass residuals to socially useful energy. Biomass residuals come from agricultural, animal, and a variety of industrial operations, as well as from human wastes. Microorganisms can convert almost all of the energy in these wastes to methane, hydrogen, and electricity. In a second approach, photosynthetic microorganisms convert sunlight into biodiesel. Certain algae (eukaryotes) or cyanobacteria (prokaryotes) have high lipid contents. Under proper conditions, these photosynthetic microorganisms can produce lipids for biodiesel with yields per unit area 100 times or more than possible with any plant system. In addition, the non-lipid biomass can be converted to methane, hydrogen, or electricity. Photosynthetic microorganisms do not require arable land, an advantage because our arable land must be used to produce food. Algae or cyanobacteria may be the best option to produce bioenergy at rates high enough to replace a substantial fraction of our society's use of fossil fuels.

Document Type: Editorial Material

Author Keywords: biodiesel; bioelectricity; bioenergy; biohydrogen; methane; microbial fuel cell; microorganisms; photosynthesis

* *

Biodiesel production-current state of the art and challenges

Author(s): Vasudevan PT, Briggs M

Source: JOURNAL OF INDUSTRIAL MICROBIOLOGY & BIOTECHNOLOGY, Volume: 35, Issue: 5, Pg.: 421-430,
Published: MAY 2008

Times Cited: 2 References: 48

Abstract: Biodiesel is a clean-burning fuel produced from grease, vegetable oils, or animal fats. Biodiesel is produced by transesterification of oils with short-chain alcohols or by the esterification of fatty acids. The transesterification reaction consists of transforming triglycerides into fatty acid alkyl esters, in the presence of an alcohol, such as methanol or ethanol, and a catalyst, such as an alkali or acid, with glycerol as a byproduct. Because of diminishing petroleum reserves and the deleterious environmental consequences of exhaust gases from petroleum diesel, biodiesel has attracted attention during the past few years as a renewable and environmentally friendly fuel. Since biodiesel is made entirely from vegetable oil or animal fats, it is renewable and biodegradable. The majority of biodiesel today is produced by alkali-catalyzed transesterification with methanol, which results in a relatively short reaction time. However, the vegetable oil and alcohol must be substantially anhydrous and have a low free fatty acid content, because the presence of water or free fatty acid or both promotes soap formation. In this article, we examine different biodiesel sources (edible and nonedible), virgin oil versus waste oil, algae-based biodiesel that is gaining increasing importance, role of different catalysts including enzyme catalysts, and the current state-of-the-art in biodiesel production.

Document Type: Review

Author Keywords: biodiesel; edible and nonedible; algae-based; waste oil; enzymes; catalysis; lipase; photosynthesis

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Hydrogen fuel production by transgenic microalgae

Author(s): Melis A, Seibert M, Ghirardi ML

Source: TRANSGENIC MICROALGAE AS GREEN CELL FACTORIES, Book Series: ADVANCES IN EXPERIMENTAL MEDICINE AND BIOLOGY, Volume: 616, Pages: 108-121, Published: 2007

Times Cited: 1 References: 76

Abstract: This chapter summarizes the state-of-art in the field of green algal H-2-production and examines physiological and genetic engineering approaches by which to improve the hydrogen metabolism characteristics of these microalgae. Included in this chapter are emerging topics pertaining to the application of sulfur-nutrient deprivation to attenuate O-2-evolution and to

promote H-2-production, as well as the genetic; engineering of sulfate uptake through manipulation of a newly reported sulfate permease in the chloroplast of the model green alga Chlamydomonas reinhardtii. Application of the green algal hydrogenase assembly genes is examined in efforts to confer H-2-production capacity to other commercially significant unicellular green algae. Engineering a solution to the O-2 sensitivity of the green algal hydrogenase is discussed as an alternative approach to sulfur nutrient deprivation, along with starch accumulation in microalgae for enhanced H-2-production. Lastly, current efforts aiming to optimize light utilization in transgenic microalgae for enhanced H-2-production under mass culture conditions are presented. It is evident that application of genetic engineering technologies and the use of transgenic green algae will improve prospects for commercial exploitation of these photosynthetic micro-organisms in the generation of H-2, a clean and renewable fuel.

