Solar Distillation vs. Heated Distillation for Recovery of Methanol from Waste Glycerol

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Excessive Waste

- According to the Environmental Protection Agency (EPA), hotels and restaurants in the U.S. generate at least 3 billion gallons of waste vegetable oil annually

  * Note: this figure excludes the quantity that is disposed of through drains

- Some of the grease is used to supplement feed farms but **majority of it ends up in landfills**

  - Landfills are engineered depressions in the ground with liners that are designed to keep the waste separate from the surrounding environment (ex. groundwater)

http://www.epa.gov/region9/waste/biodiesel/questions.html

http://www.zerowasteamerica.org/Pictures.htm

Landfills

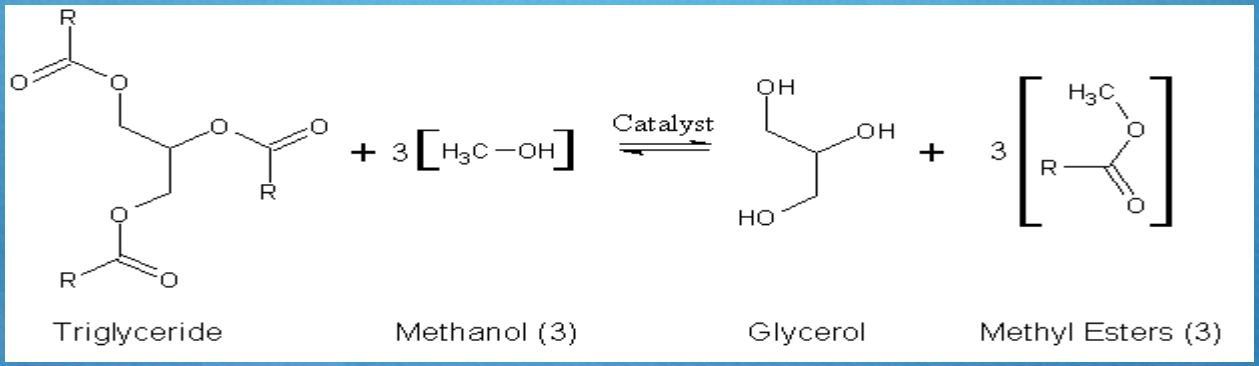
- Liners tend to fail
  - Clay , plastics (high density polyethylene –HDPE), composites (plastic and soil)
    - Crack, diffusion of organics over time, household chemicals react with plastic (changing their physical properties leading to brittleness and cracking etc)

- Environmental impact
  - Infrastructure damage, scavengers buried during soil coverage over landfill, contamination of water due to leakage, offgasing of methane (greenhouse gas) due to decaying organic wastes, etc

