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A Review on the Effect of Reaction Parameters on Biodiesel Production

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Abstract

Biodiesel is an environment friendly fuel that comes with less pollution compared to the fossil fuel, which diesel engines can use fully or as partial replacement, to the petroleum based conventional diesel. It is normally produced from locally available materials such as plants, waste cooking oil, animal fats etc. The production of biodiesel can be done through a transesterification reaction which is affected by some reaction parameters including; reaction time, reaction temperature, catalyst concentration, content of free fatty acid etc. however, literature is scarce on the review of factors affecting the transesterification reaction. Hence, this study intends to discuss the factors that influence biodiesel production.

Keywords: Biodiesel, reaction-time, reaction-temperature, catalyst-concentration, FFA

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I. INTRODUCTION

The increasing demand for a less expensive and environment friendly alternative source of energy has attracted researchers' attention to the biodiesel production which can be easily processed from locally available wastes materials as feedstock, and it comes with less emissions to pollute the environment compared to the petroleum based fuel and it is a renewable source of energy (Mathiyazhagan et al., 2011). Feedstock for biodiesel production can be vegetable oil from plants, animal fats, waste cook oils etc. the biodiesel can be produced in a transesterification reaction. This process involves the reaction of triglycerides with methanol or ethanol (i.e. alcohol) in a given temperature, time mixing rate, produce fatty acids alkyl esters called the biodiesel glycerol with the aid of a catalyst (Lalita et al., 2004). Transesterification reaction can be of the following types; acid catalyzed, alkaline, enzyme catalyzed and the supercritical methanol transesterification (i.e. non catalyzed). However, the alkaline catalyzed transesterification is the most conventionally used method because it is fast and easy. Examples of raw materials such as, soybean oil, jastropa oil, coconut oil, rapseed oil etc are used for producing biodiesel (Lalita et al., 2004)

The transesterification reaction is affected by different factors such as; reaction time (RT), reaction temperature (RTM), methanol to oil ratio (MOR), catalyst concentration (CC) etc. (Mathiyazhagan et al., 2011; Lalita et al., 2004). However, literature is scarce on the review of biodiesel yield based on the reaction parameters influence. Hence, this study intends to extensively report the influence of the reaction parameters to biodiesel production.

II. LITERATURE REVIEW

A. Reaction Temperature (RTM)

The RTM in a transesterification reaction is a significant factor that determines the yield of biodiesel. The variation in the reaction temperature can give a duration under which a better yield can be obtained. In most cases, when the RTM is increased, it lowers the viscosity of the bio-oil thereby reducing the reaction time (Mathiyazhagan et al., 2011). However, the biodiesel yield can reduce drastically when the temperature goes beyond the maximum level, (Eevera et al 2009). Leung et al., (2006) presented that, the maximum reaction temperature for a transesterification reaction is dependent on the alcohol and the bio-oil to be used. However, the range of 50oC to 60oC was recommended to be the best in their study. Encinar et al., (2001) presented a report on the production of biodiesel from *Cynara cardunculus* oil and obtained almost 92% yield at ambient temperature. Lalita et al., (2004) reported the production of biodiesel from crude palm oil using a range of temperature from 30oC to 60oC, and revealed that, the yield reduced as the reaction temperature increased, because the separation between the biodiesel and glycerol was reduced by the higher solubility based on the increased temperature. Hence room temperature was recommended by them in their study.

B. Reaction Time

This is another important reaction parameter for consideration in biodiesel production i.e. the best duration under which the maximum yield can be produced. Lalita et al., (2004) presented a report on the production of biodiesel from crude palm oil using different reaction times. Lalita et al, (2004) revealed that, there was a gradual increase but biodiesel yield was not significantly affected, but the biodiesel concentration increased with the increase in reaction time. The reversible reaction of transesterification leads to the reduction on biodiesel production in a prolong reaction period, resulting in formation of soap and loss of ester. Hence lesser reaction time is recommended in transesterification, because, further increase in reaction time does not increase the biodiesel yield. (Ma et al., 1998).