Document Type: Review

KeyWords Plus: ALGA CHLAMYDOMONAS-REINHARDTII; PHOTOSYNTHETIC ELECTRON-TRANSPORT; CHLOROPLAST SULFATE PERMEASE; REACTION-CENTER DAMAGE; FE-ONLY HYDROGENASE; GREEN-ALGA; PHOTOSYSTEM-II; S-ADENOSYLMETHIONINE; BIOTIN SYNTHASE; DESULFOVIBRIO-DESULFURICANS

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Influence of CO2 on growth and hydrocarbon production in Botryococcus braunii

Author(s): Ranga Rao A, Ravishankar GA

Source: JOURNAL OF MICROBIOLOGY AND BIOTECHNOLOGY, Vol.: 17, Issue: 3, Pg.: 414-419,
Published: MAR 2007

Times Cited: 0 References: 20

Abstract: Botryococcus braunii is a green colonial fresh water microalga and it is recognized as one of the renewable resources for production of liquid hydrocarbons. CFTRI-Bb-1 and CFTRI-Bb-2 have been reported for the first time and their performance with regard to growth and biochemical profile is presented here. The present study focused on effect of carbon dioxide (CO2) on biomass, hydrocarbon, carbohydrate production, fatty acid profile, and carotenoid content in various species of B. braunii (LB-572, SAG 30.81, MCRC-Bb, N-836, CFTRI-Bb-1, and CFTRI-Bb-2) at 0.5, 1.0, and 2.0% (v/v) levels using a two-tier flask. CO2 at 2.0% (v/v) level enhanced growth of the organism, and a two-fold increase in biomass and carotenoid contents was observed in all the B. braunii strains studied compared with control culture (without CO2 supplementation). At 1% and 2% (v/v) CO2 concentrations, palmitic acid and oleic acid levels increased by 2.5 to 3 folds in one of the strains of B. braunii (LB-572). Hydrocarbon content was found to be above 20% at 2% CO2 level in the B. braunii LB-572, CFTRI-Bb-2, CFTRI-Bb-1, and N-836 strains, whereas it was less than 20% in the SAG 30.81 and MCRC-Bb

strains compared with control culture. This culture methodology will provide information on CO2 requirement for growth of algae and metabolite production. B. braunii spp. can be grown at the tested levels of CO2 concentration without much influence on culture pH.

Document Type: Article

Author Keywords: Botryococcus braunii; microalga; hydrocarbon; biomass; carotenoids; carbon dioxide; fatty acids

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Integrated biological hydrogen production

Author(s): Melis A, Melnicki MR

Source: INTERNATIONAL JOURNAL OF HYDROGEN ENERGY, Volume: 31, Issue: 11, Special Issue: Sp. Iss. SI,
Pages: 1563-1573, Published: SEP 2006

Times Cited: 15 References: 78
Abstract: Biological systems offer a variety of ways by which to generate renewable energy. Among them, unicellular green algae have the ability to capture the visible portion of sunlight and store the energy as hydrogen (H-2). They hold promise in generating a renewable fuel from nature's most plentiful resources, sunlight and water. Anoxygenic photosynthetic bacteria have the ability of capturing the near infrared emission of sunlight to produce hydrogen while consuming small organic acids. Dark anaerobic fermentative bacteria consume carbohydrates, thus generating H-2 and small organic acids. Whereas efforts are under way to develop each of these individual systems, little effort has been undertaken to combine and integrate these various processes for increased efficiency and greater yields. This work addresses the development of an integrated biological hydrogen production process based on unicellular green algae, which are driven by the visible portion of the solar spectrum, coupled with purple photosynthetic bacteria, which are driven by the near infrared portion of the spectrum. Specific methods have been tested for the cocultivation and production of H-2 by the two different biological systems. Thus, a two-dimensional integration of photobiological H-2 production has been achieved, resulting in better solar irradiance utilization (visible and infrared) and integration of nutrient utilization for the cost-effective production of substantial amounts of hydrogen gas. Approaches are discussed for the cocultivation and coproduction of hydrogen in green algae and purple photosynthetic bacteria entailing broad utilization of the solar spectrum. The possibility to improve efficiency even further is discussed, with dark anaerobic fermentations of the photosynthetic biomass, enhancing the H-2 production process and providing a recursive link in the system to regenerate some of the original nutrients. (c) 2006 International Association for Hydrogen Energy. Published by Elsevier Ltd. All rights reserved.

