# Creating Biodiesel from Used Coffee Grounds

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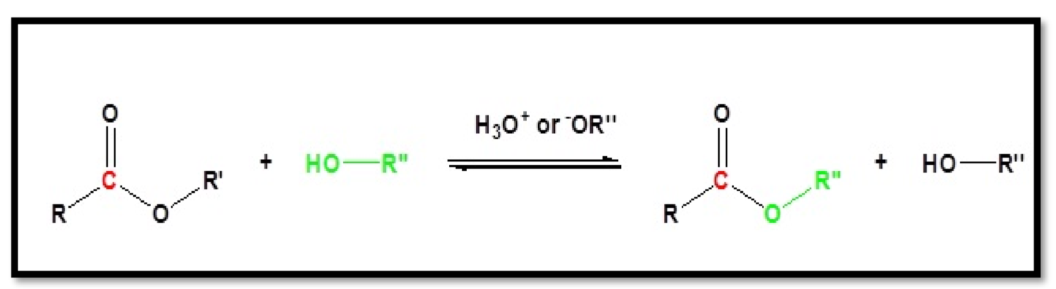
## Background Information:

- <u>HPLC:</u> High-performance liquid chromatography, a sample in a solvent (mobile phase) is pumped through a chromatographic column (stationary phase) at a high pressure
  - <u>Retention time:</u> Measure of time taken for a solute to pass through a chromatography column
- <u>Reflux:</u> When a liquid is boiled, allowed to condense, and the condensed liquid returns to the flask
- <u>Phenolics:</u> Aromatic benzene rings with one or more hydroxyl ($OH^-$) groups
  - Simplest phenol: $C_6H_5OH$
  - Mainly produced by plants for protection against stress
- <u>Ester:</u> A chemical group derived from an acid, where at least one hydroxyl group is replaced by an -O- alkyl group

## Transesterification:




- Exchanging the organic group "R" of an ester with an organic group "R" of an alcohol
  - Large excess of alcohol drives the reaction
  - Typically acid catalyzed

## Optimizing Transesterification:

- KOH: Potassium Hydroxide, Catalyst
  - MeOH: Methanol
- All reactions monitored by HPLC
- Trial 1: 1 wt% KOH and 20 v% MeOH
- Trial 2: Volume % of MeOH increased to 40%
  - Trial 3: 0.5 wt % KOH added
- Optimum conditions set as 40 v% MeOH and 1.5 wt% KOH

## Purification:

- Coffee oil mixed with 40 v% MeOH and 1.5 wt% KOH
  - Refluxed at 70˚ C
- Mixture kept static overnight and formed 2 layers
- Top layer washed with warm water to get rid of catalyst
  - Final pH of biodiesel: 6.8
- Continued washing with 0.5 wt% tannic acid
- Tannic acid wash to remove traces of catalyst left over from warm washing and to increase the antioxidant properties of the biodiesel
- Washing steps diminished intense color of biodiesel
  - indicated the removal of any water-soluble pigments

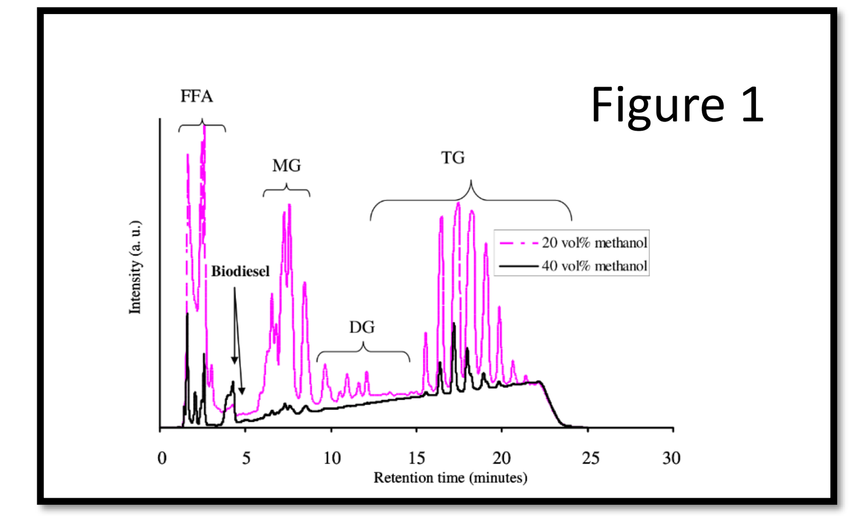
## Conclusion:

- Why is this research relevant?
- With a growing global population, humans are using more resources and energy now than ever
- Biodiesel is a green energy alternative to burning fossil fuels and coal which is heavily relied on today
- The future effects of coffee-biodiesel could remarkably impact the world

