Improving the Sustainability of Biodiesel Production

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Abstract

Biodiesel is a renewable, biodegradable, and clean-burning alternative to petroleum. Production of biodiesel typically involves reacting a lipid with excess methanol. Residual methanol and glycerol by-products are also produced. Methanol is one of the most expensive chemical inputs of the biodiesel production process. To improve the sustainability of biodiesel production, it is imperative to retrieve the methanol and utilize the glycerol by-product. This study used solar distillation to recover methanol and anaerobic digestion to produce renewable energy from glycerol. The purity of the distilled methanol was calculated as 95%. Waste glycerol was anaerobically digested to yield biogas, which consists mostly of methane.

Introduction

Fossil fuels in the form of petroleum oil, coal, and natural gas, play a crucial role in the daily function (*e.g.* electricity, transportation, *etc.*) and development of societies worldwide. However, with world energy consumption growing at a rate of 2.3% per year, it is clear that with such slow (millions of years) formation and rapid depletion of the reserves of this non-renewable resource, there is a need to find alternative renewable means of energy production.

Biodiesel has a smaller carbon footprint, is less toxic, and most importantly is a renewable replacement for petroleum. Biodiesel is made through a process called transesterification that is a simple reaction of a lipid (oil) with an alcohol (methanol) and a catalyst to form glycerol and methyl esters (biodiesel). Excess methanol is used to drive the reaction and ends up being mixed in with the glycerol at the end of the process.

This research focuses on using two different techniques to further the sustainability of the biodiesel process:

1. Solar distillation: a method of using the sun to removing one fluid from another fluid through differences in boiling point temperature. Used in this study to separate methanol from glycerol.
2. Anaerobic digestion: microbial degradation in the absence of oxygen to breakdown organics. Used in this study to convert of crude glycerol into methane.

Objectives

Discover the percentage of methanol that can be removed from glycerol with solar distillation.

Determine the volume of methane that can be produced from glycerol through biochemical methane production (BMP) assay of crude glycerol with and without methanol

Methodology

- Chemical Oxygen Demand (COD) of glycerol and methanol calculated using Hach Colorimeter, following standard methods (APHA 2005).
- Methane production measurement of waste glycerol and distilled waste glycerol was performed with biochemical methane production(BMP) assays.
- Solar distillation was performed using small mason jars filled with waste glycerol enclosed within a larger mason jar and placed in the sun.
- pH determined with Orion probe following standard methods (APHA 2005).
- Conductivity was measured with handheld probe (Hach MP-6, Loveland, Co)

Results

- The pH of the solar distilled glycerol was 9.73 and the electrical conductivity is 14.7 mS/cm.
- The pH of the crude glycerol was 9.73 and the electric conductivity was 13.38 mS/cm
- The COD of the methanol measured from the distilled glycerol averaged at 1118mg/L. The purity of the methanol was found to be at 95%, based on COD analysis of pure methanol.
- 0.224 ml of Crude Glycerol produced 475 ml of methane on average over 22 days of incubation.

