Activity Test of Temperature Variations in Cracking Process of Palm Oil using Ni/Al2o3 to Green Diesel Viscosity

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Abstract: Today petroleum reserves are running low along with the increasing demand of fuel transportation and industries, therefore we are required to find alternative fuels, one of which is derived from vegetable oil, namely Green Diesel. Green diesel is a product mixture of hydrocarbons such as diesel which is produced through a cracking process using catalyst as reaction accelerator. The catalyst is Ni/Al2O3. Aimed to understand the effect of temperature variations in palm oil cracking process using Ni/Al2O3 catalyst to the product viscosity. The cracking process is carried out using a batch reactor with temperature variations of 400ºC and 460ºC, for 10 minutes calculated from the target temperature achieved which is 400ºC. The highest amount of product acquired from 400ºC which is 20.845 gram from the total of 30 grams raw material, the product of 400ºC is the only suitable density 0.8523 g/ml which is inside the range of green diesel standard 0.8150-0.8600 g/ml, and while the product of 400ºC or 460ºC does not have suitable viscosity 6,4563 cSt and 1,4305 cSt which are not inside the range of green diesel standard 2-4.5 cSt.

1 INTRODUCTION

Currently, the world's oil reserves are running low, at the same time the human population continues to grow and it is directly proportional to the increasing demand for basic needs, one of which is the need for motor vehicle fuel.

Currently, the majority of motor vehicle fuels use petroleum derived from fossils such as pertalite, diesel, and avtur. Petroleum is the result of the evolution of fossils resulting from the extinction of living things millions of years ago on earth and has undergone a very long process to become crude oil that is ready to be processed into fuel.

With various countries trying to turn into industrial countries forcing fuel consumption to increase from year to year, the average annual increase in energy demand is 36 million barrels of oil equivalent (BOE) from 2000 to 2014. Meanwhile, energy reserves are not renewable energy sources, such as oil, natural gas, and coal, are running low. Based on the Strategic Plan (Renstra) of the Ministry of Energy and Mineral Resources for 2015–2019, Indonesia's oil reserves of 3.6 billion barrels are estimated to be exhausted in the next 13 years. (Sa'adah, et al, 2017).

Therefore, renewable fuels are required from sources other than fossils, one of the product of renewable source is Green diesel is a mixture of diesel like hydrocarbons produced via catalytic reaction involving hydroprocessing, decarbonylation, and decarboxylation of trilicerides. (Auliastuti, et al, 2020)

Biofuel has a better characteristic than biodiesel such as lower viscosity, better stability and produce more energy. (Munir and Chumaidi 2019)

Green diesel does not produce any waste, very efficient process, and all ready product can be use directly after being produced. (Ristanti, et al, 2021)

Green diesel is produced using the hydrodeoxygenation process of palm oil (triglycerides) or animal fats through catalytic treatment with hydrogen, produced a mixture of straight and branched chain saturated hydrocarbons which usually contain 15 to 18 carbon atoms per molecule (C15 to C18) (Neunofa et al. 2017)

By using Ni/Al_2O_3 catalyst as a reaction accelerator with hydrotreating process with variations in reaction temperature this research aimed to determine the most suitable temperature that produce a product with viscosity match with the Green Diesel standard.

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2 RESEARCH METHODOLOGY

There are five steps to produce green diesel using batch reactor, starting with the Al_2O_3 Catalyst Preparation, the Preparation of Active Metal Ni,Catalyst Activation, Catalytic Cracking Process, and Viscosity Measurement.

The preparation of Al_2O_3 catalyst begins with mixing 470 grams of Al2(SO4)3 and 400 ml of distilled water at a temperature of 70oC and dripping with NH3 to pH 9, stirred until it becomes a gel and filtered using filter paper, the filtered gel must be dried at a temperature of 70oC for 24 hours until it can be mashed with a mortar, after becoming a dry powder it is calcined at a temperature of 600oC with holding time of 3 hours and then removed when the furnace temperature has dropped to 70oC.

The preparation for the active metal Ni begins by lowering the commercial Ni concentration from 100% to 19% by dissolving 20 grams of Ni with 20 ml of distilled water. Then prepared 5 grams of Al2O3 which has been calcined in a 600oC furnace then dissolve it with 5 ml of distilled water and dripped with 19% Ni with the desired amount of the variable with M impregnated 2.5859 grams which is assumed to be 10% Ni concentration if required 5% of Ni then the M impregnated would be 1.2929 grams, dripping the Ni while stirring the catalyst using a magnetic stirrer, then waiting for it to dry for approximately 3 hours and mash it in a mortar and then calcined in a furnace with a temperature of 400ºC and holding time for 2 hours.

The calculation of M impregnated is carried out using the following formula:

$$M_{impregnated}(\%) = \frac{\frac{M_{initial}}{100} x\, m_{initial}}{\frac{M_{initial}}{100} x\, m_{initial} + m_{buffer}}$$

Descriptions :

$M = concentration\ (\%)$

$m = mass\ (gram)$

$M_{impregnated} = 10\%$

$M_{initial} = 19\%$

$m_{buffer} = 5\ gram$

After being calcined, the catalyst powder is formed into solid pills using a small pipe mold with the help of a press machine, the pressure used in the press machine is 100 kg/cm2 for a minute.

