Research Article

Optimization and production of biodiesel from cottonseed oil and neem oil

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Abstract

Biodiesel now a days is emerging as an alternative fuel which is a good replacement to the petroleum diesel. Biodiesel is mainly derived from fats and oils by different methods such as dilution, pyrolysis, micro emulsification and transesterification but these days most commercial method used for biodiesel production is transesterification. Among oil resources, cotton seed oil and neem oil were choosen to investigate the transesterification process for conversion to biodiesel (methyl/ethyl ester). This conversion process depends upon a number of process parameters which are required to be optimized in order to maximize biodiesel yield. For neem oil, the optimum parameters were found to be 6:1 of methanol to oil molar ratio, 1.5 wt% catalyst (NaOH), 55°C reaction temperature, 600 rpm stirring rate, 60 min reaction time. For cotton seed oil, the optimum parameters were found to be 6:1 of methanol to oil molar ratio, 2 wt% catalyst (NaOH), 60°C reaction temperature, 600 rpm stirring rate, 90 min reaction time. From the experimental studies, the optimum process conditions for transesterification of cottonseed oil and neem oil have been examined which results in good yield of biodiesel which are the best alternative fuel for petrodiesel.

Keywords: Biodiesel; Cottonseed oil; Neem oil; Optimization; Transesterification.

Introduction

Nowadays, majority of the worlds energy needs are supplied through petrochemicals sources. All these sources are finite and at current usage rates will be consumed shortly. The high energy demand in the industrialized world as well as the pollution problems caused due to the use of fossil fuels make it increasingly necessary to develop a new renewable energy source. Biodiesel refers to a vegetable oil or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters (Demirbas, 2007).

Biodiesel is an attractive alternative to fossil fuels; it is biodegradable, non□toxic and has low emission profiles as compared to petroleum fuels (Khandelwal et al. 2012). It has derived from renewable resources such as vegetable oil, which could either be fresh or waste vegetable oil are find useful in Europe, America and Asia as a feedstock in production of biodiesel, as a consequently, biodiesel derived from a wide variety of sources can be used as a direct substitute for petro-diesel fuels (Anya et al., 2012). Various vegetable oil such as palm oil, soybean oil, sunflower oil, rape seed oil and canola oil have been used to produce biodiesel (Akbar et al., 2009).

This study is concerned with the optimization and production of biodiesel from neem oil and cotton seed oil. Neem oil have high free fatty acid value which is accompanied with moisture content and some other impurities, this two have prime effect on the trans-esterification of glycerides with alcohol using catalyst. However most non-edible oil have high free fatty acid content which it leads to high production cost through trans- esterification, an FFA content more than 2% will form soap and the separation of the product will be very difficult, it produces low yield fatty acids methyl esters (Canakci et al., 2001).

Cotton seed oil was the first commercial cooking oil in the India, it has progressively lost its market share to some vegetable oils that have larger production and less cost. However, regarding the active researches on biodiesel production from vegetable oils, there is a promising prospective for the cottonseed oil as a feedstock for biodiesel production, which may enhance the viability of the cottonseed industry (Neha et al., 2013, Mathiyazhagan et al., 2011).

Materials and methods

Materials

Neem oil and Cotton seed oil were purchased from local market. Chemicals used in the experiments were purchased from Hi-Media, Mumbai and were of the highest purity.

Methods

Transesterification reactions were carried out in 500 ml flask. The reactor was filled with 100 ml of refined cottonseed oil. Sodium hydroxide catalyst was dissolved in methanol and then added to the reactor. The mixture was heated to selected temperature. After the end of the reaction, the mixture was cooled to room temperature and transferred to a separating funnel. The two layers (biodiesel and glycerol) were separated by sedimentation. The methyl ester phase (biodiesel) was washed with hot distilled water and drying was done by heating the biodiesel to a temperature above 100°C to remove water molecules. The above mentioned experimental procedure was carried out for the production of biodiesel using refined neem oil.