http://www.zerowasteamerica.org/BasicsOfLandfills.htm

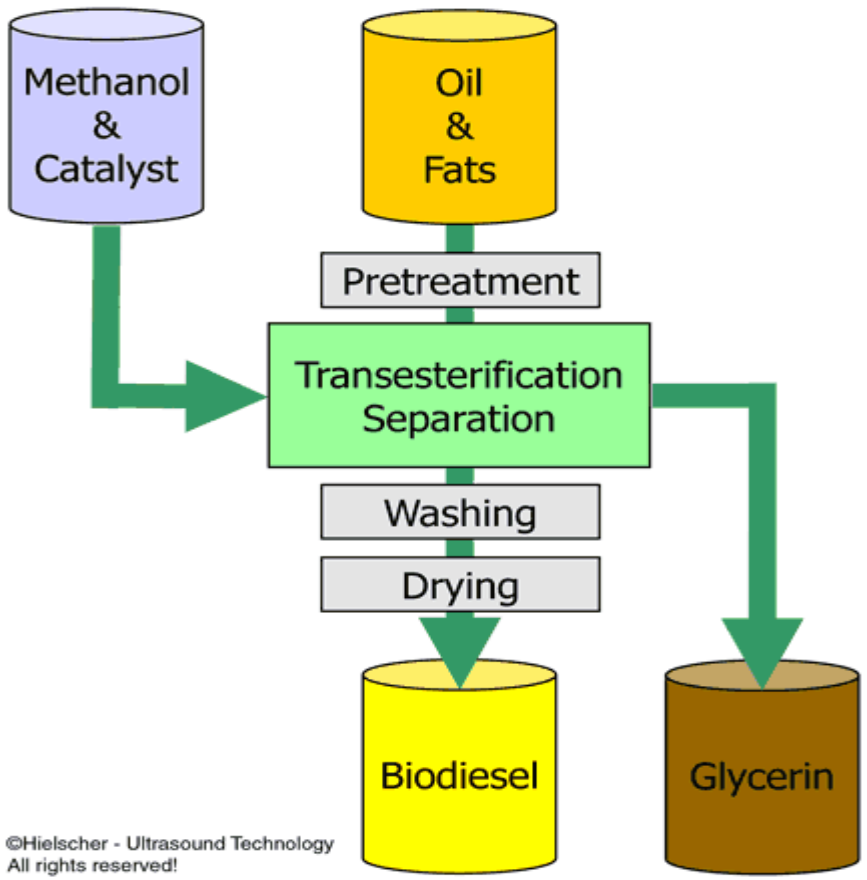
Biodiesel

- It is for these reasons Alachua County Hazardous Waste Center is now collecting waste vegetable oil for the production of biodiesel
  - A renewable fuel source resulting from a transesterification reaction of lipids with an alcohol (ex. methanol) and a catalyst (ex. sodium hydroxide)



http://upload.wikimedia.org/wikipedia/commons/7/72/Generic_Biodiesel_Reaction1.gif

By-Products



- Free glycerol
  - to which fatty acids were initially attached
- Methanol
  - Excess used for reaction

METHANOL is considered a hazardous waste because it is highly flammable and a neurotoxin!!!

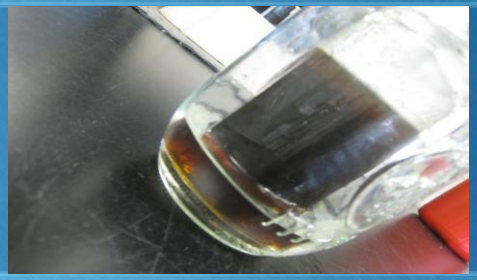
Objectives

1. Use two different distillation techniques (standard vs solar) for the recovery of methanol from waste glycerol generated from biodiesel production
2. Compare the purity and amount of methanol recovered with the aforementioned distillation techniques
3. Determine the amount of methane that can be produced from waste glycerol using the biochemical methane potential (BMP) assay

Objective 1: Separation of By-Products by Distillation

- Standard distillation is a common technique used to separate mixtures using the differences in their boiling points
  - Boiling point for methanol = 65 °C
  - Boiling point for glycerol = 290 °C
- Solar distillation uses the sun as the heating source

Procedure



- Standard
  - 100 ml of waste glycerol was placed in a beaker
  - Heated on stir plate (under hood)
    - Temperature readings were taken every 4 minutes
  - Sample was maintained at 65 °C for 10 minutes to ensure methanol evaporation
  - The volume of the glycerol was measured to see how much methanol had evaporated off
- Solar
  - 100 ml of waste glycerol was placed in a small mason jar that was within a larger mason jar
  - Jars were placed on a table outside for approximately 20 to 24 hours
    - Temperature readings were done with a infrared thermometer gun
  - Jars were then placed in the cold room for 2 hours
  - Both glyercol and collected methanol volumes were measured

Results & Conclusion

- Standard
  - Glycerol volume measured was 93.5 ml (therefore it is assumed that 6.5 ml of methanol evaporated off)
- Solar
  - 8.5 ml of methanol was recovered from the solar distillation unit, and glycerol volume measured was 91.5 ml

There will be variability with the amount of methanol that can be distilled out due to the different types of vegetable oil used to make biodiesel

Objective 2: Purity of Methanol Recovered

- Chemical Oxygen Demand (COD)
  - is method of quantifying the amount of oxygen required for the chemical oxidation of organics in a liquid
  - Procedure:
    - Crude glycerol, distilled glycerol and recovered methanol were diluted (glycerols 1:2500; methanol 1:200)
    - 2 ml of diluted samples were placed into Hach tubes
    - Then put on a digestion block for two hours
    - Then placed in Hach colorimeter

Results & Conclusions

Samples	Batch 5 glycerol *2500 mg/L	Solar distilled glycerol *2500 mg/L	Theoretical methanol reduction mg/L
1	1817.5	1817.5	1882
2	1845	1770	1912.1
3	1772.5	1880	1832.9

- The COD of the non distilled crude glycerol and the solar distilled crude glycerol had the same Cod because there was COD removed from the solar distilled glycerol as well as a volume reduction which gave it the same COD.
- There was only a 2.8 percent error between the actual and theoretical COD of the solar distilled glycerol
- The solar distillation of methanol averaged a 95 percent purity compared to the 99 percent purity found in biodiesel plants that use vacuum distillation

