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EXTRACTION OF OIL FROM ALGAE BY SOLVENT EXTRACTION AND OIL EXPELLER METHOD

NIRAJ S. TOPARE[a], SUNITA J. RAUT[a], V. C. RENGE, SATISH V. KHEDKAR[*], Y. P. CHAVAN and S. L. BHAGAT

Department of Chemical Engineering, College of Engineering and Technology, AKOLA (M.S.) INDIA
[a]Department of Chemical Engineering, Bharati Vidyapeeth University, College of Engineering, PUNE (M.S.) INDIA

ABSTRACT

Algae are a filamentous waste plant growing in any type of water such as fresh, sea water etc. Normally algae are regarded as a menace in water bodies. Algae oil is an interesting sustainable feedstock for biodiesel manufacturing. There are various methods for extracting the oil from algae, such as mechanical pressing, hexane solvent extraction etc. The paper discusses experimental method developed for the extraction of oil from algae which is obtained from open pond system. It is observed that the solvent extraction method recovers almost all the oil and leaves behind only 0.5% to 0.7% residual oil in the raw material. Because of the high percentage of recovered oil, solvent extraction is found to be an effective method for extraction of oils and fats, but is having disadvantage of being costly as compared to expeller method. An experimental investigation shows that expeller pressing method can recover 75% of the oil from algae. Even though expeller pressing method is an economical method than the hexane solvent extraction method, further to make this method more effective, some modifications in the design of expeller are required which will increase the recovery of oil.

Key words: Algae, Biodiesel, Expeller, Solvent extraction.

INTRODUCTION

Extraction refers to an operation in which one or more components of a liquid or a solid phase are transferred to another liquid phase. Extraction utilizes the differences in the solubilities of components. In liquid-liquid extraction or solvent extraction, a solute in a liquid solution is removed by contacting with another liquid solvent, which is relatively immiscible with the solution. The liquid, which is added to solution to bring about the extraction is known as solvent. This solvent layer is called extract and the other layer, the

[*]Author for correspondence; E-mail: satish21khedkar97@rediffmail.com

raffinate. Leaching involves treating a finely divided solid with a liquid that dissolves and removes a solute contained in the solid. Ex. oilseed extraction.

This paper discusses the extraction of oil by solvent extraction method and mechanical pressing method, respectively. The solvent extraction method recovers almost all the oils and leaves behind only 0.5% to 0.7% residual oil in the raw material. The solvent extraction method can be applied to any low oil content materials. It can also be used for pre-pressed oil cakes obtained from high oil content materials. Because of the high percentage of recovered oil, solvent extraction has become most popular method of extraction of oils and fats. Mechanical pressing methods include the expeller method, hydraulic presses etc.

EXPERIMENTAL

Materials and methods

Solvent extraction method

The solvent extraction method recovers almost all the oils and leaves behind only 0.5% to 0.7% residual oil in the raw material. The solvent extraction method can be applied to any low oil content materials. It can also be used for pre-pressed oil cakes obtained from high oil content materials. Because of the high percentage of recovered oil, solvent extraction has become most popular method of extraction of oils and fats. The materials use are green algae, it was obtained from the open pond system and hexane.

Experimental setup

The algae were obtained from the open pond system. It was dried by exposure to atmosphere. After drying, the algae were powdered. A 50 g sample of the dried algae was placed in the thimble of the Soxhlet apparatus. The thimble is made from thick filter paper, which is loaded in the main chamber of Soxhlet extractor. The Soxhlet extractor is placed onto a flask containing extraction solvent. The Soxhlet is than 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 same process was repeated but this time the open pond algae were 75% moist instead of complete dry. The same process was repeated but this time, the open pond algae were 50% moist instead of complete dry.