Transesterification is the reaction of a fat or oil with an alcohol to form esters and glycerol. Alcohol combines with the triglycerides to form glycerol and esters. A catalyst is usually used to improve the reaction rate and yield. Since the reaction is reversible, excess alcohol is required to shift the equilibrium to the product side. Among the alcohols that can be used in the transesterification process are methanol, ethanol, propanol, butanol and amyl alcohol. Alkali-catalyzed transesterification much faster than acid-catalyzed transesterification and is most often used commercially (Shruthi et al., 2013).

Results and discussions

Effect of catalyst on the yield of biodiesel

For neem oil, the effect of catalyst concentration on biodiesel yield was studied by conducting experiments at different NaOH concentrations namely 0.5, 1, 1.5, 2, 2.5 and 3% keeping other parameters constant methanol to oil ratio of 6:1, reaction temperature of 55°C, reaction time of 60 min and agitation speed of 600 rpm. The results are shown in Figure 1. As catalyst concentration was increased biodiesel yield was found to increase rapidly upto 1.5 % NaOH and after that yield is decreased due to reverse reaction is take place (emulsion formation).

The maximum biodiesel yield obtained was 88%. For cotton seed oil, the effect of catalyst concentration on biodiesel yield was studied by conducting experiments at different NaOH concentrations namely 1, 1.5, 2, 2.5 and 3% keeping other parameters constant methanol to oil ratio of 6:1, reaction temperature of 60°C, reaction time of 90 min and agitation speed of 600 rpm. Similar pattern of results were obtained like neem oil. As catalyst concentration was increased biodiesel yield was found to increase rapidly upto 1.5 % NaOH and after that yield is decreased. The maximum biodiesel yield obtained was 80%.

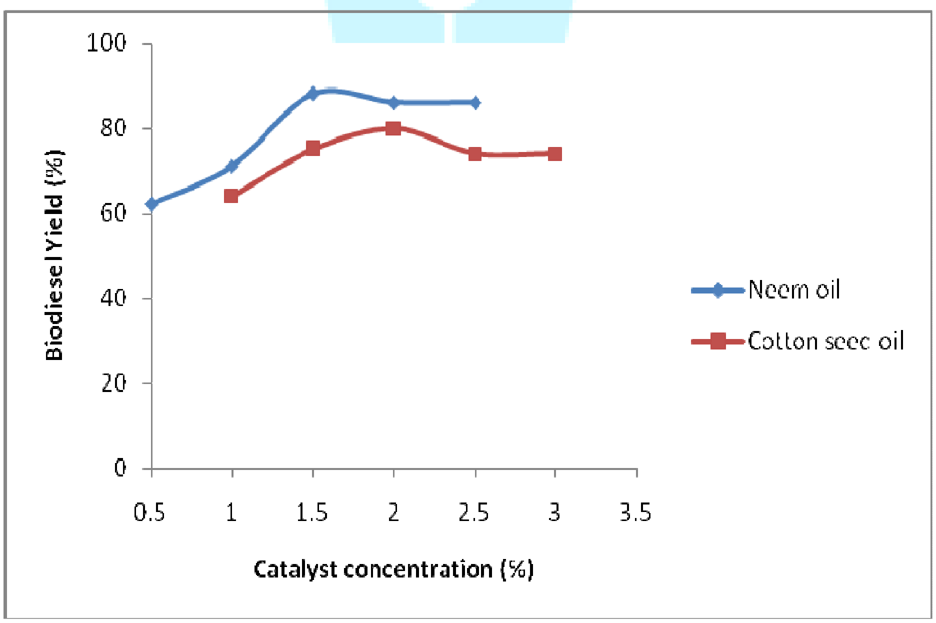

Figure 1. Effect of catalyst concentration on biodiesel yield at optimum process variables

Effect of methanol to oil ratio on the yield of biodiesel

For neem oil, the effect of methanol to oil ratio on biodiesel yield was studied by conducting experiments at different molar ratio of 3:1 to 8:1 keeping other parameters constant catalyst concentration of 1.5 % NaOH, reaction temperature of 55°C, reaction time of 60 min and agitation speed of 600 rpm. The results are shown in Figure 2. The maximum ester conversion for neem oil was found at the methanol to oil molar ratio of 6:1. The excess methanol in the ester layer can be removed by distillation. Therefore, the methanol to oil molar ratio was kept at 6:1 in the remaining experiments for neem oil. For cotton seed oil similar trend was observed. The yield of the process increased with increase in methanol to oil molar ratio up to 6:1. Ajajgiri et al., (2014) also reported that the effect of methanol to oil ratio on biodiesel yield was 6:1.