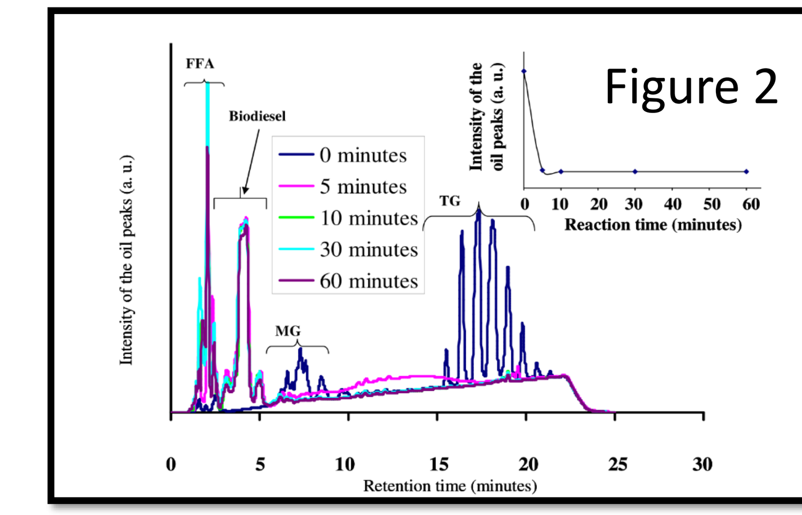
## References:

1. Kondamudi, Narasimharao. et al. Spent Coffee Grounds as a Versatile Source of Green Energy. *J. Agricultural and Food Chemistry.* **2008**, 56 (24), 11,757-11,760.
2. Izida, Thaís. et al. Monitoring the Transesterification Reaction of Vegetable Oil to Biodiesel by Fluorescence Spectroscopy with UV Excitation: Correlation with Viscosity. *Orbital*. **2018**. 10 (1), 22–25. EBSCOhost, doi:10.17807/orbital.v10i1.1026.

## Data and Results:

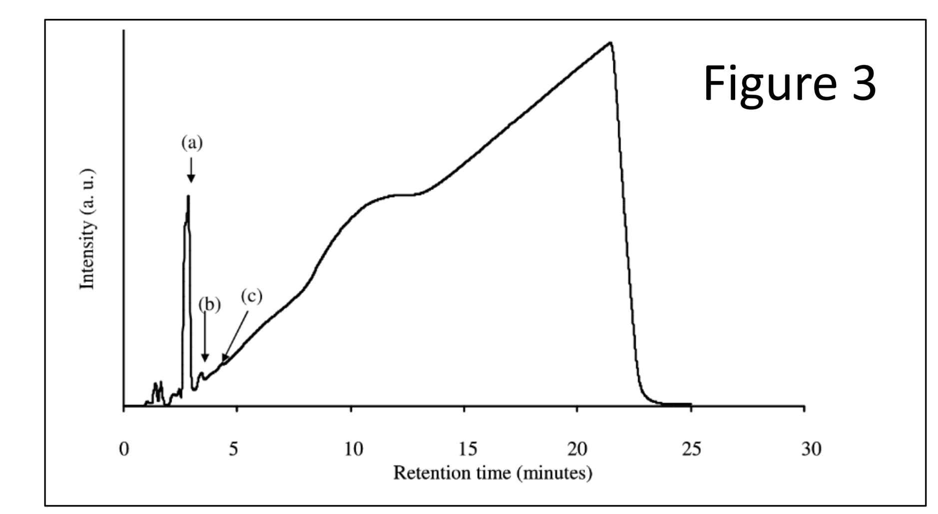



Increase in biodiesel formation shown in 40 v% MeOH




HPLC Analysis of the coffee oil transesterification process

- Want to minimize/diminish the formation of the MG, DG, TG
- HPLC Analysis: sharp decrease in intensity of oil peak within first few mins meaning oil was completely converted to biodiesel under optimized reaction conditions
  - Intensity of oil peaks monitored in HPLC to determine presence of oil
    - Oil peaks correlated with MG, DG, TG




Complete conversion of oil to biodiesel under optimum reaction conditions

Table 1:

**Table S1.** Future market scenario of coffee-biodiesel (based on waste gene Starbucks's stores).+

| Starbuck's market | USA | World | Overall World marke |
|---|---|---|---|
| Feedstock (lb/yr) | 210,000,000 | 294,000,000 | 15,000,000,000 |
| Bio-diesel (G/yr) | 2,920,000 | 4,080,000 | 208,000,000 |
| Pellets (tons/yr) | 89,150 | 125,000 | 6,375,000 |
| Revenue of bio-diesel | $13,140,000 | $18,360,000 | $936,000,000 |
| Revenue of pellets | $20,080,000 | $28,114,000 | $1,434,375,000 |
| Total revenue | $33,220,000 | $46,474,000 | $2,370,375,000 |
| Operating costs | $25,200,000 | $35,280,000 | $1,800,000,000 |
| **Total profits** | **$8,020,000** | **$11,194,000** | **$570,375,000** |

Economic benefits of coffee-biodiesel in 2008