The catalyst is activated by putting it into the reactor, then close it tightly using a wrench, then attach helium gas hose, this process is carried out to ensure that the oxygen in the reactor has been removed and replaced by helium, with the method of inputting 10 bar of helium gas into the reactor and then slowly discharge it at a rate of 20 ml/min repeated twice. After the drain has been completed, input 1 atm of hydrogen gas and heated to a temperature of 200ºC for an hour, then the gas is discharged when the reactor temperature has dropped to room temperature.

The catalytic cracking reaction begins by putting 30 grams of palm oil and 1,57 grams of Ni/Al_2O_3 catalyst into the reactor. After that, the heating process begins with temperature settings to 400ºC. Wait until the temperature is reached then start counting the time using a stopwatch for 10 minutes.

After the time is reached, the heater is turned off and the reactor is cooled with a fan and then wait for the temperature to drop to the room temperature then gas is released at a flow of 20 ml/min. After the temperature and pressure decreased the product is saved in a container jar.

Before measuring the viscosity and density, the product is first filtered with filter paper, and weighed to determine the amount of product that becomes gas and the amount of product that becomes liquid.

Then the density measurements were carried out using a pycnometer and the density was explained as follows.

The mass of the pycnometer was measured in an empty state, namely 11.0546 grams. Then the product is put into the pycnometer until it is full and the fluid rises to the top hole, after that it is weighed in the analytical balance, the mass of the pycnometer with the specimen is reduced by the empty mass with the following results.

$$\rho\ sample = \frac{m_{sample}}{m_{water}} \times \rho_{water}$$

Descriptions :

$\rho_{sample} = sample\ density\ (g/cm^3)$

$\rho_{water} = water\ density\ (g/cm^3)$

$m_{sample} = sample\ mass\ (gram)$

$m_{water} = water\ mass\ (gram)$

Furthermore, the measurement of product viscosity is carried out by inserting the specimen into the viscometer then the liquid is raised to the top line on the viscometer using a suction device, then the suction device is removed and waits for the specimen to drop to the bottom of the viscometer with a two-line indicator, when the specimen begins to descend from the top line timed until the specimen reaches the bottom line.

The results of the time calculation are entered into the following formula:

$$\mu_{din} sample = \frac{\rho_{sample}\, x\, t_{sample}}{\rho_{water}\, x\, t_{water}} \times \mu_{din} water$$

Descriptions:

$\mu_{din}water$ = *samples dynamic viscosity* $(mPa.s)$

ρ_{sample} = *samples density* (kg/cm^3)

$\mu_{din}water$ = *water dynamic viscosity* $(mPa.s)$

ρ_{water} = *water density* (kg/cm^3)

t = *flow time* (s)

$$\mu_{kinematic} = \frac{\mu_{dynamic}}{\rho}$$

$\mu_{kinematic}$ = *kinematic viscosity* (m^2/s)

$\mu_{dynamic}$ = *dynamic viscosity* (Ns/m^2)

ρ = *density* (kg/m^3)

Viscosity of water is seen from the reference table, sample flow time and water flow time are calculated from the time the fluid passes the top line and bottom line on the viscometer.

Measurement of the viscosity of the sample and water must be in the same temperature conditions and made a comparison with the table above. Then it is calculated by the formula and the viscosity value of the sample is known, with the principle that the greater the viscosity value, the thicker the sample.

In this study, we tried at a temperature of 400 and 460, because we had tried it at a temperature of 300 and the result was a solid product not liquid, so we used a higher temperature of 400 and 460, because at this temperature we found that the result was a liquid.

3 RESULT AND DISCUSSION

Green diesel products are said to meet the standards if the values indicated are 0.8150 gr/ml and 0.8600 gr/ml. And the density value of the raw materials used is 0.9112 gr/ml. While the resulting product is a solid or solid whose density value is > 0.9112 gr/ml. Therefore the resulting product does not meet the standards of green diesel fuel.

Table 1: Cracking Process Parameters.

Cracking Process Parameters	
Ni/Al_2O_3 mass	5% = 1.57 gram
RBDPO weight	30 gram
Reaction time	10 minutes
Temperature	400°C and 460°C
Pressure	1 atm

In this study, the viscosity test was carried out using an Ostwald viscometer. Green diesel products are said to meet the standards if the kinematic viscosity values shown are 2 cSt and 4.5 cSt. While the dynamic viscosity of the raw materials used is 0.39 Ns/m2. The density value of the raw materials used is 0.9112 gr/ml. Then the value of its kinematic viscosity is 428 cSt.

