Trans-esterification of Jatropha oil using heterogeneous catalysts

Arun,[1] Gurpreet Kaur, Jaandeep Singh[1]

[1] School of Chemical Engineering & Physical Sciences,
Lovely Professional University, NH–1
Phagwara–144411, Punjab, India

[2] Department of Chemistry,
GGN Khalsa College, Ludhiana

Abstract

Biodiesel is more popular due to the reason of environmental benefit and preparation from the renewable sources. Generally, there are four methods of preparation of biodiesel blending, micro emulsion, pyrolysis, and transesterification. Among these transesterification is very commonly used. In this the triglycerides (vegetable oil and animal fat) are trans-esterified with alcohol in presence of some catalyst.

Introduction

The fossil fuels pose many disadvantages such as atmospheric pollution and environmental issues and are major contributors towards the greenhouse gases which further leads to the global warming. Many researchers are finding an alternate to the sources of these fossil fuels. The best alternate is biodiesel and demand of biodiesel has significantly increased in world from 2005. It has been a good alternative to the fossil fuel (1).

Many researches are made upon the production of biodiesel from vegetables oil such as palm oil, sunflower oil, coconut oil, rapeseed oil. It is also be synthesized from animal fat but due of higher saturated fatty acid content in animal fat it exists as solid at room temperature and biodiesel production is difficult. This is the main drawback in biodiesel production from animal fat. Vegetable oil has inexhaustible potentially and is a renewable source hence they are preferred over the animal fat. Hence the interest is shifted towards the Jatropha curcas L. oil as a feedstock for the preparation of biodiesel. Due to the toxicity present in the jatropha oil it is non-edible and not suitable for human consumption. Jatropha seeds contain a high content of oil hence they can't be neglected and used as a feedstock for biodiesel production (2).

Fortunately the oils which are not used for consumption are produced by seed bearing trees and shrubs can provide an alternative (3). As the depletion of the fossil fuels day by day there is a need of an alternate source of energy to full fill the demand of these sources. So as we discussed former that biodiesel has been admitted to be the best alternative fuel for the diesel engines (4-7).

These catalysts have several advantages as compared to the corresponding homogenous catalysts. We use CaO catalyst to the transestrification reaction. CaO was chosen because it was believed to exhibit strong basicity and the presence of more active sites that would able to improve the transetrification reaction of the jatropha oil. The commercial CaO was immersed in ammonium carbonate solution to increase the basic strength and calcined at 900 ^{o}C for 1.5h. The Free Fatty Acid content of jatropha oil used was less than 0.5% which suggested that concentration of Free Fatty Acid was very low. The highest conversion of jatropha oil into biodiesel was 93% in 2.5h. When the reaction is kept for more than 3h, formation of white gel in the product was observed. This will increase the viscosity of the biodiesel, which decreases in the fuel's ability to flow further induces incomplete burning of the fuel with ignition delay. This catalyst can be reused three times without significant loss of the catalytic activity. This have been pointed out that dissolution of CaO does occur even if the catalyst can be reused for several times without significant deviation. They observed that the catalytic activity of the CaO is not only contributed by the heterogeneous active sites but also the homogenous active species due to the dissolution of CaO in methanol (8).

There are advantages of using homogenous alkaline catalyst are that it is cheap catalyst with a high order of catalytic reactivity and used to obtain a good amount of biodiesel yield from a short period of time. Many of the researchers have studied the transestrification of jatropha curcas plant oil using of homogenous alkaline catalyst. The rate of alkaline catalyzed transestrification is 4000 times higher than an acid catalyzed process. However, there are some of the drawbacks from this process. For instance, alkaline catalyst does not have ability to convert Free Fatty Acid into alkyl ester. As the source which have a significant amount of Free Fatty Acid would not be fully converted into biodiesel. Because these Free Fatty Acids undergoes saponification and leads to the soap formation. The soap formed prevents glycerol separation and will damage the engine in the long run; hence we need one more step to separate it from biodiesel (9). There is a huge number of researchers which used KOH and NaOH with methanol and ethanol despite having their drawbacks. The optimize conversion of jatropha oil to methyl ester was 98% in 90 min. It is noteworthy fact that Free Fatty Acid content of crude jatropha oil was reduced from 0.25 to 3.1% using homogenous catalyst. It is undeniable that NaOH will induce soap formation but on the same time NaOH will also neutralize Free Fatty Acid to an acceptable level to meet the biodiesel specification. But we need an extra step to remove the sodium soap after the reaction. The catalyst amount of molar ratio of the methanol and reaction time were not only investigated but also optimized. Large scale production from 25kg of jatropha oil has resulted into 24kg of biodiesel (96% of yield) which is only reduced by 2% as compared to labscale (10).

