Enhancing the oxidation stability of biodiesel form Jatropha oil using Partial Hydrogenation

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Abstract

In this research, partial hydrogenation conditions are studied to improve the stability of oxidation of biodiesel of the Jatropha oil obtained from biodiesel production to meet the standards of the Department of Energy Business (Oxidation stability greater than 10 hours) The process is implemented using this palladium catalyst on an alumina support. The optimum conditions for increasing the stability of oxidation reaction using partial hydrogenation process are at the temperature of 110°C, pressure of 5 bar, 0.2 percent of hydrogen by weight, ratio of catalysts to biodiesel oil for 0.036 using a basket containing catalysts at the speed of the stirrer for 800 rpm, and reaction time of 90 minutes. The results reveal that the biodiesel has been improved in quality by partial hydrogenation processes resulting in the composition of biodiesel with the double bond at 2 and 3 positions in the amount of 34.62% by weight, reduced to only 8.40% by weight. This results in the oxidation stability increases from 2.28 hours to 10.67 hours.

Keywords: Biodiesel, Jatropha oil, Oxidation stability

Introduction

Biodiesel produced from Esterification and Transesterification of unsaturated vegetable oils, such as jatropha oil, soybean oil, rapeseed oil, etc., will make the biodiesel oil to have a risk of low stability to oxidation [1, 2]

The raw material used in the production of biodiesel is Jatropha oil. Since the Jatropha oil is highly unsaturated, it has an amount of unsaturated fatty acids of the double bond of 2 and 3 positions of 34.62% by weight and the stability to oxidation at 2.28 hours. Therefore, biodiesel produced is sensitive to oxidation and it is found that properties are lower than the biodiesel standard of the Department of Energy Business. Partial Hydrogenation is a technology that helps improve the quality of biodiesel by reducing the amount of unsaturated fatty acids of vegetable oil so that the biodiesel produced becomes highly stable against oxidation.

Since biodiesel produced from vegetable oils with high un-saturation or with more double bonds in the molecules have a low oxidation stability, partial hydrogenation is the process of adding hydrogen atoms into double bonds of molecules to convert double bonds into single bonds resulting in the amount of unsaturated fatty acid composition to decrease or become monounsaturated ester (C18:1) [3]. Hydrogenation reaction in changing unsaturated oil with

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more than 1 double bond to only one bond without adding saturated fat. Therefore, the purposes of Partial Hydrogenation process include;

1. To increase in stability to oxidation and to improve aging properties and longer storage time of biodiesel. Normally increasing the stability of oxidation will be made by adding synthetic antioxidants superfluous

2. To avoid deterioration of properties in low temperature such as the pour point due to the higher melting point of saturated oil such as Methyl Stearate.

Materials, equipment and research methods

1 Equipment

Chemicals and equipment:

Chemicals

1. Biodiesel oil produced from Jatropha oil biodiesel (JPB) 300 gram/turn

2. Palladium catalyst on alumina (Pd/ Al2O3)

3. Acetone

4. Hydrogen with a purity of 99.999% (H2)

Equipment

1. Beaker

2. Flask, size 12, 250, 500 ml / turn

Reactor:

1. 500ml batch reactor

2. Research methodology

Prepare biodiesel from Jatropha and weigh the catalyst (Pd / Al2O3), then assemble the Hydrogenation equipment along with filling the oil and the catalyst. Then turn the equipment and heat the system on. When the system reaches the desired temperature level, then reckon the time and take the sample oil for analysis.

Results and Discussion

This research studies various factors that affect the hydrogenation including temperature, the quantity of catalyst and agitator speed. In the second part, it shows the relationship of the percentage of Polyunsaturated values to the various effects as mentioned at the beginning.

1. Various effects on Hydrogenation

From the experiment, we study the effect of temperature on the stability to oxidation. We use temperature values of 80 100 and 110°C and we find that temperature affects oxidation stability. That is, when temperature reaches 110c, it causes oxidation stability to be higher than temperature 80 100. [4] as shown in Figure 2. As the temperature increases, the reaction rate increases, while collisions and distribution of the reactant particles also increases as well resulting in high oxidation stability at the same time of reaction.

