Biodiesel production from used vegetable oil (sunflower cooking oil) using eggshell as bio catalyst

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Abstract

Bio-diesel is an attractive fuel for diesel engines. The feedstock for bio-diesel production is usually vegetable oil, waste cooking oil, or animal fats. This work provides an overview concerning bio-diesel production. Also, this work focuses on the commercial production of biodiesel. The objective is to study the influence of these parameters on the yield of produced. The biodiesel production affecting by many parameters such as alcohol ratio (5%, 10%,15 %, 20%,25%,30%35% vol.), catalyst loading (5,10,15,20,25) g, temperature (45,50,55,60,65,70,75)°C, reaction time (0-6) h, mixing rate (400-1000) rpm. the maximum bio-diesel production yield (95%) was obtained using 20% methanol ratio and 15g biocatalyst at 60°C.

Keywords: Biodiesel, Waste cooking oil, Transesterification, Methyl esters; Renewable energy, Diesel, waste vegetable oil

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1- Introduction

Bio-diesel has become an integral part of the discussion of renewable energy sources. It was produced or refined from used vegetable oil, though each with different degrees of difficulty and involvement [1]. Bio-diesel can be used in diesel-fueled vehicles without any changes into engines.

Moreover, bio-diesel can be mixed with petroleum’s diesel to create different grade off fuel that are labeled based on percentage of bio-diesel in the blends; for example, B10 is 10% bio-diesel, 90% petroleum- diesel. This means that in times of bio-diesel inadequacy, vehicles can use amix of fuel and still function the same way[2].

Bio-diesel has advantage in terms of its flexibility and applicability. It holds great potential as an alternatives fuel. Bio-diesel is created from animal or vegetable oil that is modiﬁed through a process called transesteriﬁcation, during which triglycerides in the oil are converted to methyel and fethyl esters and g-glycerin [3]. Bio-diesel effected on CO2 emissions and reduced it. Biodiesel is studied because we need to reduce consumption of nonrenewable fossil fuels [4][1]. Biodiesel can be deﬁned as fatty acid methyl esters (FAME) derived from the transesteriﬁcation of triglycerides (vegetable oils or animal fats) with alcohol and suitable catalyst. Biodiesel can be produced from diﬀerent triglyceride sources such as vegetable oils (that can be edible, non-edible or wasteoils) and animal fats (mostly edible fats or waste fats) [11].

The idea of using alternative fuels has been widely spreading for many years now as a replacement for Fossil fuels. The importance of this idea came from the large scale of utilization of Fossil fuels in mechanical power generation various sectors, like agriculture,commercial, domestic and transport, also the fact of the continuousrise in Fuels cost and their eventual vanish [12].

The advantage of Biodiesel is a renewable resource, biodegradable, nontoxic fuel,a high cetane number, good lubricity, less gas emissions, Sulphur free, carbon neutral and carbon dioxide (CO2) is very small amount emission in the atmosphere. On the other hand, wastewater is potential alternatives for diesel engines due to their nature [6][3].

The work of this research worked with many experiments to producing biodiesel from sunflower oil [5]. Methanol is used as alcohols and eggshell is selected as catalyst.

2- Materials and Methods

2.1. Feedstock

Waste vegetable oil (WVO) was collected from the staff restaurant, in Al-Hilla. It was pre-treatment process by using two steps (filtration) and (dehydration) then it was filtered using filter paper (20µm) in order to remove impurity. After that it was dehydrated using a low pressure, in order to remove trace of water content present in oil. The characteristics of Waste vegetable oil were conducted by using TLC &GC (Baghdad University).
2.2. Transesterification Process

Experiments were conducted by using a reflux fitted system (Fig. 1 a, b) the mixture of waste vegetable oil, methanol and catalyst were added to a 2000ml necked flask and submerged in a water bath at seven different temperatures (45, 50, 55 ,60 ,65 ,70 75)°C. The catalyst loading for this project were taken as (5, 10,15, 20, 25) g with constant volume of oil of 1000 ml. and methanol ratio were taken as (5,10,15,20,25,30,35) %. The rate speed of agitation is 700 rpm remained constant.

The reaction time was 6h. After collection of the mixture, the sample was left to cool down for 10-15min, after which the two-phase (glycerin and bio diesel) system was carefully separated. The bottom layer of the system consisted of glycerin, while the top layer was made up of a mixture of methyl esters, unreactive methanol and intermediates see Fig. 2.

2.3. Experimental procedure

Methyl ester was synthesized in a 2000ml boiling flask, four boiling flasks each flask having a different molar ratio and catalyst concentration while maintaining a constant temperature and agitation speed. The first experiment was kept at 60°C flasks with 15 g catalyst loading, and 20 % methanol and 1000 ml of waste vegetable oil, adding 1000 ml of waste vegetable oil in flask.

