**A REVIEW ON PRODUCTION OF BIODIESEL FROM MICROALGAE: A BIOFUEL FOR THE FUTURE THAT DEGRADES NATURALLY**

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**ABSTRACT:**

 Microalgae have emerged as a promising renewable feedstock for biodiesel as the quest for alternatives to fossil fuels continues. The photosynthetic single-celled microorganism is called a Microalgae. By utilising CO**2**, sunlight, sugar, N**2**, P, and K as nutrients, self-rejuvenation and rapid growth enable the production of lipids, proteins, and carbohydrates in enormous quantities over a short period of time. Recent technological developments have increased the efficiency of the growing, harvesting, pre-treatment, lipid extraction, and transesterification processes, bringing microalgae biodiesel closer to being commercially viable. Although microalgae are the best alternative, production costs and biofuel yield remain difficult to achieve. The algal biodiesel/green diesel has the potential to develop into a substitute supply of biodiesel to meet the rising global energy demand, it can be said.

**KEYWORDS:** Microalgae, transesterification, lipid production, algal biodiesel.

1. **INTRODUCTION:**

 The urgent need for alternative fuel sources has been justified by the rapidly growing global population, ongoing energy crises, the quick depletion of non-renewable energy sources, the explosive growth in vehicle use, the pollution risks from fuel emissions, and the related health diseases [1]. Over the ensuing two decades, it is anticipated that the global energy consumption would continue to increase [2]. Coal, petroleum-based products, and natural gas are the main sources of fossil fuels that today meet the majority of the world's energy needs. When it became clear that there is a very finite supply of fossil fuels and that burning them causes a number of additional environmental issues, including global warming, the demand for these alternative fuels increased [3]. Many greenhouse gas emissions are produced when conventional fuels like petroleum are used. Using biofuels is the best approach to cut emissions [4]. Biodiesel is a sustainable fuel that can replace petroleum-based diesel and lowers CO2 emissions [6].

1. **MICROALGAE:**

An environmentally beneficial and renewable energy source, biodiesel is created by trans-esterifying plant or animal fats with short-chain alcohols. In contrast to conventional feedstocks like rapeseed and soybean, microalgae have a high oil content and may grow quickly on non-agricultural land or in brackish water [5]. Algae has garnered the most interest among the several feedstocks for biodiesel production because of its quick growth rate, lack of competition with the availability of food and feed, and capacity to collect CO2 [6]. Microalgae are tiny, single-celled organisms that predominantly use photosynthetic processes. Despite being single-celled, some of them have the ability to group together to create colonies, such as filaments or spheres of the same species. The pigment used in photosynthetic processes enables them to photosynthesize. The dominating pigments in an algal cell have an impact on the colour of the algae. As a result, they are divided into three groups based on colour: green, red, and brown. However, some of them consume food in a variety of ways. Those who are heterotrophs—those without photosynthetic pigments feed on other creatures. Others are a mixture; they are occasionally heterotrophic and occasionally photosynthetic. Mixotrophs is a term used to describe them [7]. The unique characteristics of algae include their ability to adapt to saline water, their ability to absorb CO2 during growth, and the fact that they require less space for growth than other food crops. They also have a high lipid content. There is a wide variety of species available worldwide, and many of them contain an oil content of about 80% of their dry weight [8].

**Table 1**. Lipid content of many microalgae species (Chisti, 2007; Li et al., 2008; Mata et al., 2009; Sialve et al., 2009; Um and Kim, 2009).

|  |
| --- |
| Microalgae species Lipid content (% dry weight biomass) |
|  |
| *Ankistrodesmus sp. 24–31* |
| *Monodus subterraneus 16* |
| *Botryococcus braunii 25–75* |
| *Monallanthus salina 20–22* |
| *Chaetoceros muelleri 33* |
| *Nannochloris sp. 20–56* |
| *Chlamydomonas reinhardtii 21* |
| *Nannochloropsis oculata. 22–29* |
| *Chlorella emersonii 25–63* |
| *Nannochloropsis sp. 12–53* |
| *Chlorella minutissima 57* |
| *Neochloris oleoabundans 29–65* |
| *Chlorella protothecoides 14–57* |
| *Pyrrosia laevis 69.1* |
| *Chlorella sorokiniana 19–22* |
| *Pavlova salina 30* |
| *Chlorella sp. 10–48* |
| *Prostanthera incisa 62* |
| *Chlorella vulgaris 5–58* |
| *Prymnesium parvum 22-39* |

1. **BIODIESEL:**

 Alternative diesel fuel known as biodiesel is produced from sustainable biological sources like vegetable oils and animal fats. It has low emission profiles, is harmless and biodegradable, and is therefore good for the environment. Because it is derived from renewable resources and has positive environmental effects, biodiesel has recently gained in popularity. The biggest barrier to the product's commercialisation, however, is the price of biodiesel. The key choices to be taken into consideration to reduce the price of biodiesel include the use of spent cooking oils as raw materials, adaptation of the continuous transesterification process, and recovery of high-grade glycerol from the by-product (glycerol) of biodiesel [9]. Direct usage and blending, microemulsions, thermal cracking (pyrolysis), and transesterification are the four main processes used to create biodiesel. Vegetable oils and animal fats are trans-esterified, which is the technique that is most frequently utilised [10]. The molar ratio of glycerides to alcohol, catalysts, reaction temperature, reaction duration, free fatty acids, and water all affect the transesterification reaction.

