Impact of mixing speed & reaction time on the biodiesel production from sunflower oil

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Abstract:-

In this work the effect of stirring speed & reaction time on biodiesel production are studied experimentally by using transesterification reaction process with 1:7 oil (cooking oil) to methanol ratio, NaOH catalyst of 1wt% of oil weight and reaction temperature of 55^0C. The experiments conducted with stirring speeds of (200, 400, 600, 800) rpm and shaking times (1, 2 and 4) hours. The results showed that, the highest production of biodiesel (96%) using 600 rpm and shaking time 2hr. and the biodiesel can be used as fuel in engines and burners.

Key words: *Biodiesel, Transesterification, bio-fuel, Methanol, Stirring speed.*

Introduction

The increasing focus on the environmental impacts of fossil fuel based power generation has led to increased research with the aim of reducing emissions and improving combustion efficiency. Much of this work is driven by the increasing interest into alternative fuels such as biodiesel, bio-alcohol, chemically stored electricity, hydrogen, non-fossil methane, non-fossil natural gas, oil, and other biomass sources. The use of biodiesel is rapidly expanding around the world, making it imperative to fully understand the impacts of biodiesel combustion process and pollutant formation. Biodiesel fuel is defined as mono alkyl esters of long-chain fatty acids (FAAE). The most industrial method to produce biodiesel is chemically described as the transesterification of oil with short chain, for use in diesel engines and liquid burners [1,4,5].

Biodiesel is nontoxic and biodegradable when introduced in neat form [7], and it is an oxygenated fuel which contributes to a more complete fuel burn. Its cetane number is higher than those of vegetable oil and diesel fuel [8] and hence produce less total hydrocarbons (THC) emission [9, 10]. Biodiesel does not contain any aromatic components, and with low sulfur content produces low exhaust particulate matter (PM) emissions, sulfur dioxide and lower aromatic hydrocarbons (HC) emissions [10, 11, 12]. There are many variables such as feedstock, alcohol, molar ratio, catalyst, reaction temperature, time duration, rate and mode of stirring effects on the yield and conversion of biodiesel [6].

The stoichiometry transesterification process shows 1:3 moles of triglyceride to methanol gives 3 moles of fatty acid methanol ester and 1 mole of glycerin **Fig.1**. The reaction can be accelerated by using catalyst.

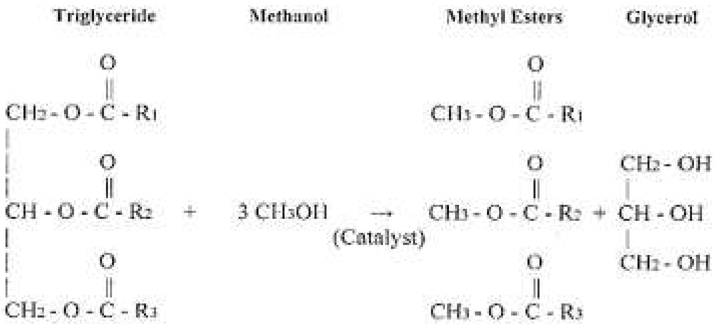

Fig. 1 Stoichiometry transesterification of triglyceride into a Fatty acid and glycerol utilizing Methanol [2].

The yield of biodiesel is affected by ratio of methanol and waste cooking oil, catalyst concen-tration and operating parameters as studied by Lakshmana Naik R. et al [13]. A.B.M.S. Hossain and M.A. Mazen [14] studied Fatty acid methyl ester (biodiesel) yield and showed that it is higher in NaOH than KOH. They used 0.5% as catalyst and obtained a maximum yield 1% NaOH compared to 0.5% and 1.5% with the case of NaOH. The biodiesel production from pure sunflower cooking oil (PSCO) and waste oil (WSCO) exhibited no considerable differences under optimum condition (1:6 oil to methanol molar ratio, 1% KOH, 40^0C, 320 rpm stirring speed) as provide by A.B.M.S. Hossain and A.N. Boyce[15].