Document Type: Proceedings Paper

Author Keywords: Chlamydontonas reinhardtii; green algae; Rhodospirillum rubrum; photosynthetic bacteria; Clostridium sp.; fermentative bacteria; photobiology; hydrogen production

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Hydrogen production by photosynthetic green algae

Author(s): Ghirardi ML

Source: INDIAN JOURNAL OF BIOCHEMISTRY & BIOPHYSICS, Vol.: 43, Issue: 4, Pg.: 201-210,
Published: AUG 2006

Times Cited: 10 References: 82
Abstract: Oxygenic photosynthetic organisms such as cyanobacteria, green algae and diatoms are capable of absorbing light and storing up to 10-13% of its energy into the H-H bond of hydrogen gas. This process, which takes advantage of the photosynthetic apparatus of these organisms to convert sunlight into chemical energy, could conceivably be harnessed for production of significant amounts of energy from a renewable resource, water. The harnessed energy could then be coupled to a fuel cell for electricity generation and recycling of water molecules. In this review, current biochemical understanding of this reaction in green algae, and some of the major challenges facing the development of future commercial algal photobiological systems for H-2 production have been discussed.

Document Type: Review

Author Keywords: green algae; hydrogen production; algal hydrogenases

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Liquid fuel production using microalgae

Author(s): Tsukahara K, Sawayama S

Source: JOURNAL OF THE JAPAN PETROLEUM INSTITUTE, Vol.: 48, Issue: 5, Pg.: 251-259, Published: SEP 2005

Times Cited: 2 References: 40

Abstract: Recently, biomass has attracted much attention as a renewable energy resource. Microalgae are particularly promising biomass species because of the high growth rate and high

CO_2 fixation ability compared to plants. Effective liquid fuel production from microalgae was studied using Botryococcus braunii and Dunaliella tertiolecta, which accumulated terpenoid hydrocarbon and glycerol, respectively. B. braunii could remove nitrogen and phosphorus from secondarily treated sewage (STS) in a batch system and a continuous bioreactor system with hydrocarbon production. The intracellular glycerol content could be controlled by post-translational modifications in D. tertiolecta. B. braunii is more profitable for liquid fuel production than D. tertiolecta based on calculating the energy balance.

Document Type: Review

Author Keywords: biomass; Botryococcus braunii; Dunaliella tertiolecta; energy balance; liquid fuel production; microalgae

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Temporal phenomena of hydrogen photobioproduction

Author(s): Dante RC, Armenta S, Gutierrez M, Celis J

Source: INTERNATIONAL JOURNAL OF HYDROGEN ENERGY, Vol.: 29, Issue: 12, Pg.: 1219-1226,
Published: SEP 2004

Times Cited: 1 References: 23
Abstract: The pbotobioproduction of hydrogen through in water alga systems has been studied as a suitable way for clean hydrogen generation from renewable solar energy and renewable bio-sources. There is evidence of such hydrogen path metabolism involving some algae types in stress conditions and it has been reported by several authors. In this paper some results of hydrogen production are shown for different stress conditions carried out in not full aseptic environment stabilized by antibiotics, Chlamydomonas reinhardtii has got resistance to. Oscillations and temporal phenomena of hydrogen production have been observed and studied by means of Fourier analysis. Their nature can be related to the variation of hydrogen production rate usually reflected on the cumulative hydrogen curves by the presence of shoulders or accentuated changes of slope. (C) 2003 International Association for Hydrogen Energy. Published by Elsevier Ltd. All rights reserved.

Document Type: Article

Author Keywords: Chlamydomonas reinhardtii; hydrogen photobioproduction; biophotolisis; Green alga; hydrogenase; renewable energies; fuel cells

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High yield bio-oil production from fast pyrolysis by metabolic controlling of Chlorella protothecoides

Author(s): Miao XL, Wu QY

Source: JOURNAL OF BIOTECHNOLOGY, Volume: 110, Issue: 1, Pages: 85-93, Published: MAY 13 2004

