

Production of biodiesel from orange peels - A senior student project

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Project Description:

The processes of orange oil extraction, hydrogenation, and the conversion of orange oil into bio-diesel fuel were reviewed. A small amount of biodiesel fuel was produced using orange peels as feedstock. The orange peels collected from several juicer establishments initially had a wet mass of 5130 grams. The peels were dried by the process of sun drying to remove unwanted water. This resulted in a net production of 6.79 ml (5.7 g) of orange oil through steam distillation. We were able to produce 0.03 ml (0.025 grams) of biodiesel fuel in less than 11 weeks. The measured heat of combustion of the biodiesel fuel was 33.65 MJ/kg. The scale of orange peel-based biofuel production must be increased by several orders of magnitude to make this process economically feasible.

The Steps

- Orange Peel Collection
- Orange Peel Preparation
- Solution Distillation
- Oil Separation
- Hexane Evaporation
- Biodiesel Production
- Calorimetry Test
- Lessons Learned

Project Background

The world produces 32 million tons of orange peel waste annually.

Citrus fruits contain a compound called D-Limonene.

This orange oil is what we need to make biodiesel.

Through the process of transesterification, orange oil can be made into biodiesel.

Project Goal: Produce 20 mL of biodiesel.

Orange Peel Collection:

- Willows Garden Juice Bar, located in Flint Farmers Market
- Squeeze the Day, located in Davison Farmers Market
- Total weight of wet oranges collected: 5.13 kg

Orange Peel Preparation

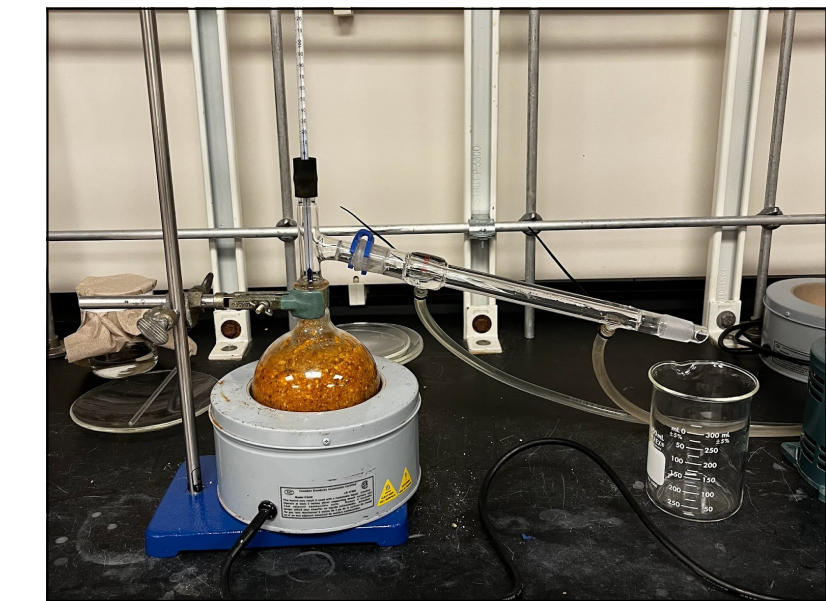
- Excess flesh removed from peels; makes drying easier.
- Peels sun dried for two days.
- Stored in airtight containers.
- Originally tried oven drying.
- Dried peels ground into a fine powder; made for easier handling in the lab



Steam Distillation

- Mixed with DI water at a roughly 2:1 ratio.
- Heated in a 500 mL round bottom flask for 2 hours at a 100 °C gas temperature.
- Water and oil mixture condensed with an air-to-water condenser.

Yield: ≈ 350 mL of water and oil solution



Oil Separation

- Distilled solution added to a 500 mL separatory funnel.
- Mixed with hexanes.
- Denser oil water solution separated from oil hexane solution.
- Process repeated.

Yield: ≈ 900 mL of hexanes and oil solution



Hexane Evaporation

- Orange oil mixed with hexanes.
- Rotavapor evaporates the hexanes.
- Pure orange oil remains in round-bottom flask.

