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Biofuels Production From Schizochytrium Algae.

Bereket Ghebrekidan, Biniam Gheresin, Ermias Ghebreyohannes, Elsa Eyasu, Robel Kibrom*, Lwam Hailu, Samuel Berihu, Abraham Yohannes, and K Eyalarasan.

Department of Chemical Engineering, Eritrean Institute Technology, Eritrea.

ABSTRACT

Algae are widespread in the seawater and wastewater. Eritrea has large sea water resources to cultivate easily algal biomass. The production of biofuel from microalgae has gained considerable attention due to the fact that they can be converted into several different types of renewable biofuels. Microalgae consume large amounts of nitrogen, phosphate, and carbon dioxide that are converted into biomass, which makes algae attractive for carbon dioxide mitigation and reduction of pollution and toxic chemicals. This paper mainly highlights the optimum conditions of reactors and reactor conditions to attain maximum growth of algae, thus maximum biofuel production. Optimum conditions for production of biodiesel and biogas derived from algae are also found from our experiments.
Keywords: biofuels, Schizochytrium algae, mitigation, biomass.

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**Corresponding author*

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INTRODUCTION

Photosynthesis is the key to make solar energy available in usable forms for all organic life in our environment. The unicellular forms are known as microalgae whereas multicellular forms are known as macroalgae. Nowadays the production of biodiesel from algae is the area of considerable interest, because: Algae have higher productivities than land plants, with some species having doubling times of a few hours. Some species can accumulate very large amounts of triacylglycerides (TAGs), the major feedstock for biodiesel production; and high quality agricultural land is not required to grow the biomass. However, several challenges need to be tackled to allow commercial production of diesel from algae at a scale sufficient to make a significant contribution to our transport energy needs. Many of the reaearch report says that microalgae yield more oil than macroalgae. As such, they are net producers of oxygen and net consumers of carbon dioxide (CO_2).

In particular, many algae produce more lipids, especially triglycerides (also triacylglycerol's or TAG), under conditions of stress. Conditions which have been shown to increase lipid/TAG concentrations include increased light, increased temperature, and nutrient depletion. In the selection of species the main criteria is the amount of lipid content in the algae type. The more the lipid content the more biofuel extracted, therefore the algae to be extracted should have high lipid content. Based on this data, the species known as Schizochytrium fits the above criteria and it has a lipid content of 50%-70%.. Schizochytrium can grow well in a place where the wide temperature ranges from 25^{o}c to37^{o}c. We have selected this species, since they can grow well in many parts of Eritrea.

MATERIALS AND METHODS

Our main aim was to extract the oily lipid content of the dried microalgae using hexane as a solvent using the soxhelet extractor in the lab scale and producing biofuels such as biodiesel and biogas. We have divided our work as three major parts as follows. **[a]** optimization of microalgae growth **[b]** optimization of biodiesel production **[c]** optimization of biogas production

METHOD OF CULTURING MICROALGAE

CLOSED PONDS (PHOTOBIOREACTORS) were selected because of its easy controllability. PBRs are flexible systems that can be optimized according to the biological features of the algal species that are cultivated. PBRs provide a protected environment with safety from contamination by other microorganisms and culture parameters can be better controlled. They allow more species to be grown than open systems, and permit especially single-species culture of microalgae. They also prevent evaporation and reduce water use, lower CO_2 losses due to out-gassing and permit higher cell concentration and consequently higher productivity. Horizontal tubular bioreactor is selected for our project because of its efficient operation.

PHOTOBIOREACTOR DESIGN CONSIDERATIONS FROM LABARATORY EXPERIMENTS

Microalgae Schizochytrium, is selected from Massawa seashore for our experiment. It is grown in a closed air lift photobioreactor system under optimum conditions as mentioned below. Sea water is chosen for our experiment.

Optimization of parameters for microalgae growth: We have optimized parameters such as lighting, mixing, water, CO_2, O_2 removal, nutrient supply and temperature to attain high algal biomass with the help of experiments to get the algal biomass. 25g/m^2.day of maximum potential yield of algae is obtained with natural sunlight during day hours and LED flashing during night hours. Mixing improves the frequency of cellular exposure to light and increases mass transfer efficiency between cells and nutrients. Bubble column reactor with air sparging provides better mixing.

