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# Study on Processing Parameters Such as Temperature, Density and Catalyst Type on Production of Biodiesel Out of Sunflower Oil

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**ABSTRACT**

In the past decade, biodiesel has been noticed as a reproducible, non-toxic and lucrative fuel. This fuel is in fact the FATTY ACID METHYL ESTER which has been resulted from Trans-esterification of Tri-glyceride. It´s expected that biodiesel will be developed throughout the world with a greater pace. With regards to the importance of biodiesel production, 18 samples of this biofuel have been made out of sunflower oil in three reaction temperatures of 60, 70, 80,℃ with two catalysts (potassium hydroxide & sodium hydroxide) with different weights of 0.5, 1, 1.5 % with 300 rpm agitation intensity under Alcohol to water ratio of 1:5 in 60 minutes period. the consequences showed that the high quality of this biofuel resulted from the catalyst of potassium hydroxide with weight percentage of 1 in comparison to the other two weight percentages of 0.5 & 1.5.
**Keywords:** Sunflower oil, biodiesel, Trans-esterification, fatty acid methyl ester.

## INTRODUCTION

Biodiesel has been introduced as one of the most promising fuels in the recent years. Therefore it is now necessary & inevitable to study such newly emerging energies. In addition to that, biofuels have several up-sides compared to petroleum as they are non-toxic, new, non-sulfur, reproducible and less-smoking [1-3].

Biodiesel is a new energy source which is environment-friendly. So, it has been considered as the perfect, suitable energy.

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The history and background of biodiesel gets back to the era of diesel engines [4,5].

Making use of biofuels has been discussed and studied since the development of diesel engines. Radolf Diesel (1858_ 1913) the inventor of diesel engine considered "peanut oil" as the fuel for his engines. Later on, a number of other oil such as "date oil:, "soya oil", "cottonseed oil: & "caster oil" were studied. Primarily reports indicated that using biofuels for diesel engines is very suitable. Contrarily, high expenses prevented them to be commonly used instead of petroleum [6-8].

Despite their application in engines, the biofuels led to some difficulties in the injection system.

The main problem of biofuel oils was their high level of viscosity which resulted in appearance of flea or sounds production in the injectors.

This will result in weaker injection & finally poorer operational performances.

Here, there are 4 ways advised to reduce the viscosity of herbal oil.

1. Trans-esterification (Ester exchange)
2. Chemical changes (temperature increment)
3. Dilution by the usage of petroleum
4. Emulsion

The most frequently-used methods are ester exchange which produces fatty acid alkyl ester and long chain mono-alkyl esters of fatty acid.

This idea first emerged in 1938. The following diagram shows a simple implementation of this reaction [9-12].

Glycerol is not pyrogenic and causes sedimentation of carbon on the engine.

On the other hand it has high viscosity. The Glycerol in molecule of triglyceride is responsible for high viscosity in herbal oil.The fatty acid (biofuel) has one-tenth of the viscosity of the herbal oil.

We should bear this in mind that, what remains from the fatty acid is known as biodiesel.Since it can be mixed with petroleum diesel at any proportion, biodiesel is very easy to use.The mixture of biodiesel & petrol diesel is often indicated by $B_2O$, 20% of which is biodiesel & the other 80%, of capacity is petro diesel [13,14].

In this paper, a vast study on input, productive technologies & specifications of biodiesel will be implemented. Productive technology in catalyst development will Also be studied & discussed. Finally, ideas will be exchanged regarding specifications and important parameters in biodiesel production. There has been wide spread researches in this field during the recent years [15-17].

In this paper we chose a herbal oil known as sunflower oil to study the effects of processing parameters such as temperature, type & density of catalysts in production of the biofuel (biodiesel) in the laboratory condition and also we declare the ideal & desirable effects of these processing parameters in the production of this fuel.

At last, the percentage of saturated methyl esters of fatty acids & unsaturated methyl esters of fatty acids of the biodiesel will be calculated.

Findings: In this experimental process which took several months, 18 samples of biofuels were produced [7].

There were 9 samples which were made of potassium hydroxide & 9 samples of sodium hydroxide. Then each catalyst were experimented under the temperatures of 60, 70, 80 °C with different densities of 0.5, 1, 1.5 weight percentages during 60 minutes of time period in an ester exchanging process.