Yield: ≈ 5.7 g of pure orange oil



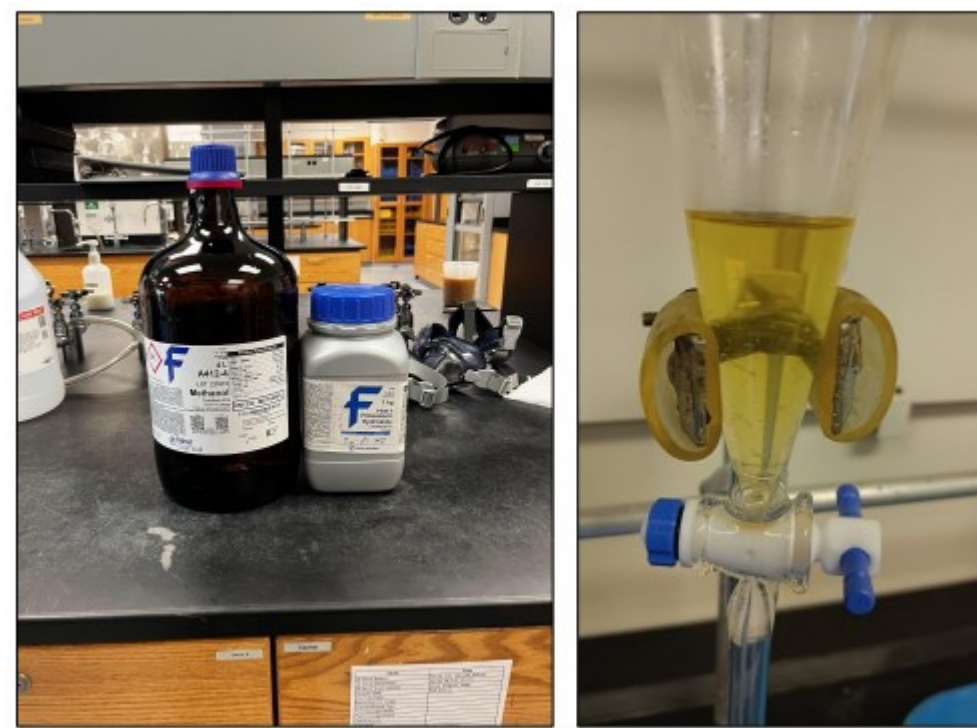
Biodiesel Production

Reaction: Transesterification

Reactants: 5.7 g orange oil, contains D-Limonene

15 mL Methanol, 1:3-5 molar ratio

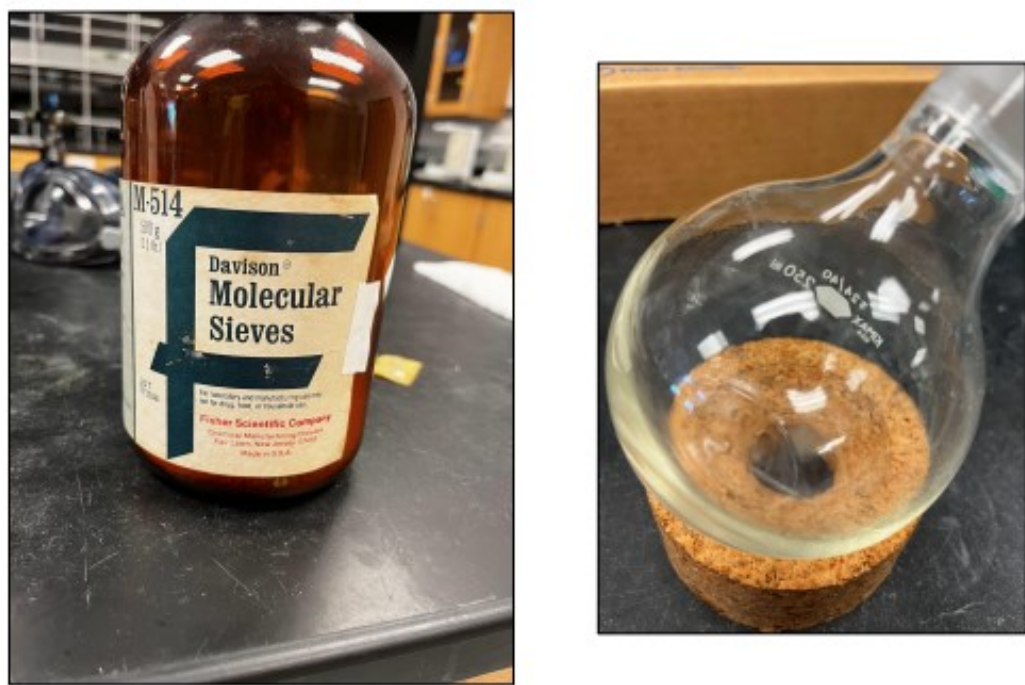
93 mg KOH, Catalyst in reaction, ≈ 0.3%wt



Biodiesel Production

- Water accidentally became a reactant in the transesterification reaction.
- Molecular sieves utilized to absorb unwanted water.
- Reaction performed again, but solution was still incorrect.
- More hexane washing/evaporation used to remove additional water.

Yield: 25 mg of Biodiesel



Calorimetry Test

Constant pressure and volume system used to calculate the heating value of a sample.

Procedure:

Test a known standard (hexane)

Ignite sample in a vessel submerged in water.

Record the temperature rise.

Clean and dry all equipment.

Repeat previous steps 3 times with wanted sample (Biodiesel).

<i>Results:</i>				
	Hexane	Sample 1	Sample 2	Sample 3
Ti (°C)	22.821	22.898	22.929	23.026
Tf (°C)	25.907	25.892	25.983	26.001
Time (minutes)	6:51:56	6:59:52	6:13:46	6:01:16

AVG LHV ≈ 33.646 MJ/kg
AVG HHV ≈ 37.347 MJ/kg

Lessons Learned

- Perform the lab procedure in incremental steps instead of waiting to collect the needed sample amount.
- Orange peel collection took longer than expected, caused rushed lab procedures.
- Develop an upscale method to perform certain lab procedures.
- Many lab procedures took upwards of 2 hours for small yield amounts.
- Be extra cautious while performing chemistry experiments. The smallest inconsistencies can drastically affect lab results.