The objective of this research is to investigate the effect of mixing speed and reaction time on the biodiesel yield from sunflower oil and methanol to find the optimization parameters of stoichiometric reaction [3].

Experimental setup

Experiments were performed in a stainless steel mixer, specifically manufactured for this regard,**Fig.2**. The container was equipped with an electric heater, electrical rotational changeable speed mixer to assure homogeneity and thermometer to monitor the mixture temperature during reactions.

The volume of alcohol (methanol)is measured using beaker (0.1 ml accuracy) and poured into the mixer,the catalyst weighted using digital balance(0.01gram accuracy). Thenthe mixture of (alcohol-catalyst) was shaken about 15 min.Avolume of sunflower oil measured and poured into the mixer containing catalyst-methanol solution. The volume of oil and methanol were calculated prior to experiments according to molecular weight and amount of moles used in reaction. The reaction mixture is stirred by using a mixer of variable speed (rpm) for each experiment. Mixing process must be maintained during the entire reaction time. After the completion of the reaction, any residual methanol should be evaporated by exposing the product to atmospheric air. The product is then poured in a deep container to enable the separation of the components into two liquid layers. The fatty acid methanol ester or (Biodiesel) forms the upper layer leaving the remaining glycerol at the bottom. To further purify the Biodiesel, it should be "washed" by distilled water. The washing process means mixing the Biodiesel with distilled water and shaking the mixture well for about one minute. Any undesired residuals of methanol, NaOH, soup and glycerin are washed out via this process. 25% ratio of water/biodiesel by volume is sufficient for good washing if it is repeated several times.

Fig. 2 The reactor used for biodiesel products

Experiments were carried out for variable mixing speeds and reaction time. Table.1 summarizes the layout of the variable and fixed parameters.

Table. 1 Experiment variable and fixed parameters.

Variable parameters	Fixed parameters
Mixing Speed (rpm) 200	Alcohol: Methanol Catalyst: NaoH 1wt%

Table 1. continued	
400 600 800	Reaction time:1h Reaction Temp.:55^{0}C
Mixing Speed (rpm) 200 400 600 800	Alcohol: Methanol Catalyst: NaoH 1wt% Reaction time:2h Reaction Temp.:55^{0}C
Mixing Speed (rpm) 200 400 600 800	Alcohol: Methanol Catalyst: NaoH 1wt% Reaction time:4h Reaction Temp.:55^{0}C

Results and discussion Effect of mixing intensity On biodiesel yield

The factor of mixing speed in the transesterification is very effective. The reaction is very slow without mixing because reaction takes place in interface between alcohol and oil layers. In this study, the effect of mixing intensity at constant catalyst concentration was examined. Transesterification was conducted with stirring speeds of 200, 400, 600 and 800 revolutions per minute (rpm) and catalyst concentration of 1wt%. The yield of methyl ester at different mixing intensities (rpm) is

Effect of mixing time On biodiesel yields

According to a lot of researches, the biodiesel production is always proportional to the times of reaction. In other words, the yield of biodiesel increases when reaction time increases. **Fig. 2, 3** show that the biodiesel production increases with reaction time increase, but the maximum biodiesel yield occurs at shown in **Figs. 2, 3 and 4. Fig 4** shows that mixing speed of 200 rpm requires reaction time of 4 hours to reach 82% yield of biodiesel. The enhancement in yield is reversed for the shaking time longer than 4 hours where increasing rpm lead to a decrease in yield due to the reversibility of the reaction. It can be seen from **Figs. 2 and 3** that increasing mixing speed accelerates the conversion. The best production of biodiesel was achieved at 600 rpm, 2hr. and 1% catalyst, reaching 96% of stoichiometric trans esterification reaction **Fig. 1**. reaction time of (2 hr.). This trend is due to the formation of higher amount of soap in biodiesel production at longer reaction times. The reason of soap formation comes from reversibility of transesterification reaction which helps the reaction between methanol and glycerol to produce the soap. Therefore increasing mixing time to 4 hours leads to a decrease in the yield and an increase into soap formation as compared to time of 2 hours.