We used air lift reactor with dual sparging system, separately for CO2 and air supply used for mixing. We have maintained the level of mixing within the cell death range by keeping the flow rate as optimum value. We found in our research work that our microalgae can withstand and grow well in seawater consisting of 20 to 30ppm salinity. Loss of water during reaction time is prevented by the closed photo-bioreactors. 5% CO_2

offered better result of algal growth. Separate sparging for CO_2 is utilized and partial pressure of CO_2 is maintained less than 0.1KPa. In a tubular airlift reactor, the algae culture regularly returned to an airlift zone where the accumulated oxygen from photosynthesis was stripped by air. A gas liquid separator mounted on top of our airlift reactor separates gas and liquid. We have prepared a low cost nutri-pack consisting of carbon, nitrogen sources, phosphorous, mineral traces and it gave a good end result. Temperature optimum for our species is 20 to 28C.

With the help of above optimum conditions, microalgae were grown in a closed air lift bioreactor and subjected to extraction as follows. Algae were dried by exposing it to atmosphere. After drying, the algae were powdered. First the algal biomass was weighed in analytical beam balance. 50g of the algal biomass is mixed with 1lit of water in a sealed gallon. The gallon was placed in hot water (64°c). The temperature is maintained at this value till the gas is extracted from the algae.

In this experiment, algae were placed in the thimbles of Soxhlet apparatus. The thimbles are made from thick filter paper, which are loaded in the main chamber of soxhlet extractor. The soxhlet extractor is placed onto flasks containing extraction solvent. The soxhlet is then equipped with a condenser. The solvent is heated to reflux. The solvent hexane forms vapors, which travels up a distillation arm, and floods into the chamber housing the thimble of solid. The condenser ensures that any solvent vapor that cools drips down into the chamber housing the solid material. The chamber containing the solid material slowly fills with warm solvent. Some of the desired compound will then dissolve in the warm hexane. When the soxhlet chamber is almost full, the chamber is automatically emptied by the siphon side arm, with hexane running back to the distillation flask. This cycle was repeated for varying time. During each cycle, a portion of the oil is dissolved in hexane. After many such cycles, desired oil was concentrated in the distillation flask. After extraction hexane was removed, yielding the extracted compound. The insoluble portion of the algae remains in the thimble. The algae oil obtained was 3g from the sample 50g used and the time of extraction was 3 hours.

BIODIESEL PRODUCTION: Transesterification is the key and the most important step to produce the cleaner and environmentally safe fuel from algae oil. The general structure of a triacylglyceride (TAG) when reacted with methanol under KOH catalyst to give fatty acid methyl esters (FAMEs- biodiesel) and glycerol. After some time, the glycerol and catalyst are drawn off the bottom, leaving FAMEs[biodiesel] in the tank.

methanol + Algae oil → Biodiesel + glycerol

The laboratory plant set up consists of cylindrical flask, which is put inside the heat jacket. Oil is used as a medium of heat transfer from heat jacket to the rector. Thermocouple is a part of heat jacket, which maintains the temperature of oil and in turn the temperature of the reactants at a desired value. The reaction is carried out at around 65-70°C. Cylindrical flask consists of three openings; the center one is used for putting stirrer in the rector, the motor propels the stirrer. Thermometer is put inside the second opening to continuously monitor the temperature of the reaction. Condenser is put in the third opening to reflux the alcohol vapors back to the rector to prevent any reactant loss.

Two liters of algae oil is mixed along with 400ml of methanol and 7gms of catalyst (potassium hydroxide). The mixture is poured into the cylindrical flask of the plant. Then the mixture is heated and stirred for one hour at the range of 60 - 65°C. The mixture is drained out from the plant and allowed for cooling. Separation of glycerol and Biodiesel is processed out. The transesterification process is optimized for different conditions in laboratory and finally the optimized result is noted as follows. It was found that the parameters affecting methyl esters formation are reaction temperature and time, the amount of catalyst, the amount of alcohol, water content and free fatty acid content

A highest biodiesel yield of 95% was obtained at optimal parameters such as 1 : 10 oil-to-methanol molar ratio, 3% w/w catalyst concentration, 65°C reaction temperature, and 2.5-hour reaction time. The product biodiesel was checked for its quality and it showed good engine performance.

