Analysis of the Application of Silica Gel and Iron Powder in Fuel Tank Storage to Reduce Biodiesel Degradation Rate

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Abstract. This study aims to determine the effect of using silica gel and iron powder to inhibit the degradation rate of biodiesel. The method used in this study was an experiment of biodiesel storage for 8 weeks. In this research, an acid number test and bacterial TPC test will be used as a parameter to measure the degradation rate of biodiesel. From this study, it is known that the use of silica gel and iron powder can reduce the rate of degradation of biodiesel and can reduce bacterial growth. This is evidenced by decreasing the degradation rate to 46% in the use of silica gel and iron powder with composition 3.2 g / l silica gel and 2.4 g / l iron powder. while in tank 7 (control) experienced the highest increase of up to 112%. In testing TPC bacteria it is known that in tank 2 which has decreased by 99.8%. while in tank 7 there was an increase in the number of bacteria by 37.6%.

1. Introduction
Starting September 1, 2018, the government officially enacted the implementation of the B20 program for both PSO (public service obligation) and non-PSO, so that the maritime sector was one of the impacts of the policy. The addition of a mixture of FAME (fatty acid methyl esters) to diesel oil is not a new item, previously in the biodiesel products owned by Pertamina, biodiesel was mixed by as much as 10%. However, increasing the mixture of biodiesel content by up to 20% still raises polemic. In general, the problems caused by the use of biodiesel are caused by poor biodiesel storage processes, which speeds up the biodiesel degradation process which has an effect on increasing acid value, increasing saponification rates, decreasing iodine and increasing levels of biodiesel [1].

Based on previous research, it is known that storage conditions can encourage degradation in biodiesel. Increasing storage temperature can increase biodiesel degradation rate and storage time is also directly proportional. The degradation that occurs in biodiesel can be seen from the increase in the amount of acid value. The increase is caused by the degradation of the unsaturated fatty acid chains that produce products such as glycerol and free fatty acids, thus increasing the value of acid value [2].

One of the causes of biodiesel degradation is bacterial contamination of fuel. Bacterial contamination of biodiesel can occur in many ways, starting from the production process, distribution process, contaminated fuel tanks, and bacterial spores that enter through the fuel tank pipe vent that can contaminate bacteria. Bacterial growth can only occur if the water content in biodiesel is more than 100 ppm. Water that settles on the bottom of the tank is an environment that is highly favored by bacteria. The bacterial activity can form a film (biological fiber) in the tank, pipe, and filter in the fuel system. Besides that, oil-degrading bacteria can produce lipase enzymes that can degrade FAME into fatty acids and methanol [3].
The use of biodiesel in ships or marine sectors can cause problems in the form of deposits or sludge which can cause blockages in the filter and settle on the unit purifier on the ship. The hygroscopic nature of biodiesel causes an increase in water content in biodiesel. The presence of this water can trigger a hydrolysis reaction on FAME so that it forms free fatty acids which can cause corrosion in iron material and degrade elastomeric material. Heating coil on tanks made of iron, tank coating containing zinc and elastomeric materials and gaskets and seals made of elastomer will be damaged in a certain period of time due to the presence of these free fatty acids. The presence of water in the biodiesel can also trigger bacterial growth in biodiesel, the activity of these bacteria can form sludge in tanks, filters, pipes and purifier units in the fuel system which in some cases can cause logging or blockage [4].

Biodiesel starting from the cetane number, viscosity, heating value to the content of the sulfur is shown in Table 1. Addition of biodiesel to diesel fuel could increase the flash point, so that it could increase the cetane number of the fuel. Increasing the concentration of biodiesel in diesel fuel is directly proportional to the increase in flash point, an increase in flash point besides being able to make combustion in the engine become perfect can also reduce the risk of fire on the ship. In addition to increasing the flash point, other significant fuel properties changes are a decrease in LHV (low heating value) so that it will increase SFC (specific fuel consumption) of diesel engines [5].

