International Journal of Engineering Research & Management Technology
ISSN: 2348-4039
May-2019 Volume 6, Issue-3
Email: editor@ijermt.org
www.ijermt.org

A Mini Review on Algal Biofuels

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ABSTRACT

In this contemporary era, owing to surge in commercialization, the demand of fuels in every sector has experienced a huge increase. Since the conventional fuels have been depleted to their ever low due to human activities, there is a need for an alternate fuel source. Nonetheless, the alternate fuel not only has to be sustainable but has to be environmentally benign. In this regard, fuel generated from biological processes could be exploited as the cleaner practice. Further, the review emphasis would be on biofuels, their production process and extraction procedures along with their merits and demerits.

INTRODUCTION

The fuels those are synthesized via biological processes, such as agriculture and anaerobic digestion are known as bio fuels. However, fuels such as coal and petroleum are produced by geological processes. The production of bio fuels by plants is referred as a direct production whereas production by agricultural, domestic or industrial wastes is referred as indirect. Additionally, biomass can also be converted into energy form through thermal chemical or biochemical conversions to achieve fuel [1-3].

Algal fuel is speculated as the future alternative to liquid fossil fuels that use algae as a source of energy. Algae fuel emits CO_2 on burning similar to fossil fuel. Algal fuel can be produce with minimal effect on water resources. This can be even grown in saline water, waste waters. It can produce upto 15 folds oil as compared to other plants sources [4-5]. Even though cost of algae fuel per unit mass is higher than other second-generation bio fuel crops due to high capital and operating costs, it is estimated to have 10-100 times more fuel per unit area. The overview of the process is given in fig 1.

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Generation of bio fuels

Today, majority of the *first generation* biofuels are sourced from crop plants as energy-containing molecules providing limited yields and have a negative impact on food security. Studies are now needed to expedite the generation of advanced biofuels by identifying and engineering effective non-food feed stocks, improving the conversion technologies and the quality of biofuels for different transport domains by bringing down the costs.

The *second generation* biofuels are based on producing biofuels from lignocellulosic feedstocks, non-food materials like straw, bagasse, and forest residues. Research is needed to maximize the renewable carbon and hydrogen being converted to fuels from *second generation* biomass [6].

The *third generation* biofuels are accomplished through algal biomass production. Extensive research is carried out in order to improve the metabolic production of fuels as well as the separation processes to remove non-fuel components in bio-oil production.

The *fourth generation* biofuels are either photobiological solar fuels or electrocutes. Technology for the production of such solar fuels via direct conversion of solar energy into fuel utilizing inexhaustible staring materials is the need of the hour. This is anticipated to occur via synthetic biology [7]. For this, one needs to discover synthetic living factories and designer microorganisms for efficient and direct conversion of solar energy to fuel [8]. Similarly, a merger of photovoltaics or inorganic water-splitting catalysts with engineered microbial fuel production pathways could be a powerful emerging technology towards efficient production offering optimum storage of liquid fuels.

Algal Source
↓
Mass Cultivation
↓
Harvesting
↓
Oil Extraction
↓
Bio-refinery
↓
Bio fuel/feed stocks

Fig 1: Algal Bio diesel Production Process

.Mass Cultivation

Open pond systems

These systems include natural waters (lakes, lagoons, and ponds) and artificial ponds or containers. These are kind of a closed loop, oval shaped re circulation channels 0.5 m deep, well-agitated so as to stabilize algae growth and production [9]. Algae broth is introduced while being mechanically agitated with CO_2.

Closed photo bioreactor

Microalgae production through closed photo bioreactor has been recommended to overcome some of the inherent problems associated with the open pond production systems. For instance, pollution and contamination risks with former systems limit their use for high-value products as in the pharmaceutical and cosmetics industry. Culture of single-species of micro algae for prolonged duration with lower risk of contamination can be run with photo bioreactors. Closed systems include the tubular, flat plate, and column photobioreactors**.** Such configurations are more suitable for sensitive strains as the closed configuration. Owing to the higher cell mass productivities attained, harvesting costs can be significantly reduced. However, the costs of closed systems are substantially higher than open pond systems. The airlift systems allows for the transfer of O_2 from the systems and transfer of CO_2 into the system providing a means to harvest the biomass. The solar receiver gives a platform for the algae growth by giving a high surface area to volume ratio.

Harvesting methods

Final selection of harvesting technique depends on characteristics of microalgae, e.g. size, density, and the value of the target products. Microalgae harvesting is a two stage process, involving bulk harvesting followed by thickening. The bulk harvesting is aimed at separation of biomass from the bulk suspension. Depending on the initial biomass concentration and technologies employed such as gravity sedimentation , flocculation or flotation. Thickening is performed to concentrate the slurry via centrifugation, filtration and ultrasonic aggregation. Hence, is generally a more energy intensive step than bulk harvesting.

Flocculation and ultrasonic aggregation

The first stage in the bulk harvesting process is to aggregate the micro-algal cells in order to increase the effective particle size. Flocculation is a prelimenary step prior to other harvesting methods. Since microalgae cells carry a negative charge preventing aggregation of cells in suspension. This may also link one or more particles through bridging, to facilitate the aggregation. Multivalent metal salts like ferric chloride, aluminium sulfate and ferric sulfate are suitable flocculants.

Harvesting by flotation is designed on the entrapment of algae cells via dispersed micro-air bubbles. A few strains naturally float at the water surface as the micro-algal lipid content increases. Though flotation has been reported as the potential harvesting method, its technical or economic viability is yet not confirmed.