BIOGAS PRODUCTION: The algal biomass is taken in a biogas generator assembly. The biogas is collected in a suspended plastic bag. Bio gas is generated efficiently by the anaerobic decomposition of algal biomass from our small scale biogas generator set up. This gas can be produced by decomposition (digesting) the algae biomas [ABM].. The industry requires high amount of carbon dioxide which can be recycled back to the algal photobioreactors from CO_2 recovery system of biogas generator. Micro algae Schizochytrium is abundant around the shores of red sea, and it can be cultivated easily in Eritrea.

Average composition of algal biomass [ABM] and cowdung[CD]

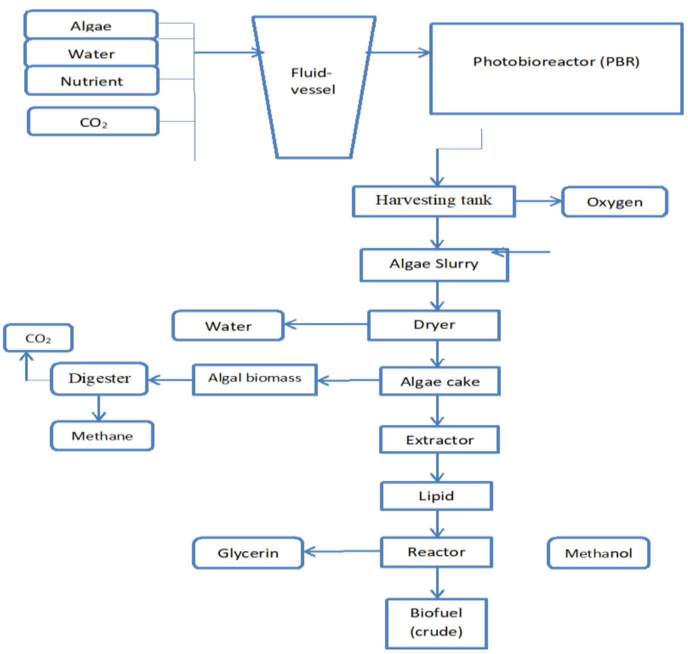
Parameters	ABM	CD
Total solids[TS] in %	8	8
Volatile solids [VS] in %	96	89
COD [mg/lt]	6600-8850	6100
BOD [mg/lt]	4000-6100	4230
N in [mg/lt]	45-55	30-38
P in [mg/lt]	36-48	10
PH	7	7.3

It is important to note that 0.46m^3 biogas per Kg volatile algal biomass solids is obtained from microalgae and cow dung mixture. We have found in our research that biogas yield from algal biomass[ABM] was 0.20m^3/Kg volatile solids[VS] better than biogas obtained from cowdung. It is highly comparable production than biogas obtained from EIT cafeteria wastes and brewery wastes. The results were tabulated as follows.

Comparison of the experimental data obtained with different mixtures of cow dung [CD] and algae biomass [ABM].

Ratio of feed content	Biogas yield[m^3/Kg VS added]	Methane yield [m^3CH_4/Kg VS added]
CD ONLY	0.18	0.10
CD : ABM 90:10	0.23	0.13
CD : ABM 80:20	0.27	0.15
CD : ABM 70:30	0.37	0.17
CD : ABM 60:40	0.37	0.20
CD : ABM 50:50	0.46	0.30
CD : ABM 40:60	0.33	0.18
CD : ABM 20:80	0.27	0.17
ABM ONLY	0.20	0.13

FLOW SHEETING OF BIOFUEL PRODUCTION FROM ALGAE



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CONCLUSION

The oil extracted from microalgae [Schizochytrium] to produce biodiesel has a number of advantages over other oil crops. Microalgae, considered as a second generation feedstock, can be grown in nonagricultural land, sea water, freshwater as well as in waste water. They are showing more productivity than crop plants and have the ability of carbon dioxide mitigation.

Closed Photobioreactors provide much greater oil yield per hectare and more controlled environment than open ponds. However, PBRs are little expensive than open ponds systems, but it can be balanced well by effective productivity, water saving and usage. The lipid content in algal oil has to be high to achieve sustainable economic performance. Although, Nutrient deficiency, typically nitrogen or phosphorous deficiency, is well known to enhance the lipid content of algae. A highest biodiesel yield of 95% was obtained at optimal parameters such as 1: 10 oil-to-methanol molar ratio, 3% w/w catalyst concentration, 65°C reaction temperature, and 2.5-hour reaction time. It was also found and proved that biogas production from microalgae biomass is highly comparable with cow dung.

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