3.1 Effect of Temperature Variations Mass

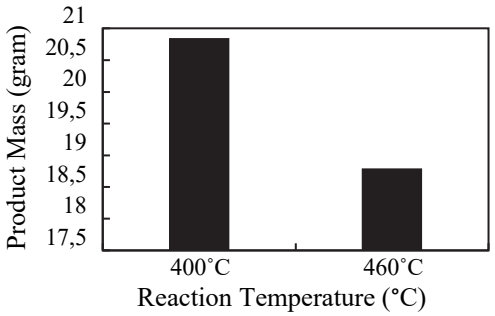

Figure 1: Effect of temperature variations in palm oil cracking process using 5% mass of Ni/Al2O3 catalyst in 400oC temperature and 1 atm pressure for 10 minutes to the product mass.

From this graph it is known that the most amount of product is produced using 400°C temperature which is 20,845 gram from the total raw material of 30 gram.

3.2 Effect of Temperature Variations on Density

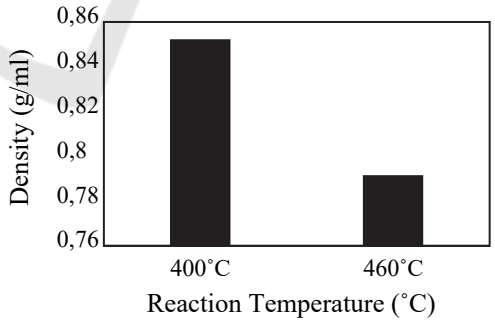

Figure 2: Effect of temperature variations in palm oil cracking process using 5% mass of Ni/Al2O3 catalyst in 400oC temperature and 1 atm pressure for 10 minutes to the product density.

From this graph it is known that only the 400°C product has the value of density that qualify the green diesel product standard, the 400°C product is 0,8523 g/ml which is between 0,8150-0,8600 g/ml.

3.3 Effect of Temperature Variations on Viscosity

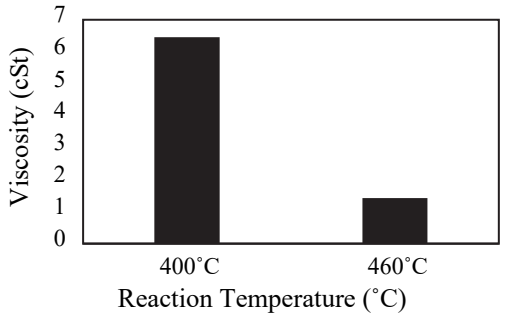

Figure 3: Effect of temperature variations in palm oil cracking process using 5% mass of Ni/Al2O3 catalyst in 400oC temperature and 1 atm pressure for 10 minutes to the product viscosity.

From this graph it is known that none of product has the value of viscosity that qualify the green diesel product standard, namely the 400ºC product is 6,4563 cSt and the 460ºC is 1,4305 cSt which both are not between 2-4,5 cSt.

4 CONCLUSIONS

The effect of temperature variations in the palm oil cracking process using Ni/Al_2O_3 catalyst on the response of product mass, density, and viscosity, it was found that the higher the temperature, the lower the value of these responses. The mass response of the product obtained the most is 20.845 grams, and the highest density response is 0.8523 g/ml, and the highest viscosity response is 6.4563 cSt.

For the product that best meets the Green Diesel standard specifications, it is analyzed from density data, namely only the 400ºC product of which have met the standard, namely 0.8523 g/ml and of which is in the standard range of 0.8150-0,8600 g/ml.

Meanwhile, the product analysis was based on the viscosity value, none of the product met the standard, namely the 400ºC product 6,4563 cSt and 460ºC 1,4305 cSt which were not in the standard range of 2-4.5 cSt.

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REFERENCES

Sa'adah, A. F., Fauzi, A., & Juanda, B. (2017). Peramalan Penyediaan dan Konsumsi Bahan Bakar Minyak Indonesia. Jurnal Ekonomi dan Pembangunan Indonesia Vol. 17 No. 2, 118–137.

Auliastuti, M. A., Munir, M. B., & Chumaidi, A. (2019). PENGARUH PENAMBAHAN KATALIS Mg-Zn Terhadap Komposisi Green Diesel Dengan Metode Dekarboksilasi. Distilat Jurnal Teknologi Separasi, 58-62.

Munur, M. B, & Chumaidi, M. (2019). Pengaruh Waktu Proses Terhadap Komposisi Green Diesel Dalam Reaksi Dekarboksilasi. Distilat Jurnal Teknologi Separasi, 147- 151.

Ristanti, R. A., Sagara, B. P., Murti, S. S., & Redjeki, S. (2020). Pembuatan Green Diesel dari Minyak Biji Kapuk (ceiba pentandra) Menggunakan Katalis NiMo/y-Al2O3 dengan Proses Hidrogenasi dan Fraksinasi. Jurnal Teknik Kimia, Vol. 15 No. 1.

Neonufa, G. F., Soerawidjaja, T. H., & Prakoso, T. (2017). *Catalytic and Thermal Decarboxylation of Mg-Zn Basic*. J. Eng. Technol. Sci., Vol. 49, No. 5, 575-586.