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Extraction of Oil from Nano-Chloropsis Species of Algae

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ABSTRACT: *The dramatic increase in the price of petroleum, the finite nature of fossil fuels, increasing concerns regarding environmental impact, especially related to greenhouse gas emissions, and health and safety considerations are forcing the search for new energy sources and alternative ways to power the world's motor vehicles. Biofuels are one possible replacement for fossil fuels and can make a significant contribution in reducing the dependency on fossil fuel imports, especially in the transport sector. Another advantage of biofuels is their contribution to climate protection, as biofuels are usually considered to be carbon dioxide neutral, their use helps to reduce greenhouse gas emissions.*
Algae produce oil, and because of their growth rate and yields, they could produce alot more another energy crops.This could be converted into fuels, chemicals and more. Microalgae, specifically, possess several attractive characteristics in the context of energy and biofuels. They provide much higher yields of biomass and fuels, 10-100 times higher than comparable energy crops. They can be grown under conditions which are unsuitable for conventional crop production. thus facilitating the reduction of increasing atmospheric CO2 levels, which are now considered a global problem. Algae biofuel is non-toxic, contains no sulfur, and is highly biodegradable.The process will demonstrate the efficient lysis of microalgae cellsand the subsequent separation of their high-energy lipids using solvent extraction.

Keywords: *Algae, Liquids,oil extraction, Nannochlorapsis*

I. INTRODUCTION

Algae represent a large group of different organisms from different phylogenetic groups.In general algae can be referred to as plant-like organisms that are usually photosynthetic and aquatic, but do not have true roots, stems, leaves, vascular tissue and have simple reproductive structures. They are distributed worldwide in the sea, in freshwater and in wastewater. Most are microscopic, but some are quite large, e.g. some marine seaweed that can exceed 50 m in length.The unicellular forms are known as microalgae whereas the multicellular forms comprise macro algae.

Microalgae comprise a vast group of photosynthetic, heterotrophic organisms which have an extraordinary potential for cultivation as energy crops. They can be cultivated under difficult agro-climatic conditions and are able to produce a wide range of commercially interesting byproducts such as fats, oils, sugars and functional bioactive compounds.Seaweed is a loose colloquial term encompassing macroscopic, multicellular, benthic marine algae. The term includes some members of the red brown and green algae. They are photosynthetic, like plants, and simple because they lack the many distinct organs found in land plants. For that reason they are currently excluded from being considered plants.

The algae have chlorophyll and can manufacture their own food through the process of photosynthesis. Almost all the algae are eukaryotes and conduct photosynthesis within membrane bound structure called chloroplasts.Oil from algae. The Environment-Friendly Oil Much of the world's petroleum is actually made up of algae that decomposed over hundreds of millions of years. But by drilling for, extracting, and burning that oil now, we are releasing carbon dioxide that was absorbed long ago. This "carbon positive" effect is much of what causes global warming. Concentrated form, directly from CO2 sources (e.g. power plants, factories, and refineries). Burning freshly produced algae oil releases only what it absorbed in the first place, resulting in a balanced "carbon neutral" effect. This makes algae oil the environmentally-friendly oil.

TYPES OF ALGAE
Bacillariophyta (diatoms)
Charophyta (stoneworts)
Chlorophyta (green algae)
Chrysophyta(golden algae)
Cyanobacteria (blue-green algae)
Dinophyta (dinoflagellates)
Phaeophyta (brown algae)

Rhodophyta (red algae)

Table 1. Algae - A Source Of Biofuel

Strain	Protein	Carbohydrates	Lipids	Nucleic acid
Scenedesmus obliquus	50-56	10-17	12-14	3-6
Scenedesmus quadricauda	47	-	1.9	-
Scenedesmus dimorphus	08-18	21-52	16-40	-
Chlamydomonas rheinhardii	48	17	21	-
Chlorella vulgaris	51-58	12-17	14-22	4-5
Chlorella pyrenoidosa	57	26	2	-
Spirogyra sp.	06-20	33-64	11-21	-
Dunaliella bioculata	49	4	8	-
Dunaliella salina	57	32	6	-
Euglena gracilis	39-61	14-18	14-20	-
Prymnesium parvum	28-45	25-33	22-38	1-2
Tetraselmis maculate	52	15	3	-
Porphyridium cruentum	28-39	40-57	09-14	-
Spirulina platensis	46-63	08-14	4--9	2-5
Spirulina maxima	60-71	13-16	6-7	3-4.5
Synechoccus sp.	63	15	11	5
Nanochlorapsis	39.6	53.3	7.1	-
Anabaena cylindrical	43-56	25-30	4-7	-

Algae produce oil, and because of their growth rate and yields, they could produce a lot more than other energy crops. Some estimates suggest that microalgae are capable of producing up to 15,000 gallons of oil per Hectare a year. This could be converted into fuels, chemicals and more.