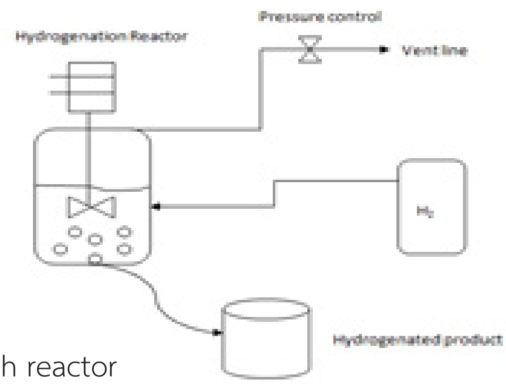

Figure 1 Schematic of a batch reactor

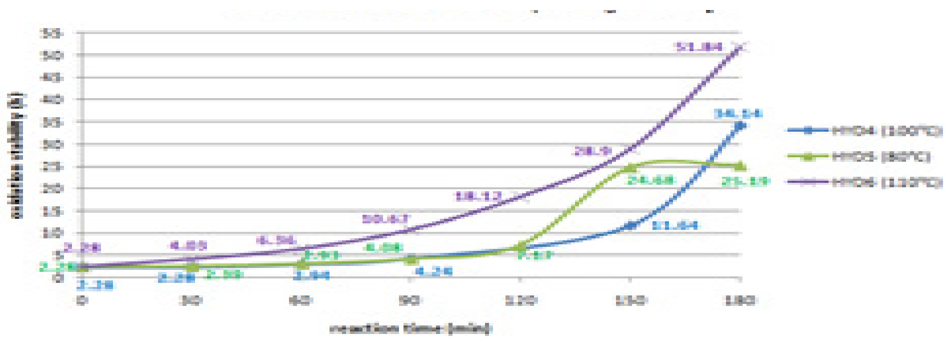

Figure 2 The effect of temperature on the Hydrogenation

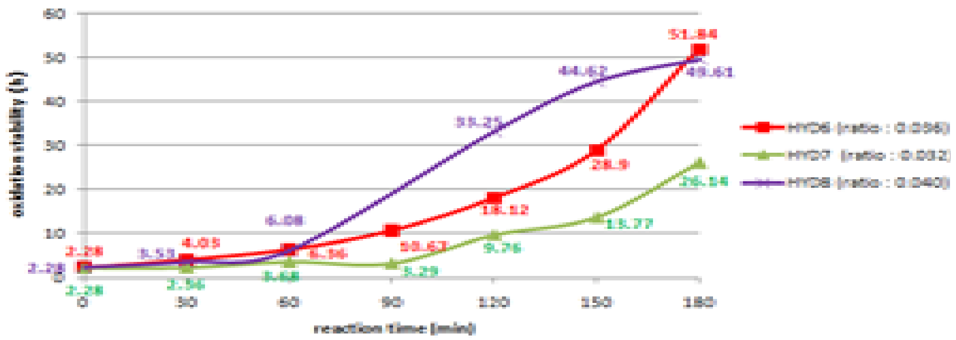

Figure 3 The amount of catalyst that affects the Hydrogenation

From the experiment, we study the effect of catalyst ratio on biodiesel to the stability of the oxidation reaction (Oxidation Stability) in Figure 3. We use the ratio of catalyst to biodiesel at 0.032, 0.036 and 0.040. We find that the ratio of catalyst to biodiesel has an effect on Oxidation Stability that is when the ratio of catalyst to biodiesel is 0.040, it causes higher Oxidation Stability with the faster reaction resulting in high Oxidation Stability at the same reaction period. However, HYD8 (ratio: 0.040) requires a lot of catalysts, therefore, resulting in a very good reaction according to the theory of the concentration of the substrate [5], which is more than required and HYD7 (ratio: 0.032) takes a lot of time to meet the standard of oxidation stability of biodiesel, that is not less than 10 hours. Therefore, HYD7 (ratio: 0.032) and HYD8 (ratio: 0.040) are not suitable for the reaction.

From the experiment, we study the effect of speed on stability at oxidation (Oxidation Stability). We experiment with the speed values at 400 600 and 800 rpm and we find that the speed affects the Oxidation Stability. That is when the speed reaches 800 rpm, it causes Oxidation Stability to be higher than that at the speeds of 400 and 600 rpm as shown in Figure 4. Due to the speed increases, it causes the reaction rate to increase because of the collisions and dispersion of the substrate particles, [6] resulting in high Oxidation Stability at the same reaction period.

