

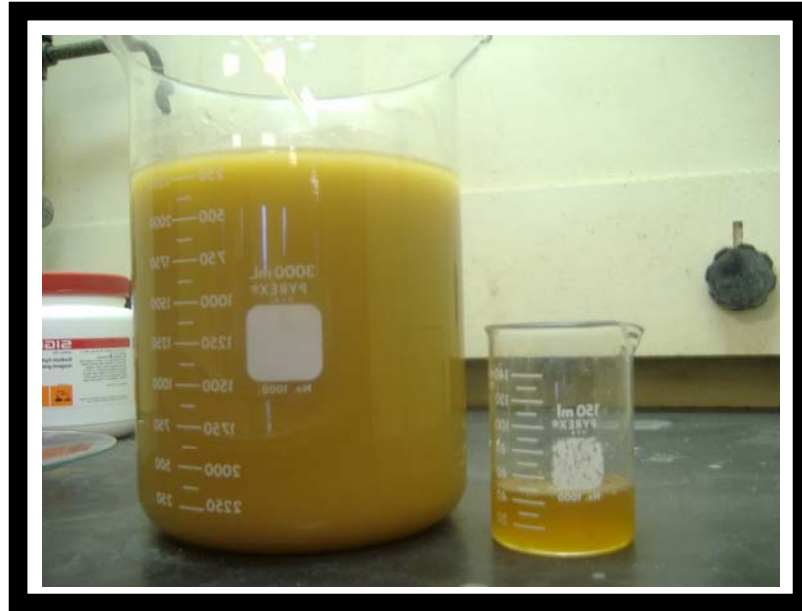


# Biodiesel Synthesis from Waste Vegetable Oil

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[http://sitemaker.umich.edu/section7group6/files/biodiesel\\_beaker.jpg](http://sitemaker.umich.edu/section7group6/files/biodiesel_beaker.jpg)

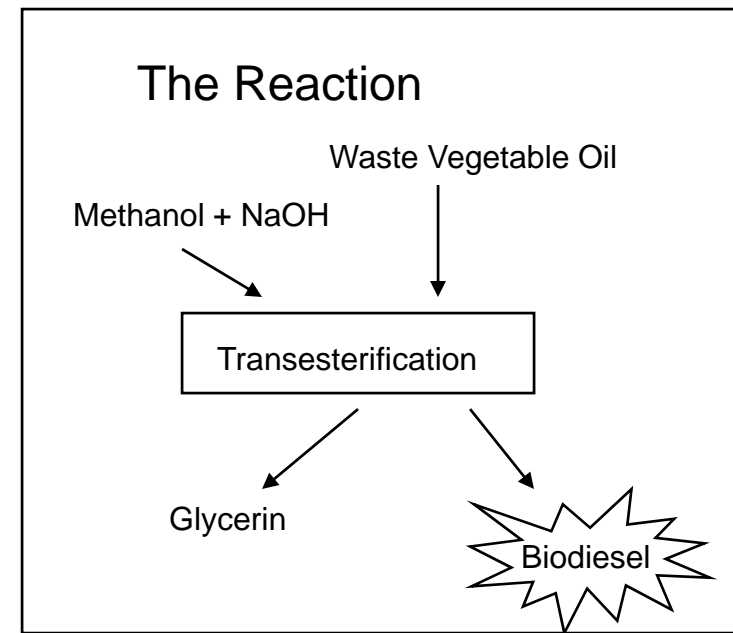
# What is Biodiesel?



Biodiesel is a clean burning alternative fuel, which is produced from renewable resources. It can be used in diesel engines with little modifications. It is simple to use, nontoxic, and safer for the environment.

We spent the first few week of our projects researching different methods and the process used to turn waste vegetable oil into usable fuel for a diesel engine. We met periodically to check in on what each group member had found and then to pick which method would work best for our project.

The method we chose was to first, after collecting all of our materials, filter the vegetable oil to remove foreign particles, then mix the waste oil with methanol and sodium hydroxide and let it sit, separate the resulting solution from the glycerin, and then distill the methanol out of the solution. The fuel would then be ready for use.



