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Microlgae: A New Vista of Green Energy

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The use of fossil fuels is increasingly questioned due to depleting natural energy resources and the accumulation of greenhouse gases (GHGs). Biofuels are competent substitute to existing fossil fuel based energy sources as they can be utilized for transport with little modification to existing techniques. They thus offer the prospect of ecological sustainability and reduced GHGs emission. Microalgae are unicellular autotrophic organisms that can convert atmospheric CO_2 into lipids which, after esterification, can be utilized as an energy source. Moreover, other bio-metabolites such as bioethanol and bio-hydrogen produced by algal cells are also potentially exploitable energy sources. On large scales, microalgae are cultivated either in open pond systems or in closed photo bioreactors. In this paper we review the prospects of microalgae for the production of valuable lipid compounds and other by-product that can be additionally used for biofuel production.

Introduction

Sustainable production of renewable energy is being debated world over. Algae have recently received a lot of attention as a new biomass source for the production of renewable energy. Oil-rich microalgae species are the most productive for biofuel as compared to conventional food crops, providing 10–100 times higher biomass and oil yield than land oil crops. Algae can be cultivated under different climatic conditions and harvested year-round, but do not compete with arable land for food and feed production. Microalgae also have many potential environmental benefits, including greenhouse gas mitigation by fixing CO_2 in the atmosphere, i.e. photosynthesis of CO_2 to fuel by sunlight, and bioremediation of wastewater by efficiently removing nutrients (e.g., nitrogen, phosphorous) and heavy metals. High lipid content of microalgae cells made them member of choice for biofuel production. Lipid content of microalgae varies from 2–60 percent of total cell dry matter depending on the species and growth conditions. Lipids are present within algal cells as membrane components, storage products, metabolites and storages of energy. Tri-glycerides and free fatty acids, a fraction of the total lipid content, can be converted into biodiesel. Algal oil is unsaturated to a larger degree making it less appropriate for direct combustion in sensitive engines. In order to efficiently produce biodiesel from algae, strains have to be selected with a high growth rate and oil content. For some algae species, the whole cell can function as a bioreactor to directly produce fuels such as hydrogen and ethanol. The starch-rich algae can also be used as feedstock for fermenting ethanol and hydrogen. Thermo chemical conversion of oil-rich algae can produce fuel gas and/or bio-oil. A technology for gasification of algal biomass with high moisture contents has been developed to produce methane and hydrogen (Elliot and Sealock, 1999). Thermal reactions by pyrolysis, liquefaction, or hydrogenation mainly convert algae to bio-oils. Algae residues remaining after oil extraction or thermal conversion can be digested under anaerobic conditions to produce biogas for electricity

Cultivation of Algae

Algae need light, CO_2, water, and macro- and micronutrients for photosynthesis. Sunlight, air, and seawater or waste water can basically meet the requirement for algae growth. However, optimal cultivation conditions can achieve better algae growth. Light wavelengths between approximately 450 nm (blue) and 650 nm (red) are usually preferred (Marsh, 2008), temperature range for algal cultivation is 25–35°C and CO_2 must be provided at an optimal concentration 350–1000 ppm. The pH of the culture media is preferred to be maintained between 7 and 9. Mixing is required to make sure algae are evenly exposed to light and nutrients. Algae can be cultivated in low cost production systems such as open ponds. This system is typically operated in a continuous mode with a fixed supply of culture media, water, and nutrients. Contamination is the main risk of open systems. Cultivating algae in an enclosed bioreactor, in which the system is strictly controlled and no contamination occurs, is an alternative to overcome the problems with open systems. However, the high investment and operating costs are the main problem for the enclosed bioreactor. This system is suggested for algae cultivation for production of high value fatty acids.

Algal biodiesel

Algal oil can be converted to biodiesel and other fuels via transesterfication in which algal oil reacts with alcohols in the presence of a base catalyst to produce glycerol and biodiesel (methyl or ethyl ester). Biodiesel yield is more than 90% and the biodiesel quality is comparable to conventional petroleum diesel (Amin, 2009).