Three samples were chosen out of the 18 and they were sent to genetic laboratory. These 3 samples were ester fatty acid from KOH which have reacted under 80 °C of temperature.

Considering the fact that there were no impurity, the above-mentioned laboratory esterified the fuel once more. Then the results were as follows. Please notice that in the following chart, the amounts of saturated fatty acids and unsaturated fatty acids in the final produced fuel are mentioned [8].

**Table 1:** Percentage of unsaturated fatty acids and saturated fatty acids in the laboratory samples

| Results | | | Fatty Acid |
|---|---|---|---|
| 1.5% | 1% | 0/5 % | |
| 0.0392 | 0/0816 | 0/0313 | C14:0 |
| 8/5839 | 9/1320 | 9/2265 | C16:0 |
| 4/1505 | 5/1917 | 4/8418 | C18:0 |
| 30/1500 | 28/7016 | 29/6779 | C18:1 |
| 55/3640 | 58/4537 | 56/1015 | C18:2 |
| 0/0807 | 0/0527 | 0/1004 | C18:3 |

It is expected that by increasing the density of the catalyst up to a determined level, the quality of the biofuel will be increased. As an instance, pay attention to the report of these researchers. The effect of the catalyst amount on the percentage of the reaction change in the current paper, potassium hydroxide was used as the most commonly used catalyst in the biodiesel industry.

To do so, the effect of potassium hydroxide with 0.25, 0.5, 0.75, 1, 1.25 & 1.5 percentage of weight were assessed.

Variance analysis shows that the effects of catalyst on the amount of reaction change on the level 1% is very meaningful.

Of course, there wasn´t a meaningful difference between the level of biodiesel production in the weight ratios of 1 & 1.25. Therefore, 1% is advised.

As the weight percentage of the catalyst increases the amount of Methyl Ester increases. At any level higher than 1%, minor changes are observed. Maximum purity of biodiesel at 11.25% of weight has been calculated as 93%. At higher percentages, due to the existence of free fatty acids & formation of soap with the alkaline catalyst, reactional viscosity will increase. This will lead to reduction of effective mixture in the reactor and considering the previous part, the percentage of reaction change will be decreased. Now we will study saturated fatty acids & unsaturated fatty acids.

Scientists found out that (C16:0) & (C18:0) have the most important effect on the power of the engine due to saturation, while (C18:1) & (C18:2) & (C18:3) had the least impacts.

As the level of saturation decreases, the less power should be expected. For example (C18:3) which has 3 unsaturated nexus has a negative impact on the quality.

Now if we take a look at chart 1 carefully, we find out that the quality of biodiesel in the 1.5% of weight is less than the other two. With a closer look to the percentage of saturated fatty acids & unsaturated fatty acids, we will find out that the quality of biodiesel with 1% weight is higher than the quality of 0.5 & 1.5%. This is due to the existence of more saturated fatty acids. Therefore, we resulted that the quality of our biofuel with 1% weight of potassium hydroxide of sunflower oil will be higher than the other two densities, and it can be more useful in production of biofuel for commercial purposes.

We hope that the costs of measuring Methyl Ester by the measuring equipment reduces, so that more samples could be measured & studied.

Now chromatographic diagrams of these there samples can be seen below.

We would remind you that these diagrams were resulted in *GC qualifying system & they are not meant to be compared.*

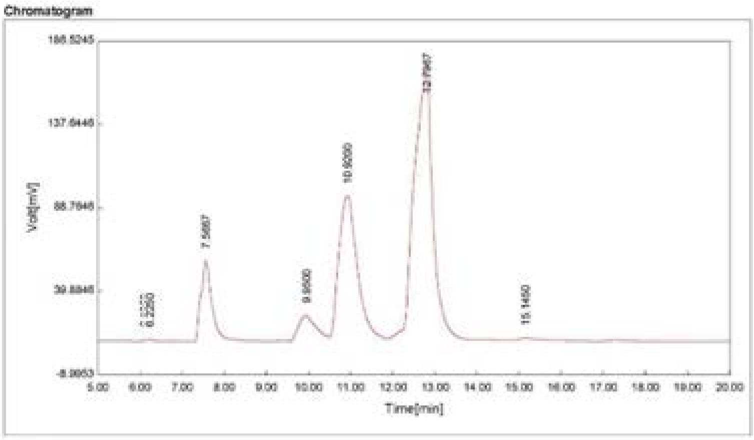
*Because the amounts of biodiesel which were used in each sample were different.*

*These chromatographs were resulted in the central Analytic laboratory of Genetic & biotechnology.*

*The chromatographic device was* GC-MS & had high voltage & included a complete series of columns to divide & measure toxics in the plant tissue and analyze fatty acids in different tissues on the basis of Iranian Standard Organization protocol.