# Budget

Waste Vegetable Oil from the  
Café free

Sodium Hydroxide, Reagent  
Grade, 97%, flakes, 1.0 kg  
\$30.20

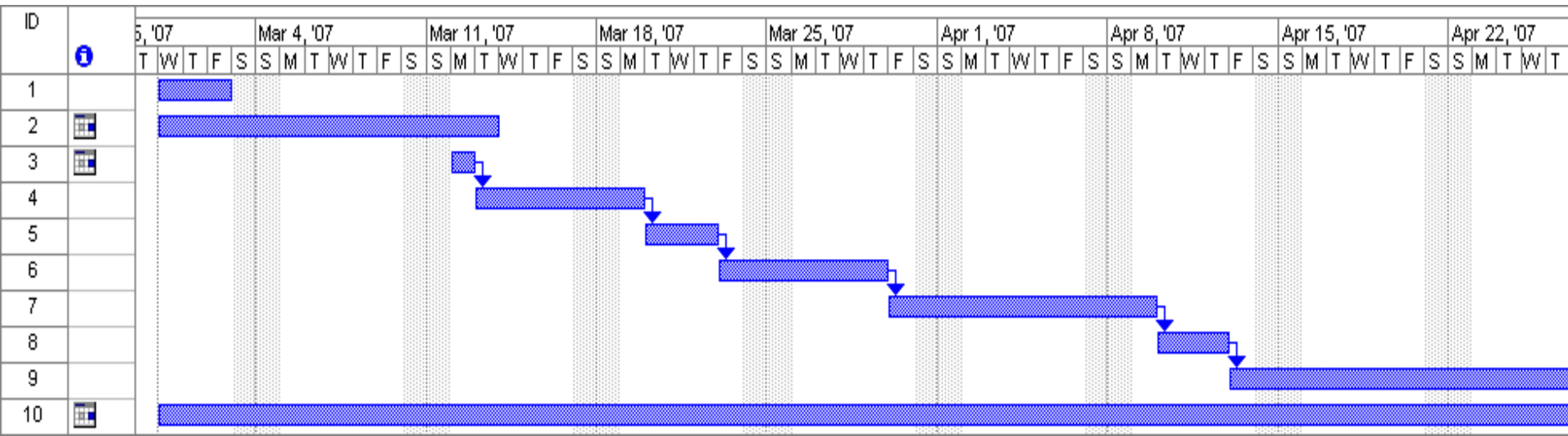
Methanol,  $\geq 99.8\%$ , A.C.S.  
reagent; 1.0 L  
\$25.50

Shipping Cost  
\$62.55

**Total Cost**  
**\$118.25**

# Initial Schedule

task	time	start date	end date	
Research Alcohol Distalation	3 days	2/28/2007 8:00	3/2/2007 17:00	
Find avaiable parts	2 wks	2/28/2007 8:00	3/13/2007 17:00	
Order Sodium Hydroxide	1 day	3/12/2007 8:00	3/12/2007 17:00	
delivery of sodium hydroxide	5 days	3/13/2007 8:00	3/19/2007 17:00	3
Bench Test	3 days	3/20/2007 8:00	3/22/2007 17:00	4
Begin Design of project	5 days	3/23/2007 8:00	3/29/2007 17:00	5
Begin Building	7 days	3/30/2007 8:00	4/9/2007 17:00	6
Test Design	3 days	4/10/2007 8:00	4/12/2007 17:00	7
Possible modification and re testing	10 days	4/13/2007 8:00	4/26/2007 17:00	8
Work on Presentation	42 days	2/28/2007 8:00	4/26/2007 17:00	



# Getting Started

## Getting Materials Together

We collected our Waste Vegetable Oil from the Market Place. And placed orders for the Sodium Hydroxide and Methanol.



The experiment was preformed in Musser Hall CH242 Lab

# Filtering the WVO

Filtering of the waste vegetable oil was done to remove any particles from the oil. First a spoon was used to scoop out any of the larger particles. Then the oil was slowly filtered through a coffee filter.



# Testing

After filtering we were left with only a gallon of waste vegetable oil, so for our bench test we decided to use only half of a gallon. The picture to the left shows the calculations we made to determine the amount of methanol and sodium hydroxide needed for the reaction, based off of our research.

$$\begin{aligned} & \frac{1}{2} \text{ gal} \approx 1.89 \text{ L} \\ & 0.95 \frac{\text{kg}}{\text{L}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol}}{882.4 \text{ g}} \times 1.89 \text{ L} = \\ & = 2.03 \text{ mol oil} \\ & 2.03 \text{ mol oil} \times \frac{3 \text{ mol CH}_3\text{OH}}{1 \text{ mol oil}} = 6.10 \text{ mol CH}_3\text{OH} \\ & 6.10 \text{ mol} \times \frac{32.04 \text{ g}}{1 \text{ mol}} = 195.6 \text{ g CH}_3\text{OH} \\ & \quad \times 2 \\ & \quad \hline & \quad 391.2 \text{ g CH}_3\text{OH} \\ & 391.2 \text{ g} \times \frac{1 \text{ L}}{791 \text{ g}} = 0.49 \text{ L} = 495 \text{ mL} \\ & 0.02 = \frac{x \text{ mol NaOH}}{6 \text{ mol CH}_3\text{OH}} \\ & x = 0.12 \text{ mol NaOH} \\ & 0.12 \times \frac{40.0 \text{ g}}{1 \text{ mol}} = 4.8 \text{ g NaOH} \end{aligned}$$



For Test Run:

Waste Oil – 1890 mL (2.03 mol)

Methanol – 495 mL (12.2 mol)

Sodium Hydroxide – 4.8 g (0.12 mol)