Objective 3: Quantifying methane produced from waste glycerol

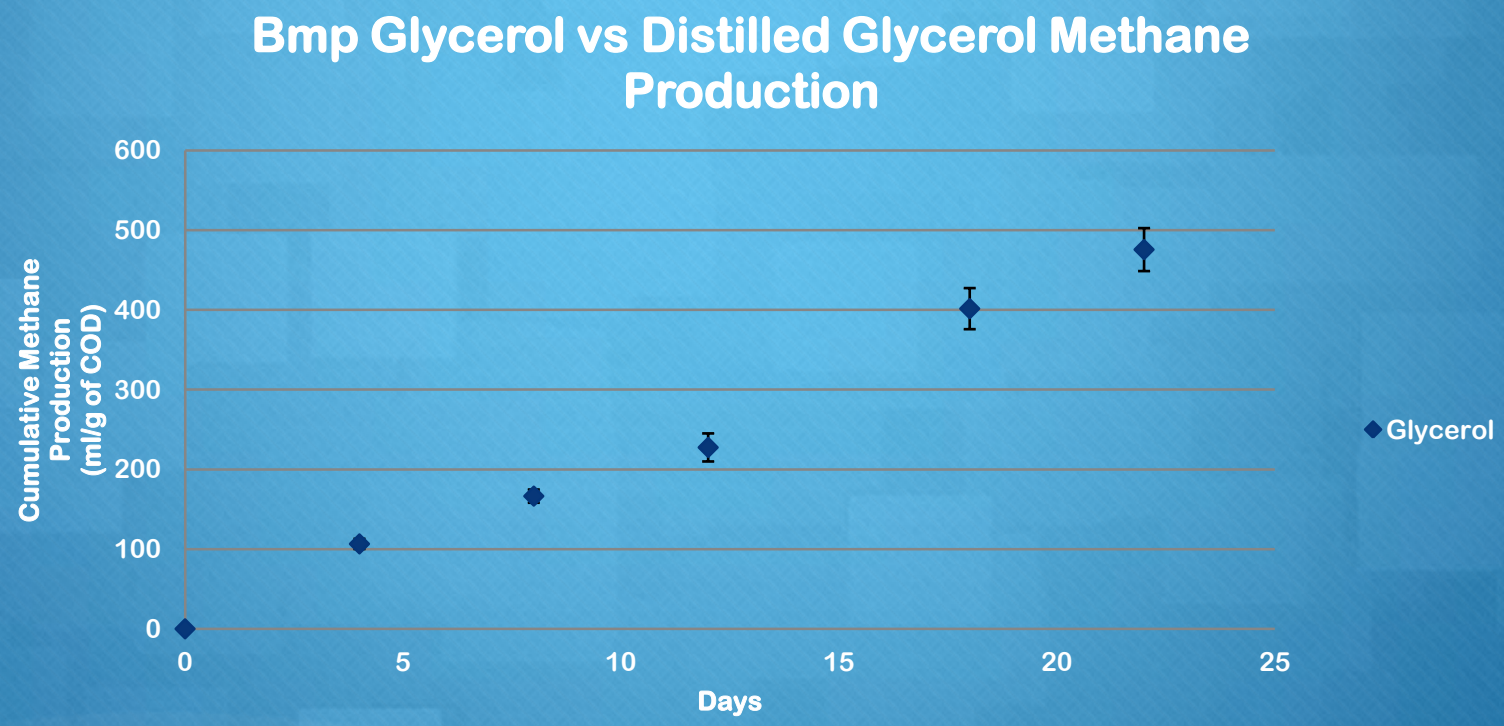
- Biochemical Methane Potential (BMP)
  - Measures the anaerobic digestibility of a given substrate.
  - It evaluates a substances ability to convert carbon into methane

Procedure

***After finding the COD from the crude glycerol it was found that .224 ml of the glycerol was needed to produce .4g per bottle

- Each bottled was filled up to 200 ml
  - Glycerol
  - Inoculum – which was effluent taking from another digester.
- Bottles were kept at 35 °C
- Measurements were done with a pipette that was hooked up to a bottle filled with alizarin and 5M KOH
- The methane from the BMP bottle would displace the waster in the KOH bottle and fill up the pipette

Results


Bmp Glycerol vs Distilled Glycerol Methane Production
Cumulative Methane Production (ml/g of COD)
600
500
400
300
200
100
0
0
5
10
15
20
25
Days
Glycerol

Conclusions

- Crude Glycerol makes a good feedstock for anaerobic digesters because small amounts of it produce high amounts of methane
- Able to break down the methanol to carbon dioxide and hydrogen which can then be turned into methane
- Has a high buffering capacity and can be used with feedstocks that have low pH's

Future Work

- Putting crude glycerol in an anaerobic digester at varying levels to see how it affects the anaerobic digester
- Scaling up the solar distillation units so that it can be used on one of the 55 gallon drums and then optimizing it