* 1. **Biodiesel from Microalgae:**

Midway through the 19th century, the first biodiesel plant in the world advocated using algae as a source of both food and energy. During the Second World War, large-scale *Chlorella* algae farming was started in Japan, England, and Israel. The idea of employing these algae to produce energy was diverted to the production of food staples due to the abundance of fossil fuels.

Recently, there has been a lot of interest in the idea of using algae to produce alternative fuel. The generalised approach for producing biodiesel from vegetable oil can be utilised to convert the lipids in algae. However, biobutanol and bioethanol are made from the sugars in algae.

**FIG. 1. STEPS AND TECHNIQUES FOR THE PRODUCTION OF BIODIESEL FROM MICROALGAE**

**IDENTIFICATION OF MICROALGAE**

**(COMPOUND MICROSCOPE)**

**MICROALGAL CULTIVATION**

**DRYING AND HARVESTING**

**(TECHNIQUES INVOLVED)**

FLOCCULATION

FILTRATION

CENTRIFUGATION

**BIODIESEL CONVERSION**

**TRANSESTERIFICATION PROCESS**

**ENZYMATIC, WET EXTRACTION, ALCOHOLYSIS, ACIDOLYSIS**

**BIODIESEL**

**4.SOURCES OF MICROALGAE:**

 A kind of plants known as algae are typically found in water. Algae, like other plants, use the pigment chlorophyll to convert sunlight into nourishment. All types of waterways, including freshwater, brackish water, and saltwater, include algae. By consuming extremely basic nutrients, microalgae may thrive in a range of environments, including fresh water, sea water, and treated industrial waste water [13]. Microalgae, among all the feedstock, has been suggested to be more viable and a rich source of lipids for biodiesel production because it does not compete with food production, farmland, or fresh water in any way. Microalgae grows on saltwater, sludge, contaminated, or wastewater on non-arable or marginal lands [14].

**5.CULTIVATION OF MICROALGAE:**

 The fastest-growing species is microalgae. The growing microalgae need light, water, fertilisers, CO2, and a temperature range of 20° to 30°C in their growing environment. Microalgae absorb CO2 and use photosynthesis to turn it into fuel. They are capable of capturing CO2 from the atmosphere, heavy industry waste gases, and soluble carbonates, three different sources. By altering the growing conditions, numerous efforts have been made to increase the productivity and lipid content of particular microalgae species [15]. To maintain high algal yields, microalgae cultivation needs a steady supply of numerous inorganic nutrients, including nitrogen (N), phosphorous (P), and potassium (K).

**6.HARVESTING PROCESS:**

 In order to get the lipid profile, the farmed algae must be dewatered. Instead of appearing as a liquid that flows freely, the dewatered algae resemble a solid-liquid transition zone [16]. According to the research, a single litre of cultivated media contains just 0.1% dry matter. The methods used to remove water from algae are centrifugation and filtration. Under these headings, numerous complex mechanics are examined. Drying algae is accomplished with the use of flocculation and membrane filtration [17]. Filtration techniques include: magnetic, deep-bed sand, cross-flow, pressure, and vacuum [18].

 **7.CONVERSION OF MICROALGAL BIOMASS TO LIPIDS:**

 One mole of a complex ester triglyceride reacts with three to four moles of alcohol to form simple esters through a process known as transesterification (Biodiesel). The transesterification process is frequently catalysed by a number of acids, including sulphonic acid and sulphuric acid, as well as bases like NaOH, KOH, sodium methoxide, sodium ethoxide, and K2CO3 [19]. Because base catalysed processes are less corrosive than acid catalysed processes, they are preferred in industrial settings. In contrast to the base catalyst, which removes a proton from the alcohol to produce a stronger nucleophile, the acid catalyst adds H+ to the carbonyl group to produce a stronger electrophile [20]. By employing methanol and ethanol, respectively, methyl and ethyl esters (biodiesel) are produced. Transesterification is driven using a heterogeneous catalysis pathway to get beyond the issues that homogeneous catalysts present [21]. Zeolites with silica alumina frameworks (MOR, HY, HZSM-5, H), mesoporous materials (MCM-41, SBA-15, MCM-48), metal oxides (ZrO2, WO3, CaO, ZnO, SrCO3), and heteropoly acids (H3PW12O40) have all been used for more than ten years.

 **8.TRANSESTERIFICATION REACTION:**

 **TRIGLYCERIDE + METHANOL METHYL ESTER + GLYCERINE**

 **CATALYST (BIODIESEL)**

 **9.TEST FOR BIODIESEL FUEL PROPERTIES:**

 One of the most effective sources of energy from microalgae that may be used in internal combustion engines is algal biodiesel/green diesel. It is necessary to understand and evaluate the green diesel's fuel qualities for use in IC engines after conversion to biodiesel. More research has been done on the extraction of microalgae oil, the conversion of algae to biodiesel, and the characterisation of the biodiesel for engine performance testing and emission studies. The biodiesel (B100) displayed higher heating values of 41 MJ/kg, 0.864 kg/L density, and 5.2x10-4 Pa s viscosity at 40 °C. According to the literature, different species of microalgae have varied heating values for biodiesel [22].

**10.CONCLUSION:**

 According to the literature, microalgae biodiesel/green diesel is an alternative to petroleum-based diesel for internal combustion engines that is both affordable and environmentally beneficial. In terms of net energy balance and impact reduction due to greenhouse gas emissions, microalgae production is the most effective. Another viable/achievable option is the large-scale cultivation of microalgae for the manufacture of biodiesel. It might also function admirably as a natural CO2 harvesting system.

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