The method commonly used to reduce degradation that occurs in biodiesel is by adding synthetic antioxidants, synthetic antioxidants consisting of various types such as BHA, BHT, Tocopherol, propyl gallate, and TBHQ. Based on previous research, it is known that the addition of synthetic antioxidants in the form of TBHQ (tetra butyl hydroxyl quinone) and BHT (butylated hydroxytoluene) can reduce the degradation rate of biodiesel. Antioxidants work by acting as acceptors so that the process of forming free radicals in the oxidation process is avoided. The weakness of the use of the antioxidant synthesis itself is that it cannot prevent bacterial activity in biodiesel. In addition, the use of antioxidants in the amount of more than 0.2% of the amount of fuel will actually trigger the formation of peroxide [6].

Table 1. Differences in specifications between RMA, DMA and biodiesel

| Fuel Parameter                  | Unit | ISO8217 RMA | ISO8217 DMA | EN-41214 biodiesel |
|---------------------------------|------|-------------|-------------|-------------------|
| Cetane number, min              | -    | 20          | 40          | 51                |
| Sulfur, max                     | ppm  | 45.000      | 15.000      | 10                |
| Density (at 15°C)               | Kg/m³| 920         | 890         | 860 to 900        |
| Flash point, min                | °C   | 60          | 60          | 120               |
| Kinematic viscosity (at 40°C)   | mm²/s| 10          | 2 to 6      | 3.5 to 5          |
| Water content                   | ppm  | 3000        | -           |                   |
| Heating Value                   | MJ/kg| 40          | 42          | 38                |
| Acid Number,max                 | mg   | 2.5         | 0.5         | 0.5               |

The rate of degradation in biodiesel can be reduced by storing biodiesel in a closed tank to reduce contamination with oxygen, as well as storing biodiesel in tanks with atmospheric nitrogen conditions (100% of the air in the tank is nitrogen). Based on previous research, it was found that the degradation rate of biodiesel at 1 liter of biodiesel with 300 ppm of antioxidant addition and conditioning of nitrogen atmosphere in the tank showed the same results at 100 hours in the aging biodiesel process by heating to a temperature of 110°C. This can prove that the reduction in oxygen concentration in the tank is as effective as adding antioxidants to reduce biodiesel degradation rates [7]. Based on Silviana...
and Luqman [1] biodiesel degradation rates can also be prevented by using tank material in the form of galvanized under closed storage conditions.

Prevention of microbial growth in biodiesel fuels by using silica gel as a medium for reducing humidity in fuel tanks. Throughout the literature search that has been done no one has done it. The novelty of this research is to apply Silica Gel on a fuel tank so that biodiesel life time can be longer. The success of this research is intended to be used as a basis for planning fuel tanks on ships when using biodiesel fuel.

Based on the theory a certain method is needed to reduce the process of biodiesel degradation during storage. This study discusses the effect of using iron powder and silica gel on fuel tanks to reduce biodiesel degradation. The objectives of this study are as follows:

1) Knowing the efficiency of the use of silica gel and iron powder in reducing the rate of degradation in biodiesel.
2) Knowing the effects of using silica gel and iron powder in reducing microorganism activity that causes degradation in biodiesel.
3) Knowing the optimal use of silica gel and iron powder on the fuel tank in reducing the rate of degradation.
4) Knowing the performance comparison using silica gel and iron powder when compared with the use of TBHQ (Tertiary Butyl Hydroxy Quinoline).

The limitations of this study are as follows:

1) This study focuses on the effect of using silica gel and iron powder on the degradation rate of biodiesel.
2) The parameter used to measure degradation rate is the amount of acid number increase from biodiesel.
3) Standard testing for biodiesel acid numbers refers to SNI 7431: 2015.
4) Experiments carried out on B20 Pertamina fuel types.
5) Material, design, and size of the tank on all variables are made the same.
6) The microorganism observed in this study is bacteria.
7) Microorganisms that cause degradation in biodiesel are based on increasing the number of bacteria found in biodiesel samples.
8) The method used to monitor the amount of bacterial growth on biodiesel is TPC (total plate count).