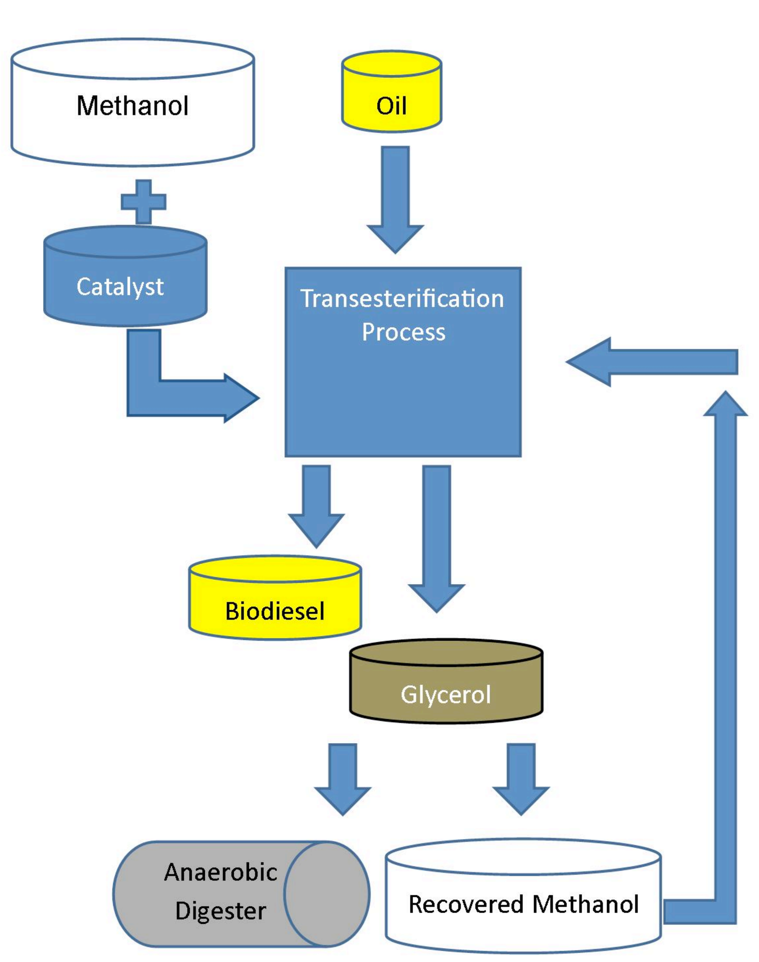

Figure 1. Sustainable biodiesel process

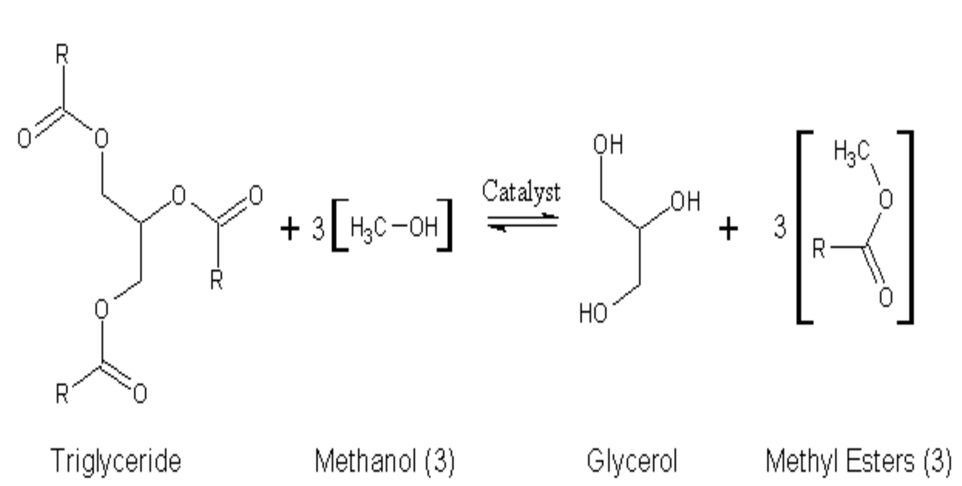

Figure 2. Transesterification process

