# COFFEE TO BIODIESEL: A QUEST FOR GREEN ENERGY

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## // Introduction

The global energy demand is increasing continuously with a greater need for more sustainable sources of energy. About 80% of the world's energy is supplied by fossil fuels. (Rocha et al., 2014)

Eight million tons of coffee grounds are produced annually and most of it goes to waste (Vardon et al., 2013). The purpose of this project was to put the spent coffee grounds from coffee to good use by extracting oil to produce biodiesel with minimal waste.

Two methods of oil extraction were explored; namely, sonication and microwave. Techniques used were inspired by the methods of Taghvaei et. al (2014) for microwave and Ponte Rocha et al. (2014) for sonication. After the oil was extracted the method by Behnia et al. (2011) was used to produce biodiesel.

## // Methods

### Oil Extraction (2 Ways)

Sonication Extraction Method

Sonicate spent coffee grounds and hexanes at a 1:4 ratio for 20 minutes.

Microwave Extraction Method

Microwave spent coffee grounds and hexanes at a 1:4 ratio for 1 minute. Then cool in an ice bath for 1.5 minutes. Repeat until 5 minutes has passed.

↓

Vacuum filter and centrifuge to remove SCG.

↓

Rotary evaporate to reclaim hexanes.

↓

Obtain the oil and dry in the oven.

### Biodiesel Production

Add 1 mL of methanol and 0.2 g of potassium carbonate to 2 g of oil and reflux for 30 minutes at 60 – 65 °C.

↓

Neutralize with acetic acid.

↓

Pipette the top layer and dry with anhydrous sodium sulfate.

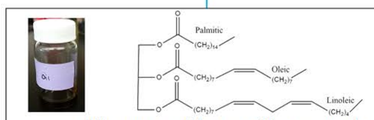
↓

Add basic alumina and stir overnight to obtain pale orange biodiesel.

### The chemistry behind the process

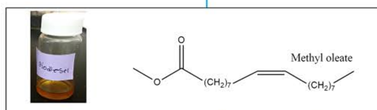
Powdered spent coffee grounds on the left and grainy on the right.

Yield of oil extracted - 10 - 14 %




Oil extracted from coffee grounds contains triglycerides.

Yield of biodiesel - 60 - 70%




Biodiesel produced contains Fatty Acid Methyl Esters (FAMES).



Oil, biodiesel and biodiesel treated with basic alumina have different shades of the same color.

### Characterization - $^1$H NMR

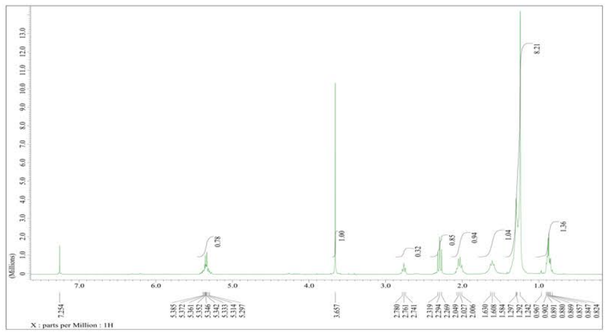


Fig. 1

$^1$H NMR ($CDCl_3$,$\delta$): 5.35 (m), 3.66 (s), 2.76 (m), 2.03 (m), 1.61 (m), 1.24 (m), 0.88 (m)

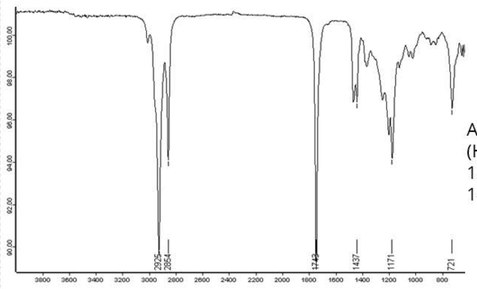
The peaks at the region of 5.35 ppm indicates the presence of vinylic hydrogens.