Microalgae, specifically, possess several attractive characteristics in the context of energy and biofuels:

1. They provide much higher yields of biomass and fuels, 10-100 times higher than comparable energy crops.
2. They can be grown under conditions which are unsuitable for conventional crop production.
3. Microalgae are capable of fixing CO2 in the atmosphere, thus facilitating the reduction of increasing atmospheric CO2 levels, which are now considered a global problem.
4. Algae biofuel is non-toxic, contains no sulfur, and is highly biodegradable

Algae processing

It involves following processes:

1. Cultivation of algae
2. Harvesting of algae
3. Dewatering& drying of algae
4. Extraction of oil from algae.

A Generalized Set of Conditions for Culturing Micro-Algae

- Light is needed for the photosynthesis process
- Temperature: There is an ideal temperature range(20-30° C) that is required for algae to grow
- Medium/Nutrients - Composition of the water is an important consideration (including salinity)
- pH - Algae typically need a pH between 7 and 9 to have an optimum growth rate
- Algae Type - Different types of algae have different growth rates
- Aeration - The algae need to have contact with air, for its CO_2 requirements
- Mixing - Mixing prevents sedimentation of algae and makes sure all cells are equally exposed to light

Photoperiod: Light & dark cycles.

Table 2. Extraction of Oil from Algae

Parameter	Range	Optima
Temperature (°C)	16-24	18-24
Salanity (g/l)	13-40	20-24
Light intensity(lux)	1000-10,000	2,500-5,000
Photoperiod (light,dark hours)		16.8(min), 24(max)
pH		8.2-8.7

1. METHODS USED FOR OIL EXTRACTION

1. Extraction using solvents
2. Soxhlet extraction
3. Expeller press
4. Extraction using a disruptor
5. Ultrasonic assisted extraction
6. Extraction using ionic liquids

II. EXPERIMENTAL

Extraction was done using various solvent systems. All the experiments were performed on the Nanochlorapsis species of algae. This species of algae has about 5%-7% lipid content of its dry weight.

Solvents system used

1. Hexane
2. Chloroform
3. Chloroform-methanol.

The best result was obtained using hexane solvent system.

The maximum yield of oil or extraction was obtained at reflux temperature (68°C), 2hr. stirring and 5 volumes of solvents.

Procedure for 5 volumes of solvents at reflux temperature

1. 40 g of algae sample was taken, and was added to 200 ml of hexane solvent.
2. This mixture was then heated for 2 hours at reflux temperature with continuous agitation.
3. Then this mixture was transferred to a separating funnel and a settling time of 2 hours was provided
4. Two separate layers were seen, the hexane layer being lighter most was found on the top. These two were separated and weighed.
5. The hexane layer separated was given several water washes till a transparent layer of water was seen.
6. The hexane layer was then put for distillation in a water bath. Heating was kept on till complete hexane was distilled out.
7. The residue obtained (algal oil) and distilled hexane was weighed.

The same procedure was followed for all the solvent systems mentioned above.