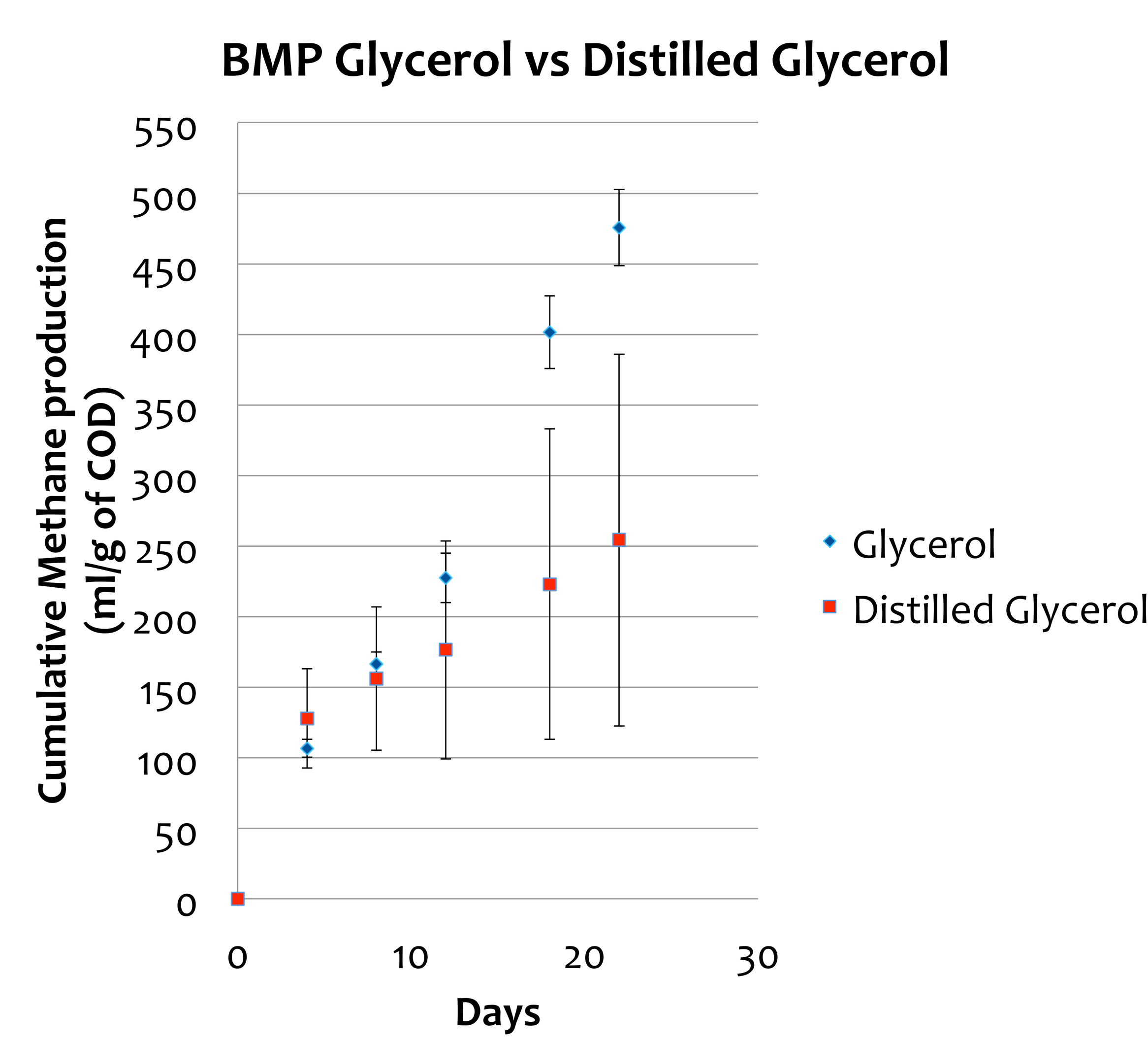

Figure 3. Methane production of glycerol over a series of days, error bars represent standard deviation