Times Cited: 15 References: 33

Abstract: The use of renewable energy sources is becoming increasingly necessary to mitigate global warming. Recently much research has been focused on identifying suitable biomass species, which can provide high-energy outputs, to replace conventional fossil fuels. This paper reports an approach for increasing the yield of bio-oil production from fast pyrolysis after manipulating the metabolic pathway in microalgae through heterotrophic growth. The yield of bio-oil (57.9%) produced from heterotrophic Chlorella protothecoides cells was 3.4 times higher than from autotrophic cells by fast pyrolysis. The bio-oil was characterized by a much lower oxygen content, with a higher heating value (41 MJ kg(-1)), a lower density (0.92 kg l(-1)), and lower viscosity (0.02 Pas) compared to those of bio-oil from autotrophic cells and wood. These properties are comparable to fossil oil. The research could contribute to the creation of a system to produce energy from microalgae, and also could have great commercial potential for liquid fuel production. (C) 2004 Elsevier B.V. All rights reserved.

Document Type: Article

Author Keywords: heterotrophic; Chlorella protothecoides; lipid; fast pyrolysis; bio-oil

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A power-law sensitivity analysis of the hydrogen-producing metabolic pathway in Chlamydomonas reinhardtii

Author(s): Horner JK, Wolinsky MA

Source: INTERNATIONAL JOURNAL OF HYDROGEN ENERGY, Volume: 27, Issue: 11-12, Pages: 1251-1255,
Published: NOV-DEC 2002

Times Cited: 5 References: 8

Abstract: Melis et al. have demonstrated that the green alga Chlamydomonas reinhardtii, when deprived of sulfur, can produce hydrogen gas for similar to70 h, then can resume hydrogen gas production after a brief period of "recharging" in the presence of sulfur. Here we describe an S-system model of H-2 production by C reinhardtii. Through that model we investigate the sensitivity of H-2 production to photosynthetic efficiency, and to contention for the protons produced by the photolysis of water, between hydrogen production on the one hand, and ATP consumption by cellular functions outside the H-2 production path on the other. The model

identifies for experimental investigation several potential systemic constraints on any genetic re-engineering effort aimed at increasing the H-2 production efficiency of the alga. (C) 2002 Published by Elsevier Science Ltd on behalf of the International Association for Hydrogen Energy.

Document Type: Proceedings Paper

Author Keywords: hydrogen; green algae; photosynthetic algae; renewable energy; solar energy; S-system

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Hydrogen production. Green algae as a source of energy

Author(s): Melis A, Happe T

Source: PLANT PHYSIOLOGY, Volume: 127, Issue: 3, Pages: 740-748, Published: NOV 2001
Times Cited: 91 References: 45
Abstract: Hydrogen gas is thought to be the ideal fuel for a world in which air pollution has been alleviated, global warming has been arrested, and the environment has been protected in an economically sustainable manner. Hydrogen and electricity could team to provide attractive options in transportation and power generation. Interconversion between these two forms of energy suggests on-site utilization of hydrogen to generate electricity, with the electrical power arid serving in energy transportation, distribution utilization, and hydrogen regeneration as needed. A challenging problem in establishing H-2 as a source of energy for the future is the renewable and environmentally friendly generation of large quantities of H-2 gas. Thus, processes that are presently conceptual in nature, or at a developmental stage in the laboratory, need to be encouraged, tested for feasibility, and otherwise applied toward commercialization.

Document Type: Article

KeyWords Plus: AMINO-ACID-SEQUENCE; CHLAMYDOMONAS-REINHARDTII; PHOTOSYSTEM-II; CLOSTRIDIUM-PASTEURIANUM; FERMENTATIVE METABOLISM; ELECTRON-TRANSPORT; ONLY HYDROGENASES; IRON-HYDROGENASE; NDH GENES; MECHANISM

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Microalgae: a green source of renewable H-2

Author(s): Ghirardi ML, Zhang JP, Lee JW, Flynn T, Seibert M, Greenbaum E, Melis A

Source: TRENDS IN BIOTECHNOLOGY, Volume: 18, Issue: 12, Pages: 506-511, Published: DEC 2000

Times Cited: 114 References: 39

Abstract: This article summarizes recent advances in the field of algal hydrogen production. Two fundamental approaches are being developed. One involves the temporal separation of the usually incompatible reactions of O-2 and H-2 production in green algae, and the second involves the use of classical genetics to increase the O-2 tolerance of the reversible hydrogenase enzyme. The economic and environmental impact of a renewable source of H-2 are also discussed.