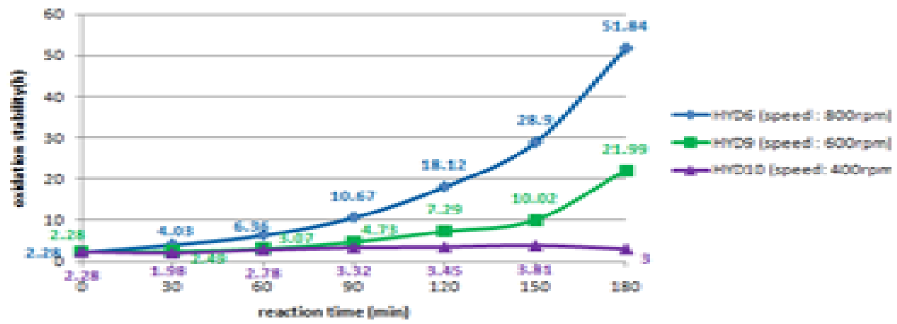

Figure 4 The speed of stirrer that affects the Hydrogenation

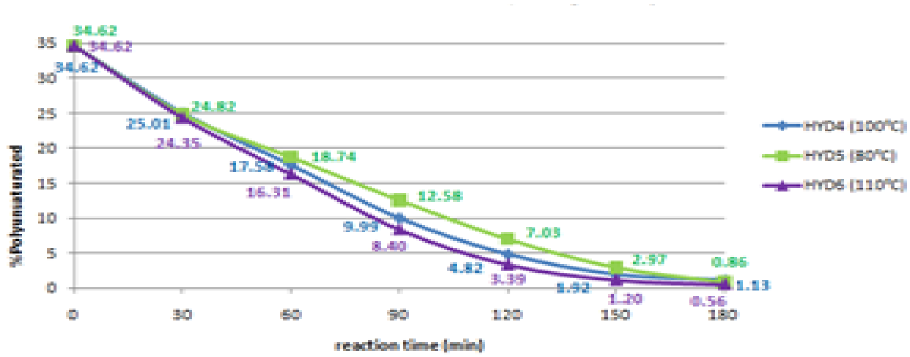

Figure 5 The relationship of% Polyunsaturated value to various temperature values

2. Relationship between %of Polyunsaturated to various effects

From the experiment, we study the effect of temperature on the percentage of unsaturated fatty acids of the double bond at 2 and 3 positions, as shown in Figure 5, using 3 temp values.

It is found that the temperature has an effect on the amount of unsaturated fatty acids of 2 and 3 positions of the double bonds. That is, when the temperature reaches 110 °C, it causes the percentage of unsaturated fatty acids of the double bonds at 2 and 3 positions to decrease more than in the temperature of 80, 100°C. This is consistent with the research of Jaokankaew (2012) [7] due to the increased temperature will cause the reaction rate to increase while collision and distribution of the reactant particles also increase, therefore resulting in the percentage of unsaturated fatty acid of double bonds at 2 and 3 positions to decrease at the same reaction period.

Therefore, when compared at a certain time, HYD6 (110 °C) has less percentage of unsaturated fatty acids of double bond in 2 and 3 positions than in HYD4 (100 °C) and HYD5 (80 ° C) which is required for the production of biodiesel because biodiesel requires a low amount of unsaturated fatty acids of the double bond at the 2 and 3 positions. HYD6 (110 °C) is therefore suitable for the reaction. From the experiment, we study the effect of catalyst ratio on biodiesel to the percentage of the unsaturated fatty acid content of double bond at 2 and 3 positions using catalysts to biodiesel ratio of 0.032, 0.036 and 0.040. And it is found that the ratio of catalyst to biodiesel of 0.040 results in a decrease in the amount of unsaturated fatty acids of a double bond of 2 and 3 positions, greater than the ratio of catalysts to biodiesel of 0.032 and 0.036. As the biodiesel of 300 grams/turn is used in all experiments, therefore, the catalyst content is increased, therefore the surface area of the catalyst is increased [7,8] resulting in a faster reaction rate. Therefore, when comparing at a certain time, HYD8 is found to have the amount of unsaturated fatty acids of the double bond of 2 and 3 positions less than in HYD6 and HYD7.