2. Method
The method used in this study is an 8 Weeks biodiesel storage experiment. The biodiesel used in this research is B20 biodiesel produced by Pertamina.

2.1. Variable Experiment
In this study there were 7 different variables, namely as follows:

1) Tank model with the installation of silica gel as much as 4 grams / l.
2) Tank model with the installation of 3.2 grams / l silica gel and 2.4 gram / l iron powder.
3) Tank model with the installation 3.2 gram / l silica gel and 3.2 gram / l iron powder.
4) Tank model with the installation of 2.4 grams of silica gel and iron powder 3.2 grams / l.
5) Model tank with 4 gram / l iron powder installation.
6) Ordinary tank model with TBHQ enhancer (Tertiary Butyl Hydroxy Quinoline) with a concentration of 0.1% or as much as 2.12 grams when referring to the amount of biodiesel used.
7) A tank without treatment (control).

2.2. Tank Design.
In this experiment, storage was carried out at a temperature and a constant humidity condition of 28 °C / 50-60%. The tank model that will be used in this study will be made with a volume of 4.5 liters
where later each tank will be filled with 2.5 liters of biodiesel from the tank volume. In each tank will be equipped with a vent hole with a diameter of 1 cm, besides that also in each tank, there are also 2 dead-end tubes with a diameter of 5 cm as a place for silica gel and iron powder to be installed on the tank. Tank model design can be seen in more detail in Figure 1.

Figure.1. Design of model tank.

2.3. Acid Value Test
In this study, two types of testing were carried out, namely acid number test and TPC (total plate count) testing of bacteria. Acid value test aims to measure the amount of free fatty acids contained in biodiesel. During the experiment, acid numbers will be tested for 4 times for each tank. Sampling will be taken every 2 weeks, in which each sample will be taken as much as 80 ml from each tank. but before the experiment is carried out or given treatment to each tank, an acid number is tested in the initial sample to be used. Acid number test in this study refers to the SNI 7431: 2015 standard. The results of the acid number testing obtained will be used as a parameter used to compare the rate of degradation of biodiesel in each tank treatment. If the tank with the use of silica gel and iron powder shows an increase in acid number is lower than the increase in the control tank, then it can prove that the use of silica gel and iron powder can reduce the rate of degradation in biodiesel. The increase in acid number can also be used to compare the performance of the antioxidant TBHQ and the use of silica gel/iron powder to reduce the degradation rate of biodiesel. The results of testing the acid numbers that have been obtained will be used to calculate the percentage increase in acid numbers using formula (1) and calculate the percentage decrease in the rate of degradation using formula (2), as follows:

\[ T = \frac{(A_x - A_0)}{A_0} \times 100\% \]  

\[ V = \frac{(A'_x - A'_7)}{A'_7} \times 100\% \]

Where \( T \) is the output percent increase in acid number, \( A_x \) is the value of acid number at week \( x \), whereas \( A_0 \) is the value of acid number in the pre-experimental test. while in formula (2) it is known to have an output variable \( V \) which is a percent decrease in the rate of degradation, where the value of \( A'_x \) is the highest acid number value in tank \( x \) while the value of \( A'_7 \) is the highest acid number value in tank 7.

2.4. Total Plate Count Bacteria Test.
In addition, to test acid number test, this study also tested the number of bacteria. In addition to testing acid numbers, in this study also tested the number of bacteria. This test aims to determine the number...
of bacterial colonies in each millimeter of bacteria. The method used in this bacterial abundance test is total plate count. Testing the number of bacteria carried out before and in the 8th week of the experiment, specifically to test the number of experimental bacteria will be continued until the 12th week, and in that week again and in that week the final number of bacteria will be tested. However, not all tank variables were tested, only three tanks were tested for the number of bacteria namely control tanks and two tanks that had the highest and lowest acid numbers in the eighth week of the experiment. The result of testing the amount of the bacteria will be used to determine the effect of the use of silica gel and iron powder on the growth of oil degradable bacteria in biodiesel.