## CHARTS FOR OBTAINED FROM GAS CHROMATOGRAPHY TESTS

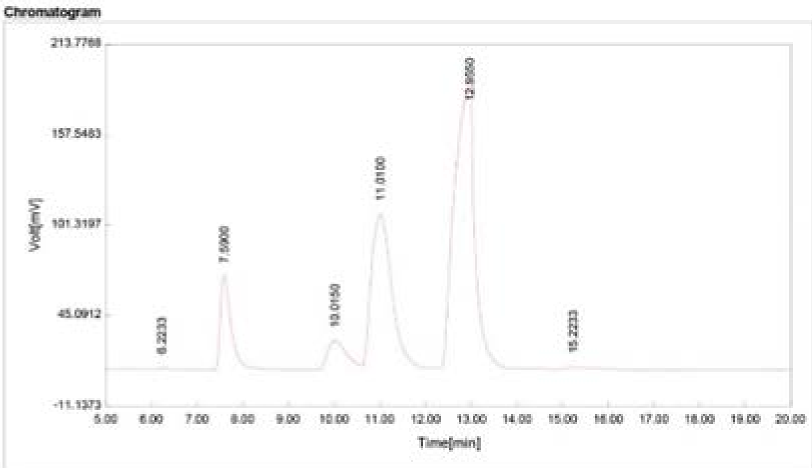
**Chart 1:** 0.5% weight of potassium hydroxide




Result

| Num | RT[min] | Area[mV*s] | Type | Width[sec] | Area% |
|---|---|---|---|---|---|
| 1 | 6.1050 | 1.8065 | BB | 8.0000 | 0.0205 |
| 2 | 6.2250 | 2.7571 | BB | 10.0000 | 0.0313 |
| 3 | 7.5667 | 812.1704 | BB | 47.0000 | 9.2265 |
| 4 | 9.9500 | 426.2041 | BB | 55.9000 | 4.8418 |
| 5 | 10.9200 | 2612.4098 | BB | 82.0000 | 29.6779 |
| 6 | 12.7967 | 4938.3622 | BB | 109.0000 | 56.1015 |
| 7 | 15.1450 | 8.8372 | BB | 21.0000 | 0.1004 |
| Sum | | 8802.5473 | | | |

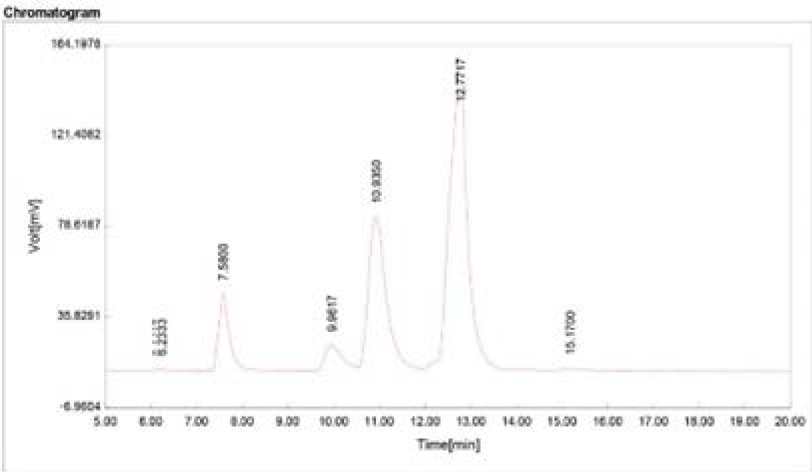
**Chart 2:** 1% weight of potassium hydroxide