Fig. 1. a reflux system, b reflux system

2.4 Product Estimation

The yield and conversion were calculated as follows:

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\text{Yield} (\%) = \frac{\text{Volume biodiesel}}{\text{Volume oil}}
\]  

3- Results and Discussion

3.1. Biocatalyst loading effecting on yield

Fig. 3 shows the effect of Bio-catalyst loading on biodiesel yield, the figure shows low yield (70%) was obtained with high catalyst loading (25g of biocatalyst), which was insufficient catalyst to completion in the formation of methyl ester. Higher bio-diesel yield (96%) was observed at an optimum concentration of (15g) catalyst loading. While at (10&20) g catalyst the bio-diesel yield was lower. Reaction rates increased as reactants occupied more catalytic sites until saturation was reached.

3.2. Effect of Temperature

Fig. 4 shows the effect of temperature on bio diesel yield, the figure shows that the best bio-diesel yield was founded at 60°C with a yield 95% under optimal conditions (catalyst loading 15 g, 20% methanol). In this current research, when temperature of the reaction increased to 60°Cwas obtained optimum biodiesel yield.
Increasing the temperature beyond 60°C resulted in a decrease in the production because the reaction occurring beyond boiling point of methanol (64.7 °C) resulted in its continuous vaporization. Hence it remained in the gas phase in the reflux, causing a decrease in methanol in the reaction media [9].

3.3. Effect methanol molar ratio

Fig. 5 shows the effect of different methanol ratio on bio diesel yield, the figure shows that the best bio-diesel yield was observed at (20%) of methanol that is 95%.

The yield decreased significantly to 70%, at a methanol ratio of 5%. This is due to the dilution effect of methanol and the interference between the high methanol ratio and the catalyst. There a subsequent increase in solubility and a decrease in the separation of glycerin and methyl ester [10].

3.4. Effect of Reaction time on bio-diesel yield.

Fig. 6 shows how the reaction time affected on bio-diesel yield when using biocatalyst (15 g), temperature 60°C and 20% methanol. The best yield 95% was obtained at 4 hours at catalyst (15 g) and methanol (20% vol.) as can be seen in figure 5. The bio-diesel yield was increased by increasing reaction from 1 to 4 hours. Reaction time for the transesterification increases with increases the conversion rate of bio-diesel had observed with the increasing of time up to 4 h, after 4h there was decreasing in the bio-diesel yield. Therefore, optimum reaction time was 4h.

3.5. Effect of Mixing on Bio-Diesel Yield

Fig. 6 shows the effect of different mixing on yield (400-1000) rpm, it can be see figure 6. The bio-diesel yield produced increased from 65% to 95% when rate of mixing increasing from 400 to 700 rpm and then decrease below 700 rpm.
Fig. 7. Effect of mixing rate on biodiesel yield

4- Conclusions

The aim of this project was to assess biodiesel production from cooking used oil in the presence of bio catalyst (eggshell). Five factors were investigated: oil/methanol ratio, catalyst, reaction time, mixing rate and temperature in order to optimize the process. The best reaction conditions obtained were methanol/oil ratio (20% vol.), catalyst amount (15g of egg shell), time of reaction (4hr), rate of mixing (700 rpm) and temperature (60°C). It was assumed that the catalyst was used in sufficient amount with respect to oil in order to shift the reaction toward the formation of methyl ester.

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إنتاج الوقود الحيوي باستخدام زيوت الطبخ النباتية المستعملة

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الخلاصة

الوقود الحيوي مهم لحل مشاكل الطاقة ونستطيع انتاجه من الزيت النباتي المستخدم باستخدام عوامل مساعدة حيوية وفي هذا البحث تم استخدام قشور البيض كعامل مساعد وكذلك استخدم ثلاثة نسب من كحول الميثانول وهي (10,5,25,30,35)% واستخدم أيضا في هذا البحث عدة أوزان من العامل المساعد وهي (25,20,15,10,5) غم من قشور البيض.

إن انتاج الوقود الحيوي يتأثر بعدة عوامل مهمة وهي نسبة الكحول (35,30,25,20,15,10,5)%، كمية العامل المساعد (25,20,15,10,5) غم، الحرارة (50,65,70,75,80,90،100,120) درجة مئوية، وقت التفاعل (0-6) ساعة و معدل الخلط (400-1000) دورات/دقيقة. وفي هذا البحث تم الحصول على أعلى كمية من الوقود الحيوي وهي 95% تحت ظروف 20% ميثانول و 15 غم من العامل المساعد الحيوي ودرجة حرارة 60 درجة مئوية.

الكلمات الدالة: وقود حيوي، زيت طبخ، الطاقة المتجددة