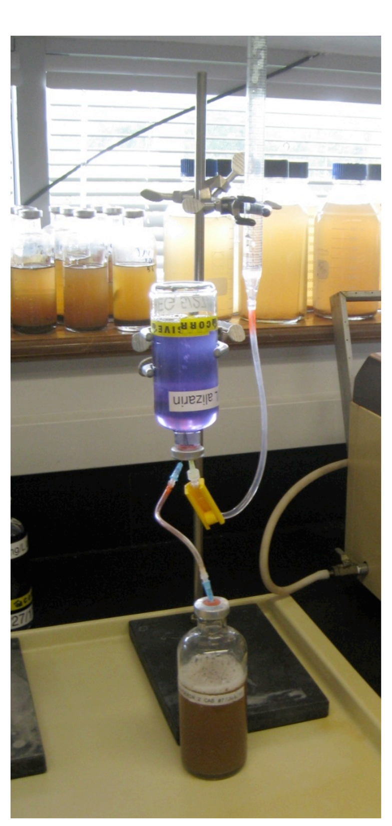

Figure 4. BMP assay of crude glycerol being measured

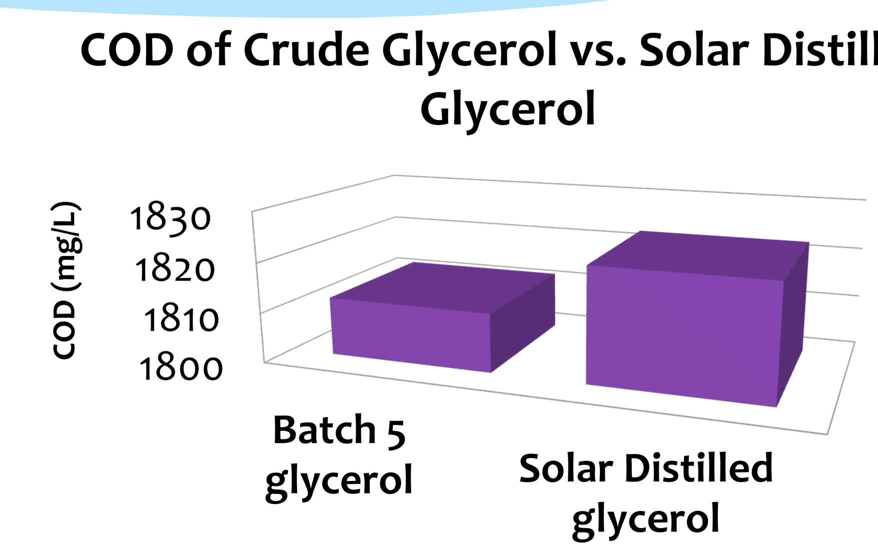

Figure 5. COD values from Solar Distilled glycerol vs. Crude Glycerol

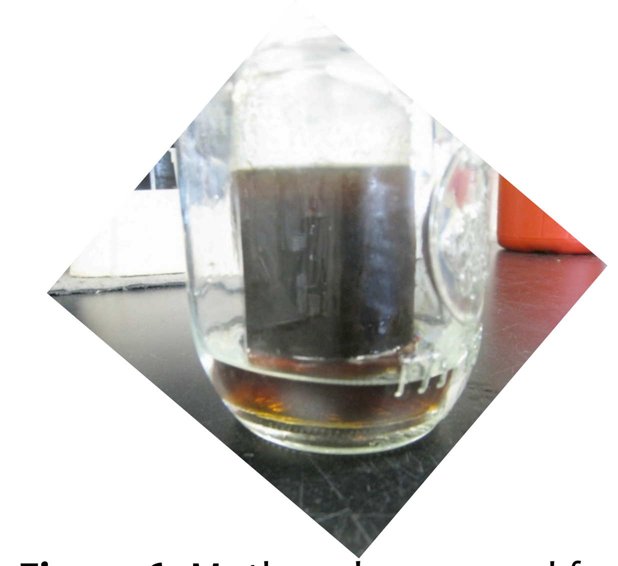

Figure 6. Methanol recovered from crude glycerol inside of mason jar

Conclusions

- Crude glycerol produces high amounts of methanol due to its COD and makes a great feedstock for anaerobic bio-digesters.
- Solar distillation can distill methanol from glycerol with only a 2.8 percent difference in purity compared to commercial processes.

Acknowledgments

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- Graduate student mentors Ryan Graunke and Scott Edmundson

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