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FULL PAPER

# Production of methyl ester biofuel from sunflower oil via transesterification reaction

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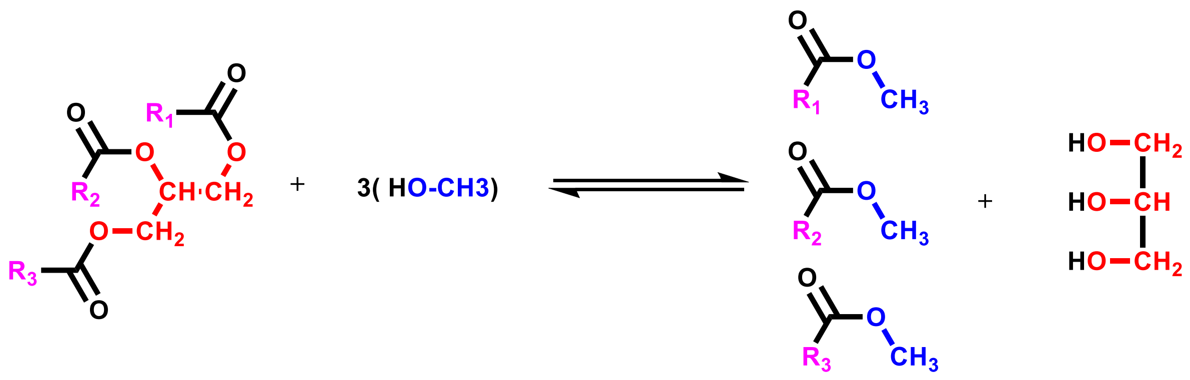
**ABSTRACT:** Methyl ester is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel oil. In this study, the transesterification of sunflower oil with methanol was studied using NaOH as catalyst. The dependence of the conversion of sonflower oil on the reactions variables as methyl ester preparation, separation of methyl ester from by-products, methyl ester purification, effect of molar ratio of Methanol to oil on transesterification and the effect of catalyst concentration on transesterification were performed.

**KEYWORDS:** Methyl ester, sunflower oil, Transesterification, biofuel.

## GRAPHICAL ABSTRACT



## Introduction

The limited fossil fuel resources along with the need to reduce Green House Gas emissions were major impulses to the development of alternative fuels. As a result, increased attention has been given to biofuels, such as biodiesel, that can be used as an alternative fuel in compression–ignition engines. Its production from renewable resources, such as vegetable oils and animal fats, makes it biodegradable and non-toxic; also, it contributes to the reduction of CO2 emissions, because it comprises a closed carbon cycle [1-6]. Generally, biodiesel is produced by means of transesterification. Transesterification is the reaction of a lipid with an alcohol to form esters and a byproduct, glycerol. It is, in principle, the action of one alcohol displacing another from an ester that referred to as alcoholysis (cleavage by an alcohol). The reaction is reversible, and thus an excess of alcohol is usually used to force the equilibrium to the product side. The stoichiometry for the reaction is 3:1 alcohol to lipids. However, in practice, this is usually increased to 6:1 to

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raise the product yield. Transesterification consists of a sequence of three consecutive reversible reactions. The first step is the conversion of triglycerides to diglycerides followed by the conversion of diglycerides to monoglycerides, and finally monoglycerides into glycerol, yielding one ester molecule from each glyceride at each step. The reactions are reversible, although the equilibrium lies towards the production of fatty acid esters and glycerol [7,8]. The reaction requires a catalyst, usually a strong base, such as sodium or potassium hydroxide, and produces new chemical compounds called methyl esters. It is these esters that have come to be known as biodiesel. Because its primary feedstock is a vegetable oil or animal fat, biodiesel is generally considered to be renewable. Since the carbon in the oil or fat originated mostly from carbon dioxide in the air, biodiesel is considered to contribute much less to global warming than fossil fuels. Diesel engines operated on biodiesel have lower emissions of carbon monoxide, unburned hydrocarbons, particulate matter, and air toxics than when operated on petroleum-based diesel

Fuel [9,10]. The objective of this paper is to describe the processing and production of biodiesel.

## 2 – Results and discussion

### Transesterification

Transesterification involves replacement of alcohol molecules from an ester by other alcohol molecules and glycerine which were produced as by-products of this reaction. This process is similar to hydrolysis, except that alcohol is employed instead of water (Srivastava and Prasad, 2000). The stoichiometry of this reaction shows that 3 moles of alcohol reacted with 1 mole of triglyceride to give 3 moles of fatty acid ester and 1 mole of glycerine. The reaction rate of transesterification could be accelerated using catalysts.

### Methyl ester preparation

The filtered oil was heated up to a temperature of 55°C in water bath to melt coagulated oil. The heated oil of 100mL was poured into the conical flask containing catalyst-alcohol solution, and this moment was taken as the starting time of the reaction. The reaction mixture was then shaken using shaker at a fixed speed of 250rpm. When the reaction reached the preset reaction time, shaking was stopped. Mechanisms of the transesterification of triglyceride with alcohol in the presence of a base or acid-catalyst are shown as follows in Fig 1 and 2.