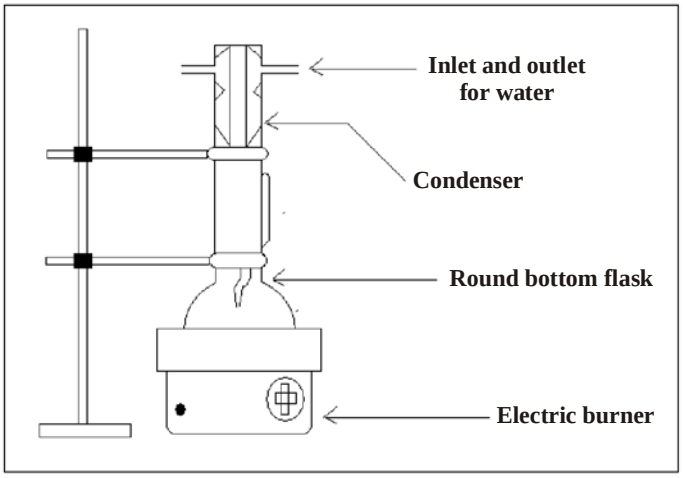

Fig. 1: Extraction of oil from algae by solvent extraction method (Soxhlet appratus)

Oil expeller method

The method we have tried is completely different than solvent extraction method. This is a mechanical method and we have made use of expeller to press the algae. Similar methods are screw expeller method, mechanical pressing method (by piston) and osmotic shock method[6,8]. In the osmotic shock method the osmotic pressure is suddenly reduced. We have carried out our work on screw expeller. The raw materials are squeezed under high pressure in a single step. Expeller presses can recover 75% of the oil from algae. The alga was obtained from the open pond system. It was dried by exposure to atmosphere. In an expeller press, as the raw material is pressed, friction causes it to heat up; in some cases, the temperatures may exceed 120^{o}F.

The expeller we used was a screw type machine that presses oil seeds through a caged barrel like cavity. Algae entered the expeller press on one side of the press and products exit was on other side of the press. The machine used friction and continuous pressure from the screw drive to compress the filamentous algae. The algae were green in long strands like fiber. Initially, the algae did not move easily into the screw. Its surface had to be wetted with water for easy movement through the caged barrel. The oil seeps through

small openings that do not allow the other components to seep through. Afterwards, the pressed algae almost form cake, was removed from the machine. Pressures involved in expeller pressing create heat in the range of 140-210^{o}F. Expeller processing cannot remove the last trace of oil from algae. A significant amount of oil was left in the cake formed. The cake formed was in large quantity. It was not subjected to solvent extraction, since the quantity of solvent required would have been much greater.

RESULTS AND DISCUSSION

Table 1: Solvent extraction method

Parameters: Algae powder (50 gm), time (3 hr), temperature (50^{o}C) for all sample

Parameters	100% dry sample	75% dry sample	50% dry sample
Algae oil obtained	1.92 g	1.58 g	1.13 g

Table 2: Expeller method

Observations	Reading
Initial weight of algae	70 Kg
Final weight of algae	68 Kg
Weight of algae oil	1250 mL

The algae used in the above experiments was obtained from open pond system. No cultivation of algae was done for experimental purpose. A particular species was not cultivated. The results from the experimental work were quite encouraging though the algae oil obtained was less in quantity. No specific species of algae was used. The apparatus used in the expeller method is almost outdated. Much work can be done regarding identification of the right species for more and better oil yield. Proper method and specifically designed expeller to obtain oil from algae. Algae can indeed be an abundant source for oil and finally for biodiesel.

CONCLUSION

The results from the experimental work were quite encouraging though the algae oil obtained was less in quantity. No specific species of algae was used. The apparatus used in the expeller method is almost outdated. Much work can be done regarding identification of

the right species for more and better oil yield. Proper method and specifically designed expeller may be used to obtain oil from algae. Algae can indeed be an abundant source for oil and finally for biodiesel. The work was carried out for preliminary investigations, which gave positive results. To say anything more authoritatively, the subject requires more investigation. More investigation will be undertaken on the subject in the near future.

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