3. Result and Discussion

3.1. Experiment Result

The results of the experiments carried out obtained 29 acid number test data and 4 bacterial abundance test data. As for acid number test data can be seen in Table 2, and TPC bacteria test result can be seen in Table 3. In TPC (total plate count) bacterial testing, not all tank treatments were sampled to be tested. Only 3 samples were taken for testing, namely samples from tank 7 which acted as controls, the other 2 samples were samples that had the highest and lowest acid number test results at 8 weeks. It is known from the results of testing of acid numbers carried out at week 8, the sample from tank no. 2 has the lowest acid number and sample from tank no. 4 has the highest acid number. As for the results of testing the number of bacteria can be seen in table 3.

| No | Tank Codes | Acid Value (mg KOH/g) |
|----|------------|-----------------------|
|    |            | 2nd Week | 4th Week | 6th Week | 8th Week |
| 1  | Tank no. 1 (Silica gel 4 g/l) | 0.82 | 1.677 | 0.8577 | 1.112 |
| 2  | Tank no. 2 (Silica gel 3.2 g/l dan Iron powder 2.4 g/l) | 0.91 | 1.401 | 0.8356 | 0.833 |
| 3  | Tank no. 3 (Silica gel 3.2 g/l dan Iron powder 3.2 g/l) | 0.88 | 1.121 | 1.1213 | 0.838 |
| 4  | Tank no. 4 (Silica gel 4.2 g/l dan Iron powder 3.2 g/l) | 0.5354 | | | |
| 5  | Tank no. 5 (Iron powder 4 g/l) | 0.73 | 1.387 | 1.1292 | 1.674 |
| 6  | Tank no. 6 (Antioxidant: TEBQ 0.1 %) | 0.87 | 1.385 | 1.1211 | 1.394 |
| 7  | Tank no. 7 (control) | 0.75 | 1.113 | 1.1214 | 1.120 |

3.2. Acid Number Analysis

Based on Table 2 it can be seen that in the testing of the 2nd to 4th week of the experiment, it was found that there was an increase in acid numbers in all tank treatments. This indicates the degradation of biodiesel which causes the release of ester groups in the fat chain to form free fatty acids, and the reaction correlates with the length of time biodiesel storage [1]. In the 4th week, it is known that the tank with the highest acid number is tank No. 1 which has an acid number of 1.6774 mg KOH/g sample and followed by tank no. 7 which acts as a control with acid number of 1.677 mg KOH/g. In the 6th week test there was a decrease in the value of acid numbers in all treatment tanks except for tank 3 and tank 6. The greatest reduction occurred in tank 1, from 1.677 mg KOH/g to 0.8407 mg KOH/g. whereas in the 8th week of the experiment, there was a decrease in the value of acid numbers at 3, while the decrease in the value of acid numbers in tank 2 was so small that it could be ignored.
The reduction in acid numbers seen in this study may occur when the stirring is less than perfect in the sampling process. As a result of the incomplete stirring it can cause the condition of the biodiesel in the tank to be less homogeneous. In this study, the experiment was carried out using biodiesel as much as 2.5 liters in each tank and 80 ml of samples were taken every two weeks for testing to determine the number of acid numbers in each tank that week. Samples taken from the tank must be able to represent the condition of the entire biodiesel in the tank. Given the degradation process on biodiesel does not take place simultaneously but partially, so before biodiesel sampling is carried out on the tank, it must be ensured that the biodiesel in the tank must be in a truly homogeneous condition. The inaccurate homogenization process can cause the test results to be inaccurate and cause the samples taken to not be able to represent the entire condition of the biodiesel in the tank, so that biodiesel number testing can appear lower than the previous tests. In addition to the homogenization process, it is also necessary to repeat the sampling so that the test results obtained are truly accurate.