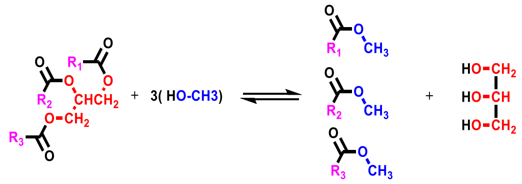


**Fig. 1.** Transesterification of vegetable oils.

### Separation of methyl ester from by-products

The product of reaction was exposed to open air to evaporate excess methanol for 30 minutes. The product was then allowed to settle overnight to produce two distinct liquid phases: crude ester phase at the top and glycerol phase at the bottom. There are few methods to separate these 2 layers, including the use of the separating funnel and removing the biodiesel using pipette. The later was used in this experiment.

### Methyl ester purification

The crude ester phase separated from the bottom glycerol phase was transferred to a clean conical flask. The produced biodiesel contains some residues including excess alcohol, excess catalyst, soap and glycerine. It was purified by washing with distilled water to remove all the residual by-products.

The volume of added water was approximately 30% (volume) of the biodiesel. The flask was shaken gently for 1 minute and placed on table to allow separation of biodiesel and water layers. After separation, the biodiesel was transferred to a clean conical flask. The washing process was repeated for several times until the washed water became clear. The clean biodiesel was dried in incubator for 48 hours, followed by using sodium sulphate. The final products were analyzed to determine related properties including viscosity, total acid numbers (TAN) and element contents. In this study, 3 experiments were carried out to study different parameters affecting biodiesel production, including alcohol to oil molar ratio, methyl ester preparation, Separation of methyl ester from by-products, methyl ester purification, Effect of Molar ratio of Methanol to oil on Transesterification, Effect of Catalyst Concentration on Transesterification. In each experiment, the parameters being studied were changed while other parameters were fixed.

**Effect of Molar ratio of Methanol to oil on Transesterification**

One of the most significant parameters affecting the yield of esters is the molar ratio of Methanol to oil. Methanol was used in the range of 1:1 to 5:1 (molar ratio of methanol to oil), keeping other parameters fixed. The reaction temperature was kept constant at 550C, and the reaction was performed between 6-8h. The reaction was performed with different concentrations of NaOH. The max Conversion was obtained at the ratio of 4:1, methanol to oil ratio for one-step base catalyzed transesterification of sunflower oil, and also for two-step process of acid-base catalyzed transesterification of sunflower oil. The reason behind using 4:1 ratio of methanol to oil rather than 3:1 for max conversion was that the excess quantity of alcohol or methanol is required to drive the reaction closer to the 99.7% yield, we need to meet the total glycerol standard for fuel grade biodiesel.

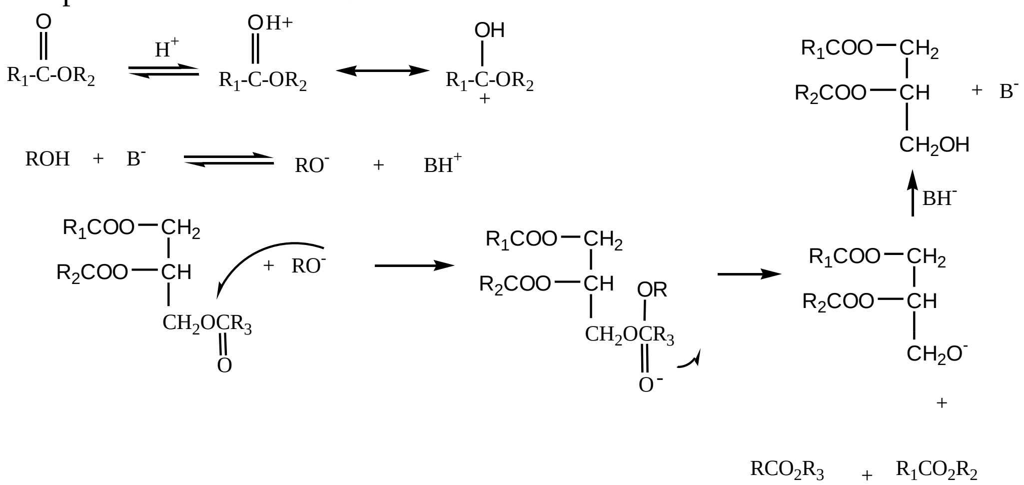

**Fig. 2.** Mechanism of the transesterification of triglyceride

**Effect of Catalyst Concentration on Transesterification**

The effect of NaOH concentration was studied in the range of 0.5%-10% (weight of NaOH/Volume of oil). The reaction temperature and reaction time were kept constant. It was found that the ester yield decreases as the amount of catalyst increased from 4% of Jatropha curcas oil and 8% of Waste vegetable oils and reduces the almost 50% of yields of methyl esters. This lesser yield at high NaOH concentration may possibly be due to soap formation. These

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viscosities, first, decrease up to 2.5% NaOH concentrations and after that it is almost constant. Excess NaOH reduces the yield and leads to undesirable extra processing cost because it is necessary to remove it from the reaction products at the end.

## Conclusion

The focus of the investigation carried during this work was oriented towards the conversion of high viscous oils to Biodiesel or Fatty acid methyl esters. Vegetable oils can be used as diesel fuel but due to high viscosity they cause many problems like poor atomization, incomplete combustion, leading to heavy smoke emissions and high flash point of oil attributes to lower volatility characteristics. The indiscriminate extraction and consumption of fossil fuels have led to a reduction in petroleum reserves, so alternative fuels, energy conservation and management, energy efficiency and environmental protection have become very important in recent years. There are four ways in which oils and fuels can be converted into Biodiesel, namely Blending, Pyrolysis, Micro emulsion and Transesterification. Alkali or Base catalyzed transesterification is the promising area of research for production of Biodiesel.

## Acknowledgment

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