Effect of Reaction Temperature on the yield of biodiesel

The reaction temperature has important role in alkaline-catalyst transesterification. For neem oil, the effect of reaction temperature on biodiesel yield was studied by conducting experiments at different reaction temperatures namely 45, 50, 55, 60 and 65˚C among these 55˚C gave maximum biodiesel yield and keeping other parameters constant methanol to oil ratio of 6:1, catalyst concentration of 1.5 % NaOH, reaction time of 60 min and agitation speed of 600 rpm. The results are shown in Figure 3. As reaction temperature was increased biodiesel yield was found to increase rapidly upto 55˚C and after that yield is decreased due to loss of methanol.

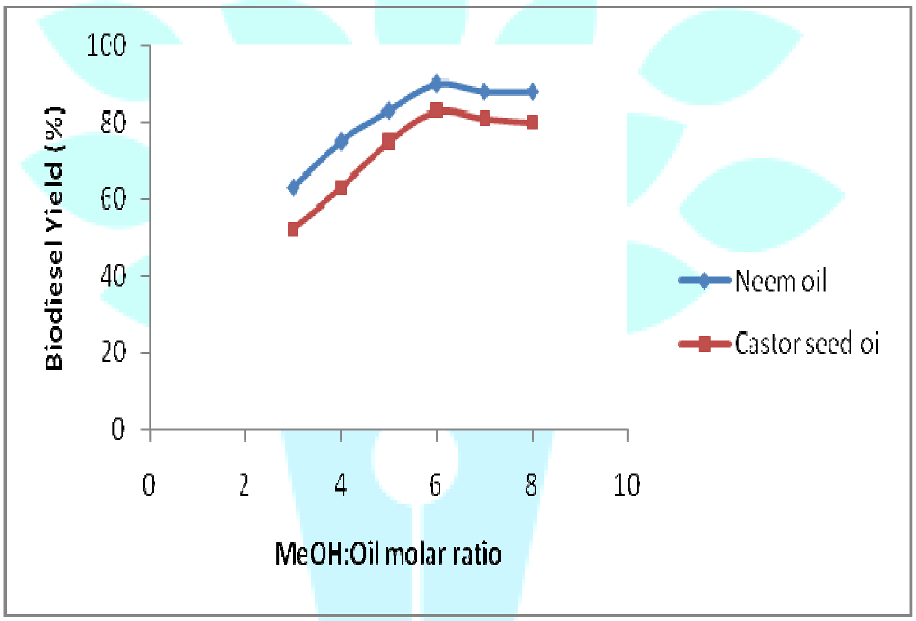

Figure 2. Effect of Methanol –oil molar ratio on biodiesel yield at optimum process variables

For cotton seed oil, the reaction temperature was studied by conducting experiments at different reaction temperatures namely 50, 55, 60, 65 and 70°C among these 60˚C gave maximum biodiesel yield and keeping other parameters constant methanol to oil ratio of 6:1, catalyst concentration of 2 % NaOH, reaction time of 90 min and agitation speed of 600 rpm.. The maximum biodiesel yield was obtained at 60ºC.

Effect of reaction time on the yield of biodiesel

The effect of reaction time on the conversion of biodiesel at the catalysis of NaOH was studied using neem oil by conducting experiments at different reaction time namely 15 min, 30 min, 45 min, 60 min, 75 min and 90 min among these 60 min gave maximum biodiesel yield of 92 % and keeping other parameters constant methanol to oil ratio of 6:1, catalyst concentration of 1.5 % NaOH, reaction temperature of 55˚C and agitation speed of 600 rpm. The effect of reaction time on biodiesel production was studied using cotton seed oil by conducting experiments at different reaction time namely 30 min, 45 min, 60 min, 75 min, 90 min and 105 min among these 90 min gave maximum biodiesel yield of 88 % and keeping other parameters constant methanol to oil ratio of 6:1, catalyst concentration of 2 % NaOH, reaction temperature of 60˚C and agitation speed of 600 rpm. The results are shown in Figure 4. Eevera et al., (2009) observed that longer reaction time leads to the reduction of end product (biodiesel) due to the reversible reaction of transesterification resulting in loss of esters as well as soap formation.