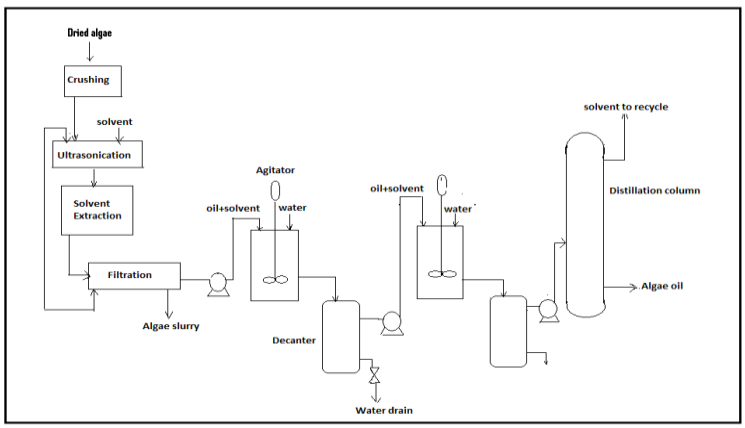

Figure 1. Flow sheet for solvent extraction

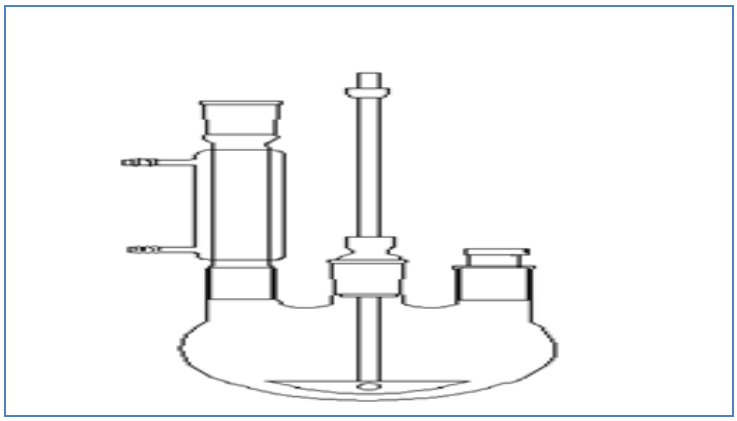

Figure 2. Experimental setup for distillation

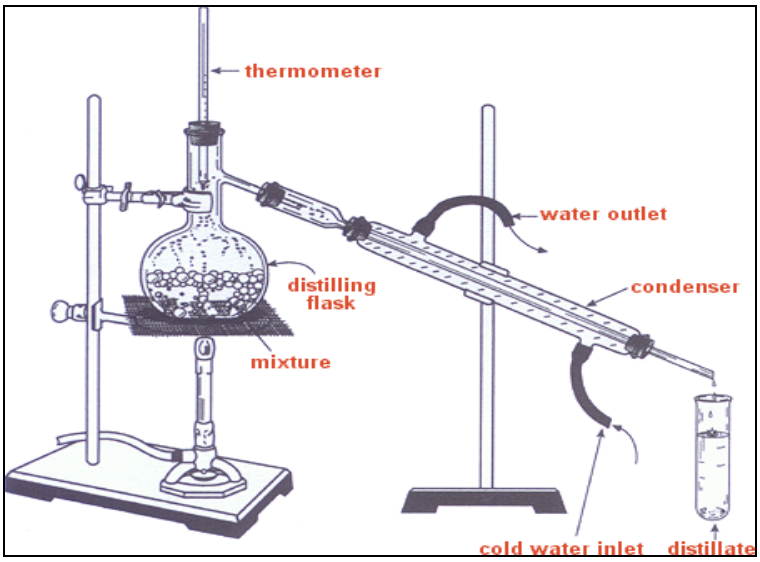

Figure 3. Soxhlet extraction

Soxhlet extraction is used where the desired compound has a limited solubility in a solvent, and the impurity is insoluble in that solvent. If the desired compound has a significant solubility in a solvent then a simple filtration can be used to separate the compound from the insoluble substance. The algae sample is placed in the thimble, made from thick filter paper, which is loaded into the main chamber of the Soxhlet extractor. The Soxhlet extractor is placed onto a flask containing the extraction solvent. The Soxhlet is then equipped with a condenser.

The solvent used is hexane, is heated to reflux. The solvent vapor travels up a distillation arm and floods into the chamber housing the thimble of solid. The condenser ensures that any solvent vapor cools, and drips back 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 solvent. When the Soxhlet chamber is almost full, the chamber is automatically emptied by a siphon side arm, with the solvent running back down to the distillation flask. This cycle may be allowed to repeat many times, over hours or days.

After extraction the solvent is removed, typically by means of a rotary evaporator, or it can be recovered using distillation process and thus also yielding the extracted compound. The non-soluble portion of the extracted solid i.e. algae remains in the thimble, and is usually discarded.

For 40g of algae sample taken, we were able to extract 0.55g of oil. The same apparatus can also be used with different solvent systems for the extraction