# Testing



rxn mixture following stirring



WVO

methanol and sodium hydroxide solution

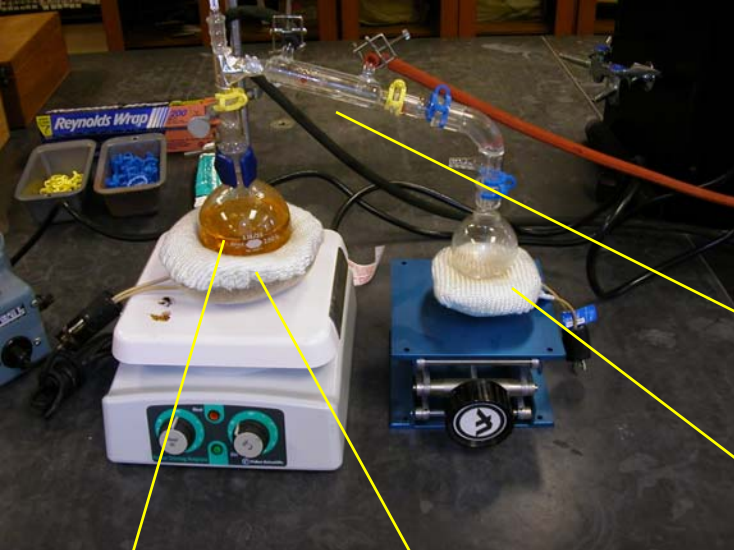
We weighted the NaOH, and then mixed the appropriate amount with the methanol.

We then added the solution to the vegetable oil

stirring vigorously by hand for ten minutes to mix everything together, and then stirring for an additional three hours via a magnetic stir bar to ensure molecular contact.

The solution was then left to sit and separate for 24 hours.

# Distillation



Biodiesel +  
methanol

Heating  
mantle

Cold water  
condenser

Collected  
methanol

Remaining methanol must be removed from the top layer before the biodiesel could be tested.

This was accomplished through a regular distillation (b.p.  $\text{CH}_3\text{OH} = 64.7\text{ }^\circ\text{C}$ ; b.p. biodiesel  $> 180\text{ }^\circ\text{C}$ )

The methanol was collected and tested via  $^1\text{H}$  NMR to ensure it was methanol being distilled.

Biodiesel remained behind, clear green in color.



# Results from Test Batch

After separating the biodiesel from the glycerin we found:

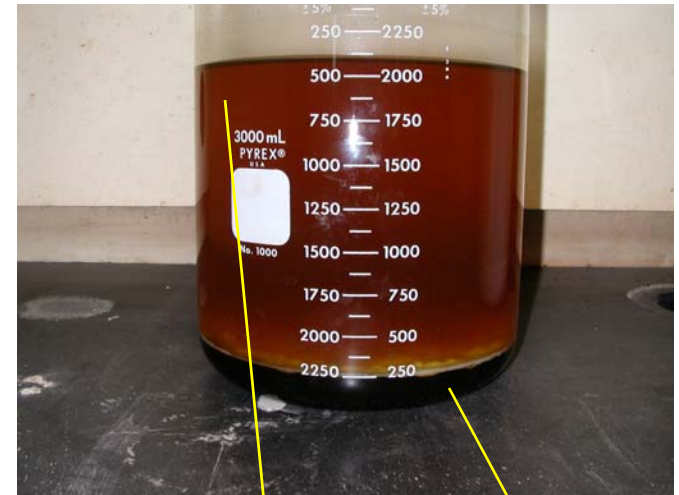
2000 mL by volume light, clear top layer  
biodiesel and methanol

250 mL by volume dark bottom layer glycerin

Approximately 550 mL of the top layer was  
distilled, producing:

500 mL of biodiesel fuel

50 mL of recycled methanol



Biodiesel +  
methanol

glycerin

# Helpful Relationships

In order to produce  $X$  gallons of Biodiesel fuel, future researchers should use the following relationships derived from our initial bench test:

$$W = \frac{X}{0.962} \quad \text{gal of waste vegetable oil}$$

$$M = 0.990W \quad \text{L of CH}_3\text{OH}$$

$$N = 19.6W \quad \text{g of anhydrous NaOH}$$

# Example

To make 20 gallons of biodiesel, you would need . . .

$$W = \frac{20.0}{0.962} = 20.8$$

gal of waste vegetable oil

$$M = 0.990(20.8) = 20.6$$

L of CH<sub>3</sub>OH

$$N = 19.6(20.8) = 407$$

g of anhydrous NaOH

	Amount	Cost/unit	Total Cost
WVO	20.8 gal	\$0.00 / gal	\$0.00
CH <sub>3</sub> OH	20.6 L	\$225.00 / 20L	\$225.00
NaOH	0.407 kg	\$30.20 / kg	\$30.20
		<b>Total</b>	<b>\$255.20</b>

# B100 Test

- We've obtained 500 mL of pure biodiesel (B100)
- We also have approximately 1.5 L of biodiesel which needs to be distilled
- **The B100 should be tested on a diesel engine to ensure the process was completed**

# To build your own Biodiesel maker

The design is fairly simple, materials needed are:

2-50 gallon drums, with a protective coating  
metal mixing apparatus  
pump set to the level of return  
distilling pipes and heater.



Thank You