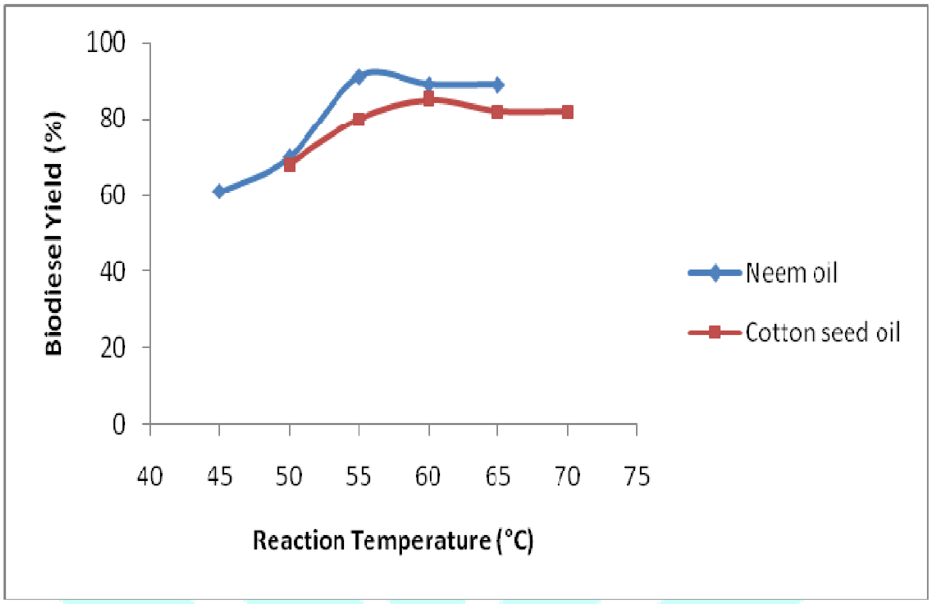

Figure 3 Effect of reaction temperature on biodiesel yield at optimum process variables

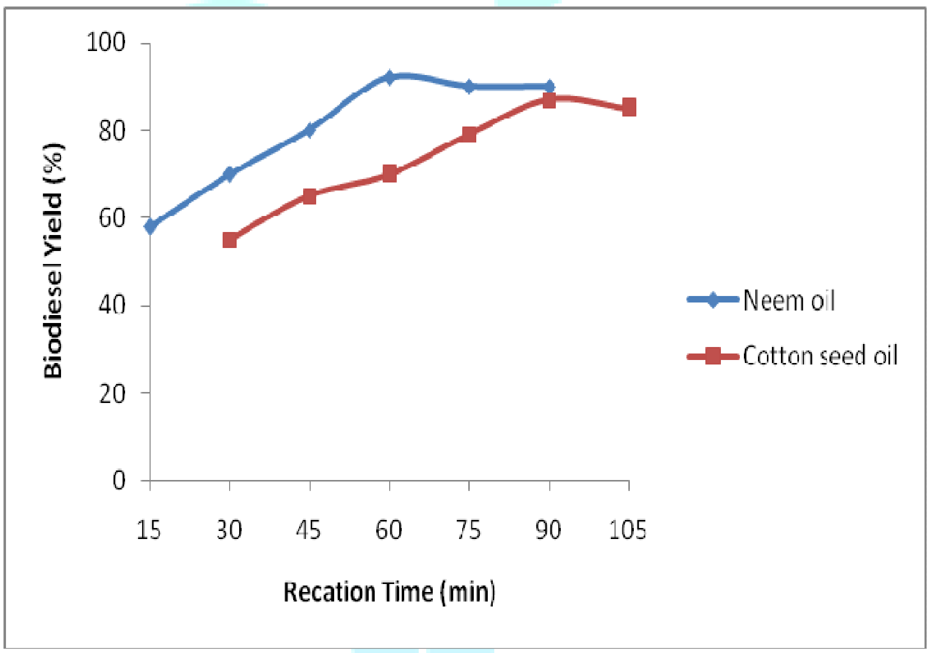

Figure 4. Effect of reaction temperature on biodiesel yield at optimum process variables