The biodiesel properties was characterized according to (ASTM) at fuel laboratory of Mechanical Engineering Department – University of Technology (Table 2).

Table. 2 Sunflower biodiesel test methods

(ASTM): American society for testing and materials

Property (unit)	Test method	Limits	Sunflower Biodiesel
Viscosity cSt at 40^{0}C	ASTM D445	3.5-5.0	4.2
Cloud point (^{0}C)	ASTM D2500	-	0
Pour point (^{0}C)	ASTM D97	-	-2
Flash point (^{0}C)	ASTM D93	Min. 120	176
Density at 15^{0}C kg/m^3	ASTM D1298	860-900	880
Cetane umber	ASTM D613	48-67	64

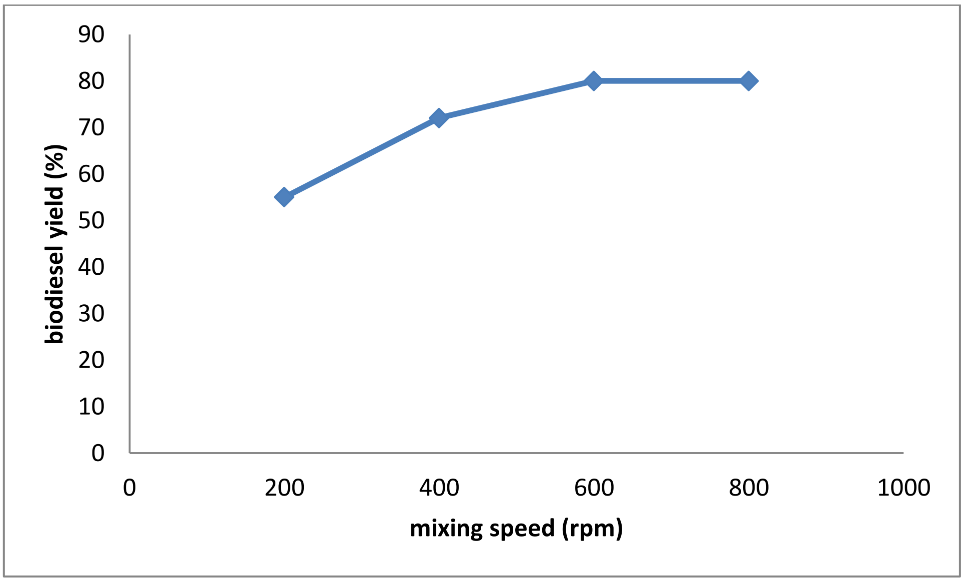

Fig. 3 mixing speed vs. biodiesel yield during 1 hour.

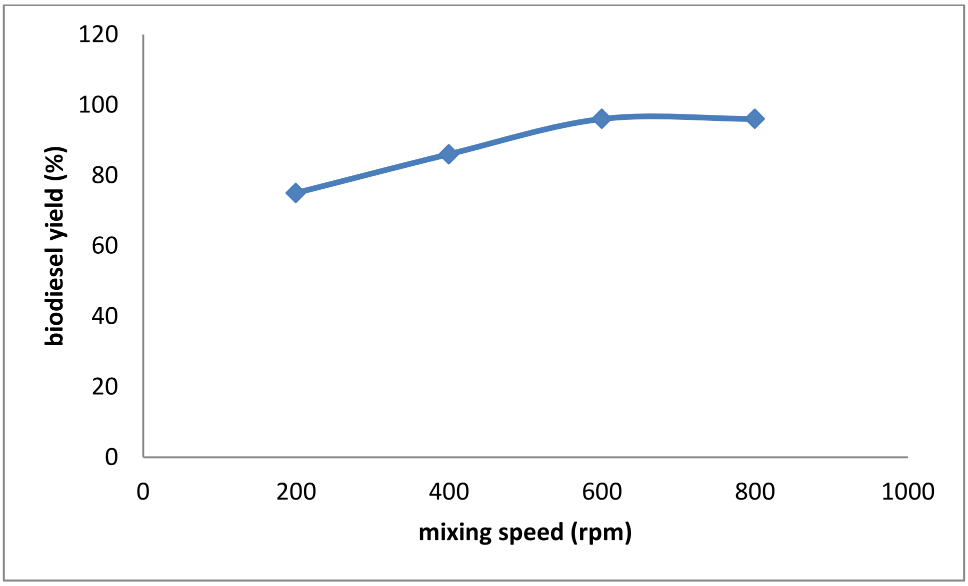

Fig. 4 Mixing speed vs. biodiesel yield during 1 hour.