Result

| Num | RT[min] | Area[mV*s] | Type | Width[sec] | Area% |
|---|---|---|---|---|---|
| 1 | 6.2233 | 8.2700 | FF | 16.5000 | 0.0816 |
| 2 | 7.5900 | 925.2037 | FF | 47.7000 | 9.1320 |
| 3 | 10.0150 | 525.9982 | BB | 56.1000 | 5.1917 |
| 4 | 11.0100 | 3054.6356 | BB | 84.1000 | 30.1500 |
| 5 | 12.9550 | 5609.1745 | BB | 90.1000 | 55.3640 |
| 6 | 15.2233 | 8.1740 | FF | 18.6000 | 0.0807 |
| Sum | | 10131.4559 | | | |

**Chart 3:** 1.5% weight of potassium hydroxide




Result

| Num | RT[min] | Area[mV*s] | Type | Width[sec] | Area% |
|---|---|---|---|---|---|
| 1 | 6.1417 | 1.2269 | BV | 5.4000 | 0.0184 |
| 2 | 6.2333 | 2.6233 | BB | 8.5000 | 0.0392 |
| 3 | 7.5800 | 573.8684 | BB | 45.5000 | 8.5839 |
| 4 | 9.9617 | 277.4799 | BB | 53.5000 | 4.1505 |
| 5 | 10.9350 | 1918.8190 | BB | 77.5000 | 28.7016 |
| 6 | 12.7717 | 3907.8682 | BB | 104.5000 | 58.4537 |
| 7 | 15.1700 | 3.5262 | BB | 14.5000 | 0.0527 |
| Sum | | 6685.4120 | | | |

As the ester input has been given to the device, some peaks will be given to us. These diagrams would be analyzed by the device. Results show that all the samples contain the desirable mixtures. However the length & width of the peaks were different in the chromatograph, but it showed that the maximum amount is related to *C18:2.*

*It must be said that the numbers on the peaks are related to time. After considering the* chromatographs and the peaks, we would find out that the quality of biodiesel at 1% of weight is higher than the other two weight percentages. *This should also be reminded that the wider the peaks are, the more impure the fuel is. This means that there might be water of other impurities might exist.*

As you saw in the diagram of biofuel, the thinner peaks indicate the more purified experimental conditions.

In each chromatographic diagram, there was 6 peaks that each peak shows the type of our fatty acid in the plant fuel of our biodiesel. As an example: the highest peak is the fifth one which is related to *C18:2, the percentage of which is higher than the rest. Each experiment took 15 minutes which totally took 45 minutes.*

## DISCUSSIONS AND FINDINGS:

According to the researches done in this paper which were in the same direction with laboratory studies of other researchers:

1. NaOH catalyst dissolved in Methanol slower than KOH. Also it was observed that in the separation operation KOH caused a slow-down on the separation of water from oil compared to NaOH. This caused difficulties in the separation of water from fuel.
2. Temperature plays an important role in esterification. In other words, the higher Temperature leads to biodiesel production increment.
3. According to the studies, Temperature has a great impact on leaching the biodiesel. The minimum leaching time, has the least amount of soap remaining in the biodiesel.
4. The pace of separating the biodiesel from water in purifying actions was faster at 70°C compared to 60°C.
5. According to the observations, the impurities existing in the biodiesel were less at the Temperature of 70°C compared to 60°C.
6. The more catalyst used, the faster it was to purify.
7. Water existing in the biodiesel caused opaque that can be removed by heating.
8. At higher Temperature, water & biodiesel will be separated from one another easier.
9. Increasing the Temperature & density of catalysts causes leads to more efficient biodiesel.
10. Since we used 5% phosphoric acid in this experiment and we had 85% acid in the laboratory, we had to dilute the acid from 85% to 5%. So we would add 6 ml of 85% acid into 100 ml of water to make 5% acid.
11. Choosing a trans esterification depends on the amount of free fatty acid & the water existing in the input. The process of trans esterification with Alkaline in changing Triglycerides to ester will be more effective when the amount of free fatty acids is less than 1%.

KOH is also the most common Alkaline catalyst in the production of Biodiesel out of wasted cooking oils. When the amount of free fatty acids of the input is more than 1%, Acid trans esterification will be more effective. However this process requires high density of catalyst which causes corrosion.

12. In this chromatography experiment we found some very attractive results.

A) Mixing water & oil will make it more difficult to gain and calculate the percentage of esters in the fatty acids.

B) We used GC qualitative method in this experiment. If one aims to compare the fatty acid esters he must use quantitative methods.

13. Purity of the input is the key factor in production of a desirable fuel.

## Notes on Contributers

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