Although there are some decreases in certain data, overall, the seven tanks observed in this study experienced an increasing trend in acid numbers. However, to facilitate data analysis it could be eliminated on data identified as outliers. SPSS Statistics 22 software was used to identify outliers on acid number data, while the method used to identify outliers was a box-plot method, with this method data that has a value that exceeds $1.5 \times \text{IQR}$ (inner quartile range) is measured from UQ (upper quartile) or a value lower than $1.5 \times \text{IQR}$ measured from LP (lower quartile) [16]. From the results of data analysis using the SPSS Statistics 22 software found several outliers found in the analyzed acid number data. There are two data identified as outliers, namely the 4th week data on tank 1 and 4th week data on tank 2.

After eliminating the data identified as outliers, the new acid number graph can be plotted as shown in Figure 2. From the picture, the trend chart for acid number increase can be seen in Figure 3. Looking at the acid graph trend in Figure 3, it can be seen that tank 2 is the tank with the lowest increasing trend, where the value of the acid number from the beginning to the end is relatively the same or there is no increase. Tank 2 received treatment in the form of using silica gel as much as 3.2 gr / liter of biodiesel and iron powder of 2.4 gr / liter of biodiesel. As for the tank that has the highest incremental trend when referring to Figure 3 is tank 4, where the incremental trend exceeds the incremental trend in tank 7 which is a control tank. When compared with the increase in the amount of acid in tank 6 which has a 1% increase in antioxidants, the increase in the amount of acid in tank 6 is still higher when compared to the trend of increasing the amount of acid in tank 2.

This shows that in this study the treatment of silica gel is as much as 3.2 gr / l and iron powder of 2.4 gr / l in the tank are more effective in preventing biodiesel degradation when compared to the use of TBHQ (tertiary butyl hydroxy quinoline) antioxidant as much as 0.1% by weight of biodiesel.

![Figure 2. Graph of Acid Number Increasing](image-url)
This is possible because the antioxidant TBHQ can inhibit the occurrence of oxidation in oil by the mechanism of giving hydrogen ions to lipid radical compounds and turning them into more stable molecules, so that the degradation process in oil is inhibited [6]. However, antioxidants have a weakness that cannot prevent the degradation of lipid molecules caused by fat degradation bacteria [10]. Whereas in tank 2 silica gel and iron powder are used which can reduce oxygen and moisture content in the tank thus creating an environment that prevents bacteria from growing, besides also being able to prevent oxidation in the biodiesel the same time.

Looking at Figures 2 and 3, the increase in the amount of acid in tank 1 (silica gel 4 gr / l) shows a fairly good trend, where until the eighth week only shows the highest increase below 1.2 mg KOH / gr. While in tank 5 using iron powder as much as 4 gr / l showed unsatisfactory results, where until the eighth week there was an increase of more than 1.4 mg KOH / gr. This can be caused by very little use of iron powder, so it is not effective in preventing oxidation in biodiesel. The use of iron powder with a greater amount is likely to prevent biodiesel oxidation better.

![Trend line Graph of Acid Number Increasing](image)

**Figure. 3.** Trend line Graph of Acid Number Increasing

The increase in acid number in biodiesel is based on pre-experimental data, so that the percentage of acid can be obtained. From Table 3, it can be seen that the acid number value in tank 7 which is a control tank has increased up to 115% from the initial acid number value. In tank 2 it shows a low percentage increase of only 39%, whereas in tank 4 it has a percentage increase in the amount of acid up to 115% or relatively the same as the highest increase in the amount of acid in the control tank. Whereas in other tanks namely tank no, 1,3,4 and 6 showed a lower percentage increase than the control tank. So it can be said that in this study tank treatment 1,2,3,5 and 6 can reduce the rate of degradation in biodiesel.
Table 3. Percentage of Acid Value Increasing