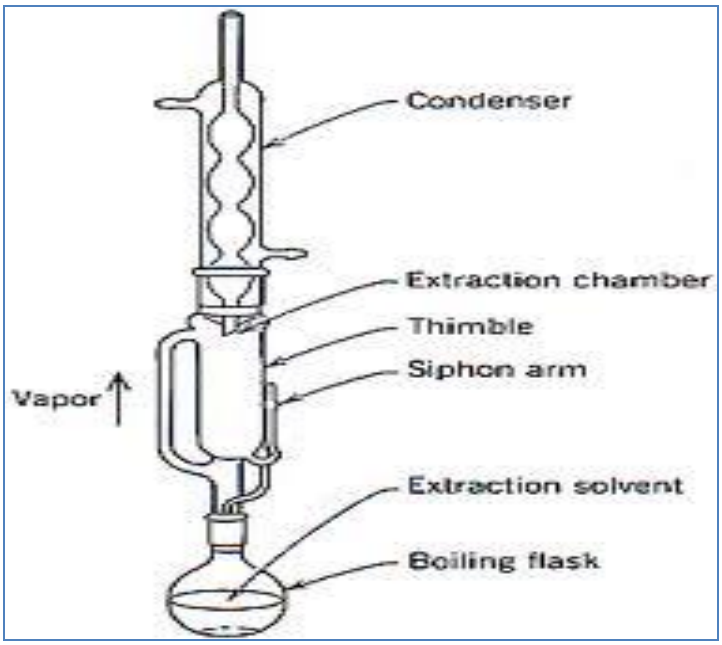

Figure 4. Experimental setup for soxhlet extraction

4.1 Expeller press

Algae when dried, it retains its oil content, which then can be pressed out with an oil press. Since different strains of algae vary widely in their physical attributes, various press configurations (screw, expeller, piston, etc.) work better for specific algae types. Many commercial manufacturers of vegetable oil use a combination of mechanical pressing and chemical solvents in extracting oil.

4.2 Extraction using disrupter

The apparatus consists of a plurality of deflectors, against which a mixture of algae and water is forcibly impacted upon the urging of a pump. The impacting of algae cells against the deflectors ruptures their cell walls and liberates the lipids and other material contained in them. A tank collects the mixture and after a settling period the mixture forms at least three layers comprising oil, water, and algal residue. The oil layer is removed through one or more conduits into a holding tank for further refining and use.

4.3 Ultrasonic Extraction

Intense sonication of liquids generates sound waves that propagate into the liquid media resulting in alternating high-pressure and low-pressure cycles. During the low-pressure cycle, high-intensity small vacuum bubbles are created in the liquid. When the bubbles attain a certain size, they collapse violently during a high-pressure cycle. This is called cavitation. During the implosion very high pressures and high speed liquid jets are produced locally. The resulting shear forces break the cell structure mechanically and improve material transfer. This effect supports the extraction of lipids from algae. The ultra-sonication reactor can be easily retrofitted into existing facilities, improving algae extraction.

4.4 Ultrasonic Solvent Extraction

The high pressure cycles of the ultrasonic waves support the diffusion of solvents, such as hexane into the cell structure. As ultrasound breaks the cell wall mechanically by the cavitation shear forces, it facilitates the transfer of lipids from the cell into the solvent. After the oil dissolved in the cyclohexane the pulp/tissue is filtered out. The solution is distilled to separate the oil from the hexane

III. RESULTS & DISCUSSIONS

In chemical methods of extraction of oil from algae, different solvent systems were used such as chloroform, chloroform-methanol (Bligh & Dyer method), and hexane solvent. Out of these it was found by experimental analysis that Hexane gives the maximum extraction of oil. The reason behind using these hydrophobic solvents is that lipids or fatty acids are hydrophobic in nature. By the law of chemistry of "Like dissolves Like", the lipids get dissolved in these solvent or get extracted by these solvents. The water washes given after the extraction, are for the removal of any polar impurities like chlorophyll and other non-desirable products. The distillation is carried out for the recovery of solvent.

IV. CONCLUSION

It can be stated from the literature survey that the chemical methods are best suited for extraction of oil from algae. But still the yield of oil is very poor. Hence to increase this low yield we can try combination of two different methods. In the next attempt we plan to try the combination of one mechanical method and one chemical method (i.e.ultrasonication+ solvent extraction). We also plan to do a parameter study of it that is to study the experiment at different conditions of sonication and temperatures in order to get the maximum yield.

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REFERENCES

[1]. Lin Chen, Tianzhong et al.Bioresource Technology, 111, (2012), P 86-90.
[2]. AshikSathish, Ronald C. Sims, Bioresource Technology, 118, (2012), 643-647.
[3]. Michele Aresta, Angela Dibenedetto, GraziaBarberio Fuel Processing, Technology,(2005) 86, 14–15.
[4]. AsgharSafaralie, ShohrehFatemi, AlirezaSalimi, Food and Bioproducts Processing,Issues 2–3,(2010),312-313.
[5]. Glacio S. Araujo et al,Bioresource Technology, 102, I8, (2011),5248-5250.