Document Type: Review

KeyWords Plus: PHOTOSYNTHETIC ELECTRON-TRANSPORT; CHLAMYDOMONAS-REINHARDTII; FERMENTATIVE METABOLISM; HYDROGEN METABOLISM; CYANOBACTERIUM; NITROGENASE; EVOLUTION; PROTEIN

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Pyrolytic characteristics of heterotrophic Chlorella protothecoides for renewable bio-fuel production

Author(s): Peng WM, Wu QY, Tu PG

Source: JOURNAL OF APPLIED PHYCOLOGY, Volume: 13, Issue: 1, Pages: 5-12, Published: FEB 2001
Times Cited: 5 References: 30

Abstract: Heterotrophic Chlorella protothecoides cells were pyrolyzed in a thermogravimetric analyzer to investigate the pyrolytic characteristics and determine the kinetic parameters. Heating rates of 15, 40, 60 and 80 degreesC min(-1) up to a final temperature of 800 degreesC were used. The pyrolysis reactions mainly took place between 160-520 degreesC with a volatile yield of about 80%. The devolatilization stage consisted of two main temperature zones (I and II) with a transition at 300-320 degreesC. Crude lipid in cells decomposed at Zone II while other main components at Zone I. The increase of heating rate caused a lateral shift to higher temperatures in the thermograms, a decrease of activation energies for the devolatilization stage and an increase of both the instantaneous maximum and average reaction rates. The difference of activation energies between two zones implied that more energy input for lipid pyrolysis seems needed in comparison with other main components. These data are useful for the design, operation, and modeling of the pyrolysis systems for microalgae.

Document Type: Article

Author Keywords: Chlorella protothecoides; devolatilization; heterotrophic culture; microalga; pyrolysis; thermogravimetric analysis

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Hydrogen production by microalgae

Author(s): Benemann JR

Source: JOURNAL OF APPLIED PHYCOLOGY, Volume: 12, Issue: 3-5, Pages: 291-300, Published: OCT 2000

Times Cited: 31 References: 64

Abstract: The production of H-2 gas from water and sunlight using microalgae, 'biophotolysis', has been a subject of applied research since the early 1970s. A number of approaches have been investigated, but most proved to have fundamental limitations or require unpredictable research breakthroughs. Examples are processes based on nitrogen-fixing microalgae and those producing H-2 and O-2 simultaneously from water ('direct biophotolysis'). The most plausible processes for future applied R & D are those which couple separate stages of microalgal photosynthesis and fermentations ('indirect biophotolysis'). These involve fixation of CO2 into storage carbohydrates followed by their conversion to H-2 by the reversible hydrogenase, both in dark and possibly light-driven anaerobic metabolic processes. Based on a preliminary engineering and economic analysis, biophotolysis processes must achieve close to an overall 10% solar energy conversion efficiency to be competitive with alternatives sources of renewable H-2, such as photovoltaic-electrolysis processes. Such high solar conversion efficiencies in photosynthetic CO2 fixation could be reached by genetically reducing the number of light harvesting (antenna) chlorophylls and other pigments in microalgae. Similarly, greatly increased yields of H-2 from dark fermentation by microalgae could be obtained through application of the techniques of metabolic engineering. Another challenge is to scale-up biohydrogen processes with economically viable bioreactors. Solar energy driven microalgae processes for biohydrogen production are potentially large-scale, but also involve long-term and economically high-risk R&D. In the nearer-term, it may be possible to combine microalgal H-2 production with wastewater treatment.

Document Type: Proceedings Paper

Author Keywords: biophotolysis; fermentations; hydrogen; microalgae; photobioreactors; photosynthetic efficiencies

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Azolla: A review of its biology and utilization

Author(s): Wagner GM

Source: BOTANICAL REVIEW, Volume: 63, Issue: 1, Pages: 1-26, Published: JAN-MAR 1997

Times Cited: 37 References: 122

Abstract: The Azolla-Anabaena symbiosis is outstanding due to its high productivity combined with its ability to fix nitrogen at high rates. Because of this, in recent decades, countless studies have been conducted on this association, but with insufficient synthesis and coordination. This paper, therefore, attempts to review and synthesize past and recent findings concerning the biology and utilization of Azolla in hopes that this will facilitate increased future collaborative research on this "green gold mine." It reviews the taxonomy,distribution, morphology, physiology, and reproduction of Azolla as well as new developments in its manifold uses.