The peak at the region of 3.66 ppm indicates the presence of esters. The singlet indicates that all esters are of the same type (in this case methyl esters).

The peaks at the region of 2.76 ppm indicates the presence of carboxylic acids.

## // Results

### Characterization - FTIR



ATR - FTIR ($cm^{-1}$): 3015 (H-C=), 2925, 2854, 1743 (C=O, ester), 1437, 1171, 721

Fig. 2

### Characterization - GCMS

The GC had 4 significant peaks. The mass spectrum data is as follows,

**Unknown**
GC-MS (m/z, relative abundance): 326(60), 283 (36), 167 (100), 143 (42), 87 (93), 74 (95)

**Methyl Stereate**
GC-MS (m/z, relative abundance): 298 (38), 255 (33), 143 (33), 87 (77), 74 (100)

**Methyl Oleate**
GC-MS (m/z, relative abundance): 296 (11), 264 (47), 222 (29), 123 (29), 110 (33), 96 (60), 87 (39), 81 (67), 74 (47), 67 (74), 55 (100)

**Methyl Palmitate**
GC-MS (m/z, relative abundance): 270 (41), 239 (29), 227 (44), 143 (38), 87 (75), 74 (100)

### The effect of temperature and time on sonication

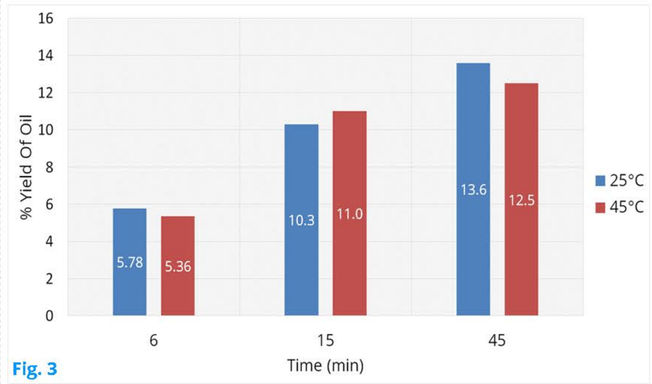



Fig. 3

### The effect of power and time on microwave extraction

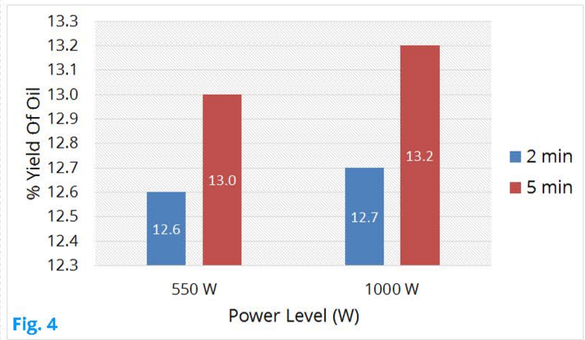



Fig. 4

## // Conclusions

The NMR spectrum (fig. 1) has strong support for the presence of FAMES. It also looks similar to methyl oleate (the most abundant FAME in coffee biodiesel).

The IR data of the biodiesel (fig. 2) shows the presence of esters, double bonds and single bonds. The presence of FAMES is supported.

The GC of the GC-MS indicated the presence of 4 significant peaks. Three of the FAMES were suspected to be methyl stereate (298 g/mol), methyl oleate (296 g/mol), methyl palmitate (270 g/mol). The first FAME could not be identified.

It can be concluded from fig. 3 that temperature has no significant effect on the yield of oil extracted through sonication. It can also be concluded that increased time for sonication allowed for greater oil extraction.

From fig. 4, it can be concluded that increasing the time and/or power for microwave extraction caused an increased yield of oil.

Waste produced is very minimal; the aqueous layer from the biodiesel production and the defatted spent coffee grounds are the only waste produced.

## // Future Work

Extracting sugars from defatted spent coffee grounds to produce ethanol.

Extracting waste glycerol from biodiesel production to produce organic building blocks (ex: pyruvate).

## // References

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