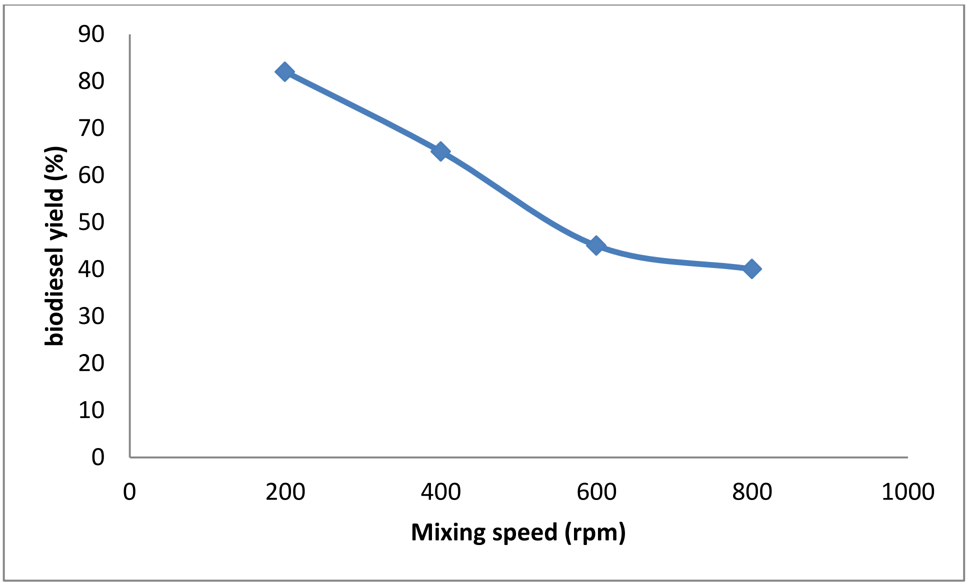

Fig. 5 Mixing speed vs. biodiesel yield during 1 hour.

Conclusion

An experimental study was performed on the production of biodiesel from sunflower. The following conclusions can be drawn from the present study:-

1. The highest yield of biodiesel from the transesterification was obtained at mixing speed of 600 rpm, 2 hours reaction time, oil:methanol ratio of 1:7 and 1% NaOH as catalyst.
2. The biodiesel yield increases with mixing speed until certain time limit (less than 4 hours). After that

the yield decreases with mixing speed.

3. The produced biodiesel has properties compatible with global standards. This qualifies it as a suitable alternative in diesel engines and furnace combustors.

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تأثير سرعة وزمن الخلط في انتاج الوقودالحيوي من زيت زهرة عباد الشمس

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الخلاصة

في هذا البحث تمت دراسة تأثير سرعة التحريك وزمن التفاعل على إنتاج الديزل الحيوي تجريبيا باستخدام عملية تفاعل ألاسترة بنسبة 1: 7 الزيت الى الميثانول باستخدام هيدروكسيد الصوديوم كعامل مساعد بنسبة 1٪ من وزن الزيت ودرجة حرارة التفاعل $55C^0$ قمنا بالاختبار باستخدام سرع تحريك (200 و 400 و 600 و 800) دورة في الدقيقة وزمن تحريك (1 و 2 و4) ساعة. وأظهرت النتائج أن أعلى إنتاجية لوقود الديزل الحيوي (96٪) باستخدام 600 دورة في الدقيقة مع زمن تحريك (تفاعل) 2ساعة . حيث ان وقود الديزل الحيوي المنتج يمكن استخدامه كوقود في المحركات والشعلات.