| Tank Code  | 2nd Week | 4th Week | 6th Week | 8th Week |
|------------|----------|----------|----------|----------|
| Tank no.1  | 30%      | Outlier  | 31%      | 59%      |
| Tank no.2  | 39%      | Outlier  | 32%      | 31%      |
| Tank no.3  | 36%      | 60%      | 60%      | 31%      |
| Tank no.4  | 21%      | 84%      | 60%      | 115%     |
| Tank no.5  | 35%      | 86%      | 60%      | 87%      |
| Tank no.6  | 23%      | 59%      | 60%      | 60%      |
| Tank no.7  | 49%      | 115%     | 94%      | 87%      |

Table 4 is the degradation value at each treatment shown in the sample tank. The first column is the type of treatment in the tank; the second column is the value of acid number in the last week of sample measurement. In the third row, the difference in acid values in the last week is reduced by the acid values in the pre-trial. The greater the difference between acid numbers indicates that the correlation with biodiesel degradation on bacterial growth is greater.

Decrease in degradation rate in each treatment tank is calculated by comparing the highest acid number in each processing tank with the highest amount of acid in the control. Percentage decrease in the amount of acid in each tank treatment can be seen in Table 4. Viewed from Table 4 it can be seen that the most effective treatment to reduce the rate of degradation is tank 2 (3.2 g / 1 silica gel and 2.4 g / 1 iron powder), which can reduce the degradation rate by 46%. While in tanks 1 and 3 can reduce the rate of degradation by a percentage that is relatively the same as tank 6 that uses the antioxidant TBHQ by 0.1%.

Table 4. Percentage degradation rate decreasing

| Tank code  | Highest Acid Value (mg KOH/ g) | Degradation Rate Decreasing (%) |
|------------|--------------------------------|--------------------------------|
| Tank no.1  | 1,112                          | 34%                            |
| Tank no.2  | 0,91                           | 46%                            |
| Tank no.3  | 1,1213                         | 33%                            |
| Tank no.4  | 1,674                          | 0%                             |
| Tank no.5  | 1,394                          | 17%                            |
| Tank no.6  | 1,1214                         | 33%                            |

3.3. Bacterial Count Analysis

Table 5 shows a decrease in bacterial growth. Two effective treatments were selected and compared with the control tank shown in tank 7. In this control tank biodiesel was not given any treatment. So we can measure changes in the form of treatments that have been carried out. These values are shown to emphasize the best treatment of this experiment. Table 5 is obtained from the analysis of TPC bacterial data. It can be seen that there is a decrease in the number of bacteria in tank 2 and tank 4, where both tanks use treatment in the form of silica gel and iron powder. While the opposite results are obtained in tank 7 which acts as a control, where there is an increase in the number of bacteria in tank 7 from 1.54x105 to 5.6x106, or to be thirty times before. From these results it can be seen that the use of silica gel and iron powder can prevent bacterial growth on biodiesel.
| Tank code | Number of Bacteri (cfu/ml) |
|-----------|---------------------------|
|           | Prb | Week 8th | Week 12th |
| Tank no.2 | $2 \times 10^5$ | $6.2 \times 10^4$ |
| Tank no.4 | $1.54 \times 10^5$ | $1.1 \times 10^4$ | $1.7 \times 10^4$ |
| Tank no.7 | $2.12 \times 10^5$ | $5.6 \times 10^6$ |

Although it gets the same treatment in the form of use silica gel and iron powder, there are differences in the number of bacteria between tank 2 and tank 4 after experiments. From Table 5 we see that a large decrease in the number of bacteria in tank 2 in the 8th week but experienced a high enough to be $10^4$ in the next test. Whereas in tank 4 the change tends to be stable ie a decline in the 8th week to $10^4$ and a slight increase in the 16th week. The difference in the number of bacteria is probably caused by differences in the composition of silica gel and iron powder used in both tanks, where in tank 2 uses a composition of 3.2 grams/l silica gel and 2.4 grams / l iron powder while in tank 4 using composition of 2.4 grams / l silica gel and 3.2 grams / l iron powder. Judging from the above composition on tank 2, silica gel is used more when compared to iron powder; on the contrary in the tank 4 iron powder is more used than silica gel. A difference in the composition that might just cause a decrease in the number of bacteria that is higher in tank 2 is compared to the tank 4.

