SFE542: Supercritical Extraction of Lipids from Microalgae for Biodiesel Synthesis

Introduction

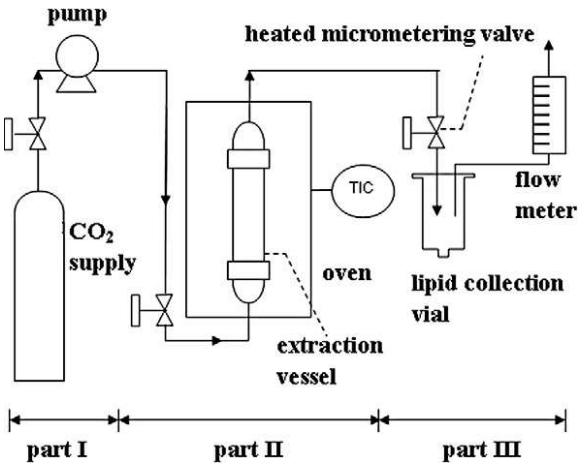
The rapid depletion of fossil fuels has increased interest in finding alternate energy supplies that are renewable. Fatty acid methyl esters (FAME) or biodiesel is a prime candidate to replace fossil fuels. Commercial production of biodiesel usually involves alkaline-catalyzed transesterification of triglycerides found in soybeans and rapeseed. Unfortunately, these crops are a source for food throughout the world and therefore are not sustainable as a fuel source.

Microalgae are a promising alternative to food crops as a source for biodiesel lipids. They are photosynthetic organisms that can accumulate up to 50% of dry cell weight as lipids. In addition, many microalgae grow in brackish water or seawater, eliminating the need for fresh water.

Supercritical carbon dioxide (SCCO2) extraction is a green technology that can replace the use of traditional organic solvents for lipid extraction. The benefits of using SCCO2 extraction include solvating power that is tunable, low toxicity, favorable mass transfer equilibrium , and the production of solvent-free extracts.

Equipment

Applied Separations Supercritical Extraction Equipment including the Helix, SFE 2, SFE 4, or Basic model.



Materials

Liquid CO2 cylinder

Methylation catalysts -(10 wt% H2SO4 in methanol and 25 wt% KCH3O in methanol)

n-hexane, isopropanol, and methanol were analytical grade.

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The microalgal strain used for this study was a *Chlorococcum* sp. and was cultivated in outdoor bag bioreactors. The species had a high growth rate, survived well in outdoor conditions and displayed wide temperature tolerances over the period of the study.

Method

Sample Preparation

Dewatering
Dewater the microalgae culture via centrifugation and rinse the microalgal paste with deionized water to remove residual salts.

Dry ,Grind and Mix
The microalgal paste was dried at 85 _C in an oven for 16 h. A ring mill was then used to grind the dried biomass into powder. Microalgal powder (20 g) was mixed with inert diatomaceous earth) at specific ratios (powder: d.e. = 2:1 w/w). The resulting homogeneous mixture was tightly packed into an extraction vessel.

Supercritical CO2 Extraction Conditions

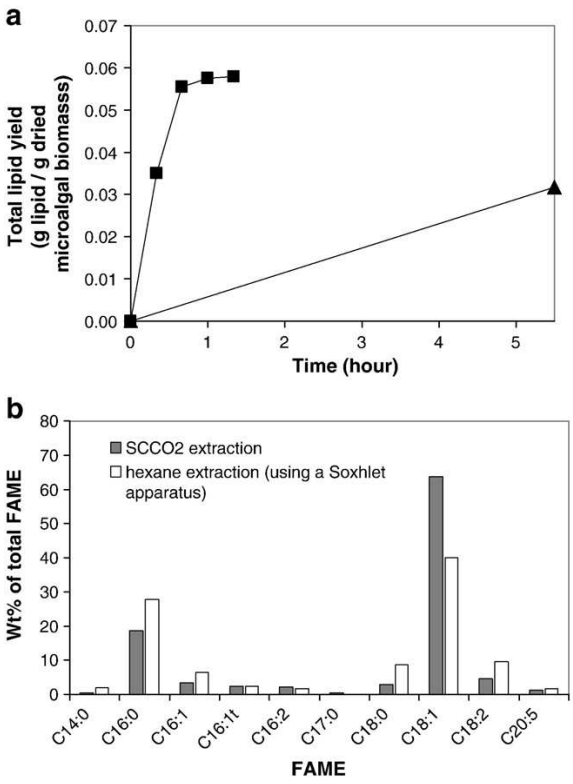
Sample: 20 g
Pressure: 500 bar
Temperature: 60 ºC
Valve temperature: 120 ºC
CO_2 Flow Rate: 0.4 L/min (gas)
Collection: 60 mL pre-weighed vial
Dynamic time: 80-120 minutes

Fatty Acid Methylation

Acid Catalysis
Redissolve the lipid extract in 20 mL of hexane. Add 20 mls of methanol and 1ml of 10 wt% H2SO4 in methanol to each vial. Transfer the mixture into a flask, heat to 50 _C, and moderately agitate for 2 h. Replenish evaporated methanol as required.

Alkaline Catalysis
25 wt% KCH3O in methanol was added dropwise to the gently stirred reaction mixture until a pH value of 13 was attained. Heat the mixture to 55 _C and moderately agitate for 2 h. Replenish the evaporated methanol as needed. Evaporate the mixture in an oven @ (60 _C) to obtain the dried post-methylated lipid extract. Finally, the lipid was re-dissolved in 20 mL of hexane for FAME analysis.

Results



(a) Comparison of total lipid yield between dynamic SCCO2 extraction and dynamic hexane extraction . ■ SCCO2 extraction, ▲ Hexane extraction (using a Soxhlet apparatus).
(b) FAME composition of the crude lipids.

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Conclusion

The yield of the SCCO2 lipid extraction of microalgae was found to decrease with temperature and to increase with pressure. There was no significant difference in the FAME compositions of lipid extracts obtained under different SCCO2 extraction parameters. Soxhlet extraction using hexane was found to be significantly less efficient than SCCO2 extraction.
Supercritical carbon dioxide extraction is a promising green technology that can potentially be used for large-scale microalgal lipid extraction. It is rapid, non-toxic, has high selectivity towards acylglycerols, and produces solvent-free lipids.

References

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