However, HYD8 uses a lot of catalysts. Which is more than necessary causing the HYD8 to be unsuitable for the reaction as shown in Figure 6

From the experiment, we investigate the effect of stirring speed on the percentage of the unsaturated fatty acid content of the double bond of 2 and 3 positions. It is found that at speeds of 400, 600 and 800 rpm, the amount of unsaturated fat of the double bond of 2 and 3 positions reduces due to unsaturated fatty acids of the double bond of 2 and 3 positions of biodiesel without hydrogeneration. In which the HYD6 at the speed of 800 rpm, the amount of unsaturated fatty acids of the double bond of 2 and 3 positions is lower than those in the speed of 400 and 600 rpm as shown in Figure 7.

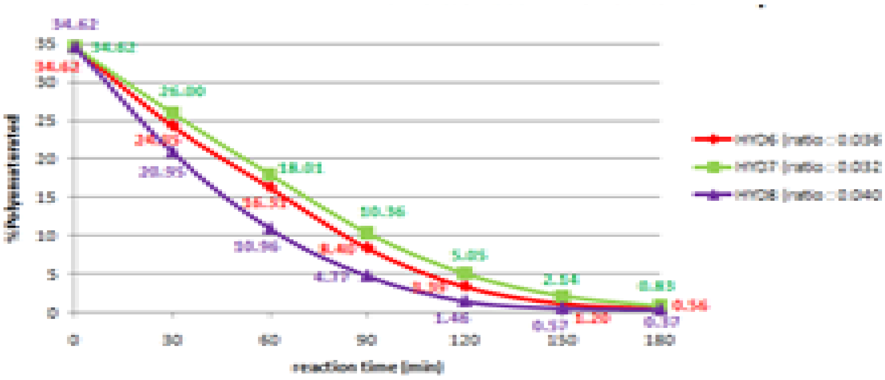

Figure 6 the relationship of% Polyunsaturated value to the amount of catalyst

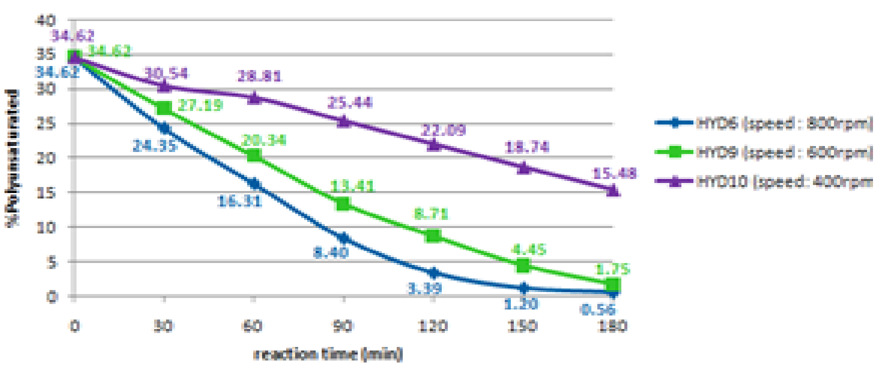

Figure 7 the relationship of % Polyunsaturated to RPM values

Summary

From the analysis of the experimental results, it is found that when increasing the temperature, collision, and distribution of the particles increase which makes the reaction better. Therefore the temperature of 110 °C is used which is suitable for several factors to cause an effective reaction. As for the proportion of the catalyst ratio to biodiesel, the ratio of biodiesel 300 grams/turn is used in all experiments, thus causing the catalyst to increase. Since adding catalysts will help for faster reaction, however, the catalysts used are quite expensive, thus, the ratio of catalysts to biodiesel of 0.036 is an appropriate proportion. As for the speed, the increase in speed affects the collision and distribution of particles of the reactants, therefore resulting in better reactions, the speed at 800 rpm is chosen. And from the analysis of reaction time, from all the test results, the reaction time at 90 minutes is the best for good quality of reaction.

Therefore, it can be concluded that the optimal conditions for the production of high-quality biodiesel by the hydrogenation process in a batch reactor are at the temperature of 110°C, the ratio of catalysts per biodiesel of 0.036, the speed of 800 rpm and the reaction time of 90 minutes with the stability to oxidation equal to 10.67 hours, which meet the standards of oxidation stability of biodiesel. That is not less than 10 hours and at the pour point of 4 °C, which is consistent with the result of Sonthisaeate T. (2009) research [6]

Acknowledgments

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