C. Oil to Methanol ratio

The mix ratio of methanol to the vegetable oil for the transesterification is another major reaction parameter that affects yield of biodiesel (Leung et al., 2006). Too much of alcohol in the mixture drastically accelerates the rate of fats conversion to sugar very quckly. Hence, biodiesel production increases, as the alcohol concentration increases to a certain level and at the same time, the cost of alcohol recovery becomes more expensive (Leung and Guo., 2006). The type of catalyst used may also determine the ratio of alcohol content required in the mixture. For instance, a ratio of 6:1 for alcohol to catalyst is required when using alkali catalyst in the transesterification reaction for biodiesel production (Lalita et al., 2004). However, an acid catalyst will be needed, if there is much free fatty acid (FFA) in the oil because, alkali catalyst will not give a good result in such condition. Hence, using the acid catalyst will require more volume of alcohol in the reaction than the former. The simple reason is because, the acid catalyst can withstand the water and FFA presence in the samples of oil. Lalita et al., (2004) reported that, raising the reactants mass ratio enhances the interaction of the oil and methanol to produce a higher concentration of methyl ester. But as the mass ratio of reactant increases, the production yield drops.

D. Catalyst Concentration (CC)

The yield of biodiesel in the transesterification reaction can also be influenced by the conc. of the catalyst used in the reaction. The most commonly used catalysts in transesterification reaction for biodiesel production are sodium hydroxide and potassium hydroxide. However, in a study by Freeman et al., (1984) stated that, the use of sodium hydroxide as a catalyst in biodiesel production results in a little quantity of water, which in turn inhibits a good yield of the biodiesel due to the hydrolysis reaction. Therefore, it is always advisable to mix the catalyst with the methanol before adding to the oil.

Again, when the concentration of the catalyst in the oil is increased, it will significantly increase the yield of the production of biodiesel from the triglycerides. Also, insufficient catalyst causes partial conversion of triglycerides to fatty acid esters (Leung et al., 2006). The best yield of the catalyst approached 1.5wt%, but increasing the concentration of the catalyst also had some negative impacts on the yield of biodiesel because, formation of more soap will result when an excess of alkali catalyst reacts with the triglycerides (Leung and Guo 2006).

E. Content of Water and Free Fatty Acid (FFA)

In a transesterification reaction, the availability of water and FFA are significant factor that enhance the rate of biodiesel production. The raw materials normally used for biodiesel production must be water free and low acid value of less than one (Demirbas, 2009). However, when there is too much FFA contained in the oil for the biodiesel production, then such reaction will need much catalyst to certainly neutralize the FFA to obtain a better yield of the biodiesel. The presence of water in the oil can enhance the production of soap and foaming which is not a good requirement in biodiesel production, because, it increases the viscosity of the oil there by making it more difficult to be converted to biodiesel. Also, the development of gels and foams makes it difficult for glyceryl separation from the biodiesel (Demirbas 2009). The presence of water and FFA in the oil is always known for negative effects in the transesterification reaction that leads to the formation of soap which consumes much of catalyst. Again, the presence of water and FFA in the oil for transesterification can as well reduce the methyl ester. Hence, Kusdiana and Saka (2001) suggested supercritical methanol approach, when they used a temperature of 623K and a pressure of 43MPa for 4 minutes of treatment for an oil to methanol ratio of 1:42. The result obtained in their study was compared with the alkaline and acid catalyzed methods. It was revealed that, water has less effect on the supercritical methanol approach.

III. CONCLUSION

Biodiesel production and usage had been widely encouraged around the globe due to its renewability and low cost of production. Biodiesel which is normally produced from vegetable oils, animal fats etc. by a transesterification reaction which reduces the viscosity of the oils in the presence of a catalyst. This process is normally affected by some reaction parameters including reaction time, reaction temperature, oil to methanol ratio, catalyst concentration and FFAs.

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