Continuous biodiesel production I: Trans-Esterification via Sonication

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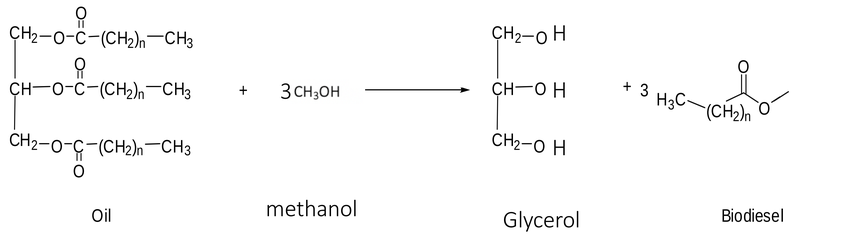
Abstract

Bio-derived fuels such as ethanol and biodiesel, hold the potential to significantly impact modern society's struggle to provide reliable energy to the world's population and mitigate emission that have a negative effect on climate systems. Biofuel are carbon-neutral and can be easily disturbed using current infrastructure and substituted into existing vehicles, engines, generators, etc. A major obstacle to widespread adoption of biofuels has been cost; biofuel production is expensive due to the batch nature of processing. A simple, continuous and inexpensive production method of biofuels could make them cheaper than fossil fuels and accelerate their adoption.

We report the results of a project designed to develop a continuous production cycle of biodiesel from various old feedstocks. Primary trans-esterification occurs via sonification as the oil feedstock and Potassium Methoxide mixture is pumped along a continuous flow reactor. Flow speed, tube diameter and tubing length varied in order to achieve 100% conversion of triglycerides to methyl-ester (biodiesel).

Introduction

Biodiesel is a fuel composed of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animals fats, designated B100, and meeting the requirements of the American Society for testing and Materials (1). Store-bought vegetable oil and waste vegetable oil obtained from a local restaurant were used to synthesize biodiesel at a medium level in UNC-Pembroke's biochemistry laboratory. The fundamental goal is to learn to make biodiesel and the ideal conditions for an appreciable yield. To determine if biodiesel was in fact synthesized, the Gas Chromatography-Mass Spectrometry (GC-MS) instrument and bomb calorimetry were utilized.



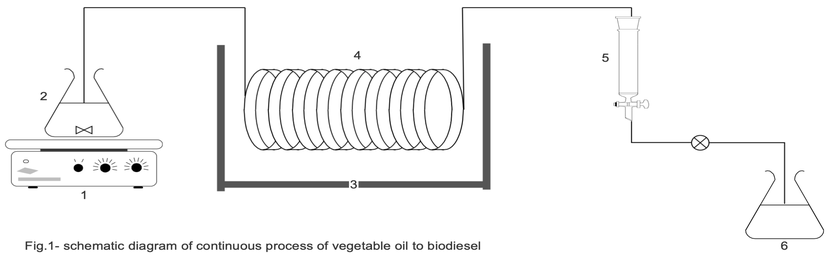


Fig.1- schematic diagram of continuous process of vegetable oil to biodiesel

1- agitator, 2- reaction vessel, 3- sonicator, 4-tubular rector, 5- separation column, 6- collection vessel

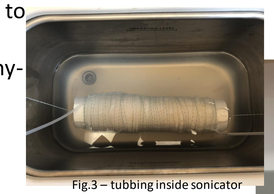


Fig.3 – tubbing inside sonicator

Fig.2- equipment setup

Materials

To convert vegetable oil into biodegradable diesel, we used the following components: vegetable oil, methanol, and potassium hydroxide.

- Sonicator
- Pump
- Beaker
- Stand
- Canola oil
- Methanol
- Potassium Hydroxide
- Nalgene 50 silicone tubing

Method

Nalgene silicone tubing of 12.73 meters wound over a PBC tube of 1.5in external diameter. The temperature is maintained at 65°C in the sonicator and the mixture of Vegetable oil, Methanol, and Potassium hydroxide is mixed and passed through the tubular reactor at a flow rate of 12mL/min. The mixture was recycled four times and the resulting solution was passed through a packed column containing silica.

Results

Total volume of the reaction mixture to be reacted = 130 mL
Tubular Reactor Holdup Volume = 28 mL
Flow Rate = 12 mL/min
Time Required for the completion of the reaction = 60 min
Temperature = 65°C
No of times the solution needs to pass = 130/28 = 4.64 times
Time required to pass 28 mL through the holdup volume = 28/12 = 2.33 min
Time required to pass 130 mL for the reaction = 4.64 * 2.33 = 10.8 min
Total no of passes for the completion of the reaction = 60/10.8 = 5.5 passes

Discussion

Sonicator helps the molecules to collide faster and efficiently to speed up the reaction due to high frequency. The idea of the tubular reactor is to convert the oil to biodiesel in a progressive way. The result with five times times recycling is not sufficient for reasonable conversion. The work is in progress to recycle more for better conversion with increased tube length.

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