Effect of agitation speed on the yield of biodiesel

The agitation speed enhances the contact of the reactants during the transesterification process, causing the reaction to be initiated faster. For neem oil, the effect of agitation speed on biodiesel yield was studied by conducting experiments at different agitation speed from 400 rpm to 800 rpm among these 600 rpm gave maximum biodiesel yield of 94 % and keeping other parameters constant methanol to oil ratio of 6:1, catalyst concentration of 1.5 % NaOH, reaction time of 60 min and reaction temperature of 55˚C. For cotton seed oil, the effect of agitation speed was studied in the range of 400 rpm to 800 rpm.

The maximum biodiesel yield of 90 % was obtained keeping other parameters constant methanol to oil ratio of 6:1, catalyst concentration of 2% NaOH, reaction time of 90 min and reaction temperature of 60˚C. The results are shown in Figure 5.

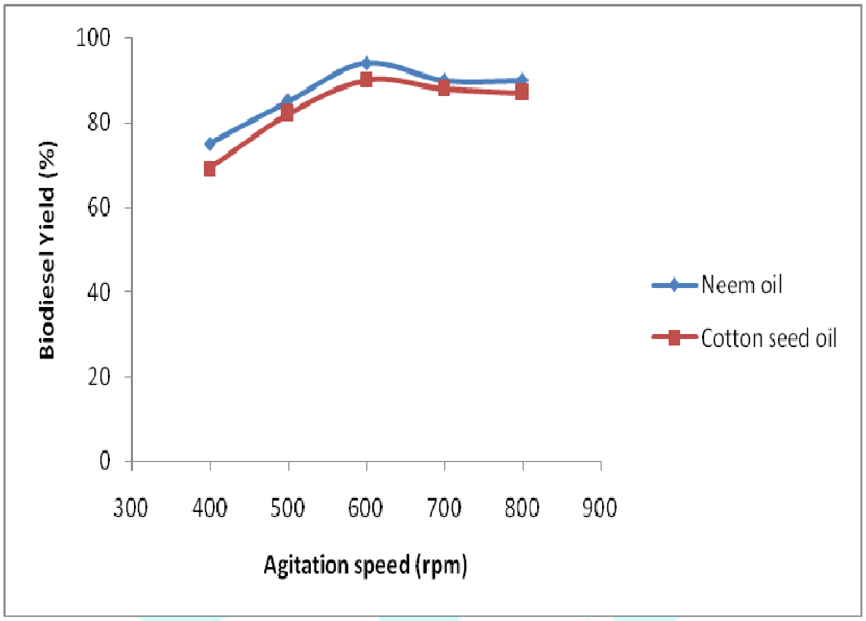

Figure 5. Effect of Agitation speed on biodiesel yield at optimum process variables

Conclusions

Biodiesel can be produced with minimum environmental pollution by using low cost and renewable feedstock. Biodiesel production costs can be reduced by utilizing locally available neem oil and cotton seed oil and by utilizing process by-products as raw materials in other chemical processes. Based on the experimental results, it was concluded that the optimal conditions for the transesterification of neem oil are as follows: methanol to oil molar ratio 6:1; reaction temperature 55°C; catalyst concentration, 1.5 % at reaction time 60 min and agitation speed of 600 rpm respectively. In the same manner transesterification of cotton seed oil was carried out and optimized parameters as follows: methanol to oil molar ratio 6:1; reaction temperature 60°C; catalyst concentration, 2 % at reaction time 90 min and agitation speed of 600 rpm respectively.

Conflict of Interest

The authors declare that they have no conflict of interest in the publication.

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