Bioethanol

Microalgae produce carbohydrates and proteins that can be used as carbon sources for ethanol fermentation. In addition, they exhibit greater sustainable and commercial advantages over conventional biofuel crops. These include: (1) microalgae grow rapidly and in a wide range of locations, with or without soil (2) microalgae have the potential to absorb CO_2 and other GHGs for photosynthesis with using less agricultural land (3) microalgal cells have a very short harvesting period (1-10 days) compared to with other feedstock's and consequently provide adequate supplies to meet ethanol production demands. Microalgae biomass can be used for the production of bioethanol using either fermentation or thermo chemical conversions. The main debate being put forth is the food vs. fuel necessities. Thus, both of these compete with food as well as land use. The recent practices for production of bioethanol are focused on microalgae as biomass for fermentation process. Microalgae are a rich source of polysaccharides and proteins that can be utilized as the carbon source during the fermentation. Fermentation of microalgal biomass involves minimum input of energy and the whole process is less complicated compared to biodiesel production. Moreover, carbon dioxide produced during the process can be stored and a significantly proportional of it used as the carbon source for the cultivation of microalgae.

Bio-hydrogen

The large scale production and utilization of bio-hydrogen has been difficult due to its low conversion rate. However, it can be used for generation of electricity via small fuel cells. Microalgae can produce bio-hydrogen either by direct bio-photolysis (Chader *et al.*, 2011) or by indirect bio-photolysis by other cyanobacteria and certain nitrogen-fixing bacteria. Unfortunately, few studies report the practicality of coupling bio-hydrogen production to the operation of fuel cells. The production of hydrogen derived from algal cells has received significant attention in recent years. Nevertheless, there are several challenges that need to be overcome before bio-hydrogen production is considered a viable technology. These include the restriction of photosynthetic hydrogen production by accumulation of a proton gradient, the competitive inhibition of photosynthetic hydrogen production by CO_2, required bicarbonate binding at photo system II (PSII) for efficient photosynthetic activity and competitive drainage of electrons by oxygen in algal hydrogen production (Beer *et al.*, 2009).

Bio-methane production

Microalgal biomass can be used for biogas production during anaerobic digestion, after lipid extraction. Biogas mainly comprised of methane and carbon dioxide that can be used for the production of electricity. Anaerobic digestion of microalgal biomass can be carried out in a wide range of temperature from mesophillic to thermophillic range (25-50 °C). The integrated processes that combine algae cultivation and wastewater treatment system for biogas production can be the most appropriate method to reduce cost and make it more advantageous (Schenk, 2008).

Conclusion

With depletion of petroleum-based fuel sources, rising crude oil and gas prices, and global warming related to use of fossil fuels, domestic production of biofuels and bioenergy from renewable resources could become attractive. Current biodiesel production uses renewable resources but these sources face a dilemma in that they are either competing with food supplies (i.e., oilseed crop) or cannot meet demand. By producing algae instead of land oil crops for biodiesel production, farmland can be reserved for food production. Since resources for algae cultivation (e.g., water, land, CO_2, sunlight, nutrients) are easily accessible, algae have a good potential to be commercialized in the future.

References

Amin S. 2009. Review on biofuel oil and gas production processes from microalgae. *Energy conver. Manag.* **50:** 1834–1840.

Beer LL, Boyd ES, Peters JW and Posewitz MC. 2009. Engineering algae for biohydrogen and biofuel production. *Cur. Opinion in Biotechnol.* **20:** 264- 271.

Chader S, Mahmah B, Chetehouna K, Amrouche F, Abdeladim K. 2011. Biohydrogen production using green microalgae as an approach to operate a small proton exchange membrane fuel cell. *Int. J. of Hydrogen Ener.* **36(6):** 4089-4093.

Elliot DC and Sealock LJ. 1999. Chemical processing in high-pressure aqueous environments: Low temperature catalytic gasification. *Trans. J. Chem. Eng.* **74:** 563–6.

Marsh AA. 2008. The use of algae. Available at: http:// www.scribd.com/doc/32918391/A-Study-Into-the- Cultivation-of-Algae-Presentation-2008.

Schenk PM, Thomas-Hall SR, Stephens E, Marx UC, Mussgnug JH, Posten C, Kruse O and Hankamer B. 2008. Second generation biofuels: high-efficiency microalgae for biodiesel production. *Bioenergy Res.* **1:** 20-43.