Gravity and centrifugal sedimentation

Sedimentation methods such as gravity and centrifugation have Stoke's law as the basis, i.e. settling characteristics of suspended solids is determined by density, cell radii and sedimentation velocity. Gravity sedimentation is the most common harvesting technique for algae biomass in wastewater treatment because of the large volumes being treated and the low value of the biomass generated. However, the method is only suitable for large microalgae such as *Spirulina*. Centrifugation recovery (CR) is desired for harvesting of high value products and extended shelf-life concentrates in aquaculture.

EXTRACTION METHODS

Oil presses also known as screw presses are used for continuous mechanical oil extraction, simply defined the main function of the vegetable oil press is to press the vegetable oil out and get the oil cake. Generally there are two processing systems for oil pressing, one is per-pressing or preliminary oil pressing (the material is fed into the first oil press) and the other is full-pressing or final oil pressing (right after the material had been extruded it is fed into the final oil press, mechanical oil extraction process).

Bead beating is the method used to disrupt mechanically a wide range of biological samples. Bead beating is accomplished by rapid agitation of a sample with grinding media like beads or balls in a bead beater. Bead beaters have been designed to homogenize samples in micro well plates, tubes, or vials with beads or balls made of silica, zirconium or steel.

Bead beating is a very versatile method to break down most samples. Unlike handheld rotor-stators, bead beaters do not come in direct contact with the sample, thereby minimizing the risk of cross-contamination while processing multiple samples. These instruments vary in terms of the number of samples that can be processed at a time, agitation speed or physical motion.

Hexane solvent method employs extracting oil from oil-bearing materials by treating it with a low boiler solvent in contrast to extracting the oils by mechanical pressing methods. The solvent extraction method recovers almost all the oils leaving behind the residual oil in the raw material. Owing to the high percentage of recovered oil, solvent extraction is considered as the most popular method of extraction for oils and fats. In a nutshell, the extraction process consists of pre-treating the material with hexane with subsequent recovery of the oil by distillation of the resulting solution of oil in hexane. Evaporation and condensation from the distillation of this residue recovers the hexane absorbed in the material. Recovered hexane can be reused for extraction. The low boiling point of hexane with high solubility of oils and fats in it are some of the properties exploited in the solvent extractions.

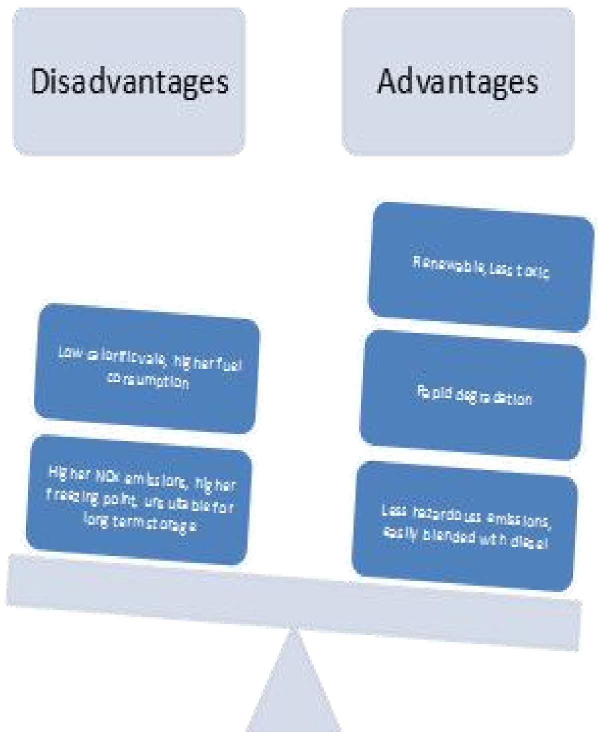

Fig: 2 Advantages of biofuel overweighs its disadvantages

Future Prospects

As shown in fig 2, the merits of biofuels overweighs their demerits, some of the potential liquid biofuels are presented here. Biobutanol is a promising fuel due to its superior physical and chemical properties. Butanol, has the potential to augment or replace ethanol as a gasoline additive due to low vapor pressure, enhanced miles per gallon and blending options with increased concentration. Biological acetone-biobutanol-ethanol (ABE) fermentation has been studied for its potential to replace chemical synthesis for butanol production. The carbohydrates in starch comprising of micro-algae above 40% are considered as an adequate feedstock for microbial growth and biobutanol production. There are primarily three methods to undertake fermentation viz. batch fermentation, fed-batch fermentation and continuous fermentation. In a biobutanol batch process, reactor productivity is limited for a number of reasons, including reduced cell concentrations, down time, and product inhibition [10-12].

Over the last two decades substantial amount of research has been focussed on the use of alternative fermentation and product recovery techniques towards biobutanol production. The cell-mass concentration inside the bioreactor can be improved by immobilization, cell recycle or i*n-situ* removal of butanol. The gases are bubbled through the fermentation broth, cooled in a condenser in recovery by gas stripping. In liquid-liquid extraction, a water-insoluble organic extractant is mixed with the fermentation broth. Butanol solublizes in the organic extractant phase than in the aqueous fermentation broth phase. Therefore, butanol selectively concentrates in the organic phase. As the extractant and fermentation broth are immiscible, the separation of extractant from the fermentation broth after butanol extraction becomes feasible.

CONCLUSION:

Since there is hype in the usage and availability of biofuels over the last two decades, it becomes vital to overcome certain concerns in terms of the biofuel production. Today, the researchers across the globe have major challenges to overcome associated with algal biofuels. These are eradicating the high amount of moisture present with such sources and the scale up of the production process. Once these challenges are met, the day is not far when the energy sector would see a major transformation.

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