Experiment:

Extraction of oil: Solvent used =n-hexane

In this method we have used 20.3 g of jatropha seeds and then we crushed them in motor and pestle apparatus to use further. These crushed seeds were added into the 250ml round bottom flask and the set up prepared for refluxing. Then we add 80 ml of n-hexane in it and start the heating mantle. The temperature was maintained of 55 to 60^{0}C and the seeds were refluxed for 5h on this temperature. After the completion of the reaction, the set up was cooled to room temperature. The mixture was filtered for any solid waste followed by evaporation of hexane. It resulted into the formation of pale coloured oil.

Production of biodiesel:

2g of extracted oil was added into 50ml Round bottom flask, followed by addition of 0.20g of KOH (as catalyst). Further 24ml of MeOH was added into the mixture. The mixture was refluxed for 4-5h at 60^0C. After the completion of reaction, the content of methanol was reduced to 2-3ml. The separation of glycerol was carried out by using cryogenic method.

Cryogenic method for separation of biodiesel:

So we adopted new method for separation i.e. cryogenic method. In this method we take the biodiesel mixture into centrifugation voile and then we plunged it into the ice bath at a temp below -20^0C. Since the glycerol the glycerol tends to solidify during the lowering of the temperature the separation becomes very easy. The complete separation was carried out within 1 hr. The viability of this method was explore on different batches of biodiesel and it was successful every time. The results are very clear from IR spectroscopy basis it is clearly distinguishes between glycerol and biodiesel peaks. This method has been supported so far till the best of our knowledge.

Results and Discussion

Extraction of oil:

The project was completed by using Jatropha curcas L. oil extraction separation. The oil extraction was done by using n-hexane as a solvent and we can recover the whole solvent used in this process which can be done by using rota evaporator.

Separation of biodiesel:

We are facing very difficulties during the separation of biodiesel. This is due to the effect of gravity pull which affects the separation of biodiesel. The major problem is the separation of glycerol from our product. Then we use cryogenic method for the separation. We reduce the temperature to -25^0C. This method made our separation easy. It only takes 1 hr to separate the glycerol from biodiesel. This is very effective method for separation which reduces cost of separation and time.

Moreover, it was found out that the biodiesel synthesized by using NaOH/KOH as catalyst gives off better yield as compared to CaO as catalyst since NaOH/KOH since it is a stronger catalyst as compared to Calcium oxide. Further, CaO is moisture sensitive and the activity decreases as it comes in contact with air.

Conclusion:

Due to the increase in pollution day by day and depletion of the fossil fuels biodieselis a good alternative source of energy. Non edible oils are becoming leading raw material for biodiesel production. There are several methods of biodiesel production but transestrification of non-edible oil with the base catalyst in the presence of alchol is the most common and preferable method for its production.

References:

1] Joon Ching Juan, Ta Yeong Wu (2010) "Biodiesel production from jatropha oil by catalytic and non catalytic approaches."

2] May Ying Koh(2011) "A review of biodiesel production from the Jatropha curcas plant".

3] HannyJohanesBerchmans(2007) "Biodiesel production from crude Jatropha curcas L. Seed oil with a high content of free fatty acids".

4] A.E Atabani(2012) "A comprehensive review on biodiesel as an alternative energy resources and its characteristics".

5] Baljinder Singh(2014) "Production of Biodiesel from Plants Oils".

6] Ivana B. Bankovic(2012) "Biodiesel production from non edible plant oils".

7] Joon Ching Juan, Ta Yeong Wu (2010) "Biodiesel production from jatropha oil by catalytic and non catalytic approaches".

8] Shu Yu Lui (2011) "Extraction of oil from jatropha seeds".

9] AyhanDemirbas (2002) "Biodiesel from vegetable oils via transesterification in supercritical methanol".

10] Hak-Joo Kim (2004) "Transesterification of vegetable oil to biodiesel using heterogeneous base catalyst".