Because of the growing concern about conservation of the environment and the need for deploying renewable, sustainable resources; the application of Azolla as a biofertilizer on agricultural crops, in order to provide a natural source of the crucial nutrient nitrogen, can be very beneficial to the future of our planet. Besides the environmental appropriateness of the use of Azolla, for multitudes of farmers in many parts of the world who cannot afford chemical fertilizers, Azolla application can enhance their economic status, increasing yields while minimizing costs. Due to the fact that rice paddy fields form an ideal environment for Azolla, one of its most suitable applications is on rice.

Besides its utilization as a biofertilizer on a variety of crops, Azolla can be used as an animal feed, a human food, a medicine, and a water purifier. It may also be used for the production of hydrogen fuel, the production of biogas, the control of weeds, the control of mosquitoes, and the reduction of ammonia volatilization which accompanies the application of chemical nitrogen fertilizer.

Document Type: Review

KeyWords Plus: BLUE-GREEN-ALGAE; WHEAT CROPPING SYSTEM; ANABAENA SYMBIOSIS; NITROGEN-FIXATION; ACETYLENE-REDUCTION; RICE CULTURE; FLOODED RICE; WETLAND RICE; PHOSPHORUS; PINNATA

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Alternative fuels from biomass and their impact on carbon-dioxide accumulation

Author(s): WYMAN CE

Source: APPLIED BIOCHEMISTRY AND BIOTECHNOLOGY, Volume: 45-6, Pages: 897-915, Published: SPR 1994

Times Cited: 24 References: 31

Abstract: A number of transportation fuels can be produced from renewable resources. The major fractions of lignocellulosic biomass, cellulose and hemicellulose, can be broken down into sugars that can be fermented into ethanol. Biomass can also be gasified to a mixture of carbon monoxide and hydrogen for catalytic conversion into methanol. Algae could consume carbon dioxide from power plants and other sources to produce lipid oil that can be converted into a diesel fuel substitute, Through anaerobic digestion, a consortium of bacteria can break down lignocellulosic biomass to generate a medium-energy-content gas that can be cleaned up for pipeline-quality methane. Catalytic processing of pyrolytic oils from biomass produces a mixture of olefins that can be reacted with alcohols to form ethers, such as methyl tertiary butyl ether (MTBE), for use in reformulated gasoline to reduce emissions. Each of these technologies is briefly described. The costs have been reduced significantly for biofuels, and the potential exists for them to be competitive with conventional fuels. An analysis of energy flows is presented for ethanol production as an example of these technologies, and a carbon dioxide balance is provided for the fossil fuels used. This analysis includes consideration of fuel utilization performance and assignment of carbon dioxide to coproduct. Biofuels technologies are shown to require little, if any, fossil fuel inputs. As a result, most or all of the carbon is recycled through their use, reducing substantially the net release of carbon dioxide to the atmosphere.

Document Type: Proceedings Paper

Author Keywords: CARBON DIOXIDE; ENERGY BALANCE; BIOFUELS, BIOMASS; CONVERSION

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Solar-energy conversion from water photolysis by biological and chemical-systems

Author(s): DELAROSA MA, NAVARRO JA, RONCEL M

Source: APPLIED BIOCHEMISTRY AND BIOTECHNOLOGY, Vol.: 30, Issue: 1, Pages: 61-81, Published: JUL 1991

Times Cited: 4 References: 104

Abstract: The production of chemicals and fuels, or energy-rich compounds, from water by sunlight is described as a particularly attractive means for the conversion of solar energy to a valuable renewable resource. The redox properties of photoexcited molecules and the operating mechanism of light-driven systems are first considered. The mechanism of water oxidation carried out by higher plants and green algae - which is actually one of the most important biochemical reactions - as well as that of artificial photosystems, up-to-now designed trying to simulate the natural process with higher efficiency and simplicity, are likewise discussed. A number of biological and chemical light-driven systems are presented as practical ways to solar energy conversion.

Document Type: Review

Author Keywords: WATER PHOTOLYSIS; ARTIFICIAL PHOTOSYNTHESIS; ENERGY-RICH COMPOUNDS; SOLAR ENERGY CONVERSION; PHOTOCHEMICAL SYSTEMS