Basically the growth of hydro-carbon degrading bacteria is supported by the presence of oxygen and water on biodiesel. The growth of the degrading bacteria will be optimal at 30-90% moisture content in oil deposits, lack or low water content will have a direct impact on the development of bacterial oil degrading growth [8]. Based on previous research, in conditions of low oxygen levels can reduce the rate of growth of bacteria and even prevent the growth of oil degrading bacteria which are generally aerobic. Aerobic bacteria are bacteria that need oxygen in their metabolic processes [9].

3.4. Discussion

The degradation supply chain of biodiesel fuel is easily oxidized with humid open air. Plus in certain conditions the water vapour in the air will condense at a certain temperature. The hydrolysis process is also the result of direct contact between biodiesel and the air which can be the cause of degradation of the fuel. Water vapour in the air also carries bacteria so that if there is a medium in the form of water in the fuel and bacteria carried by the humid air will ignite the growth of bacteria in the biodiesel fuel.

The growth of bacteria in biodiesel fuel is associated with the acid number of the fuel. This acidity figure can be used as an indicator of fuel degradation. Biodiesel which is originally from this plant has very little life time. Especially when juxtaposed with crude oil, its characteristics are clearly visible. Starting from where the measurement of acid numbers is used as an indicator in research analysis.

In this study also the term control tank. Actually the control tank is a measure of the success of this study. The control tank is a tank of biodiesel which is not treated as normal biodiesel is used today. By comparing various treatments with control tanks we can analyse various variables from the sample.

From the results of the acid number test as can be seen in Figure 2 there is an increase in the acid number which is quite high. In the control tank because it was known to have a number with an initial value of 0.5606 mg KOH / g, the biggest increase was 1.677 mg KOH / g measured at week 4. Meanwhile, when compared with previous studies conducted by Anggranti [6]; which in this study also measured acid numbers as an effect of biodiesel degradation. In the study, it was found that biodiesel treated with control experienced an increase in the amount of acid from 0.2 mg KOH / gr to 0.36 mg KOH / gr.
This high increase in acidity is thought to be caused by high biodegradation activity on biodiesel. Given the initial bacterial abundance test results are $1.54 \times 10^5$ cfu/liter, where the value is quite high in biodiesel. We cannot control this high value because in the research B20 used commercial production which was not known by the supply chain before. The analysis of this study was based on a study conducted by Dodos [11] which measured the amount of bacterial growth in ULSD type ultralow sulphur diesel (biodiesel) which had increased to 105-106 cfu/liter in the 16th week of incubation. The magnitude of the value proves that the amount of bacterial abundance in the initial sample of biodiesel used in this study is quite high. This can be caused by bacterial contamination during the production or distribution of biodiesel.

Even though there are significant differences in the samples with different treatments, the use of samples from commercial products is indeed not good because there are too many growing bacteria. It would be better if the sample is made alone so that bacterial growth is still ideal.

4. Conclusion

Based on the data analysis that has been done in this study, then we get some conclusions as follows:

1) Percent decrease in the rate of degradation in tank 1 (4 g / 1 silica gel) tank 2 (3.2 g / 1 silica gel and 2.4 g / 1 iron powder), tank 3 (3.2 g / 1 silica gel and 3.2 g / 1 iron powder), 4 tanks (2.4 g / 1 silica gel and 3.2 g / 1 iron powder) and 5 tanks (4 g / 1 iron powder), respectively 34%, 46%, 33%, 0% and 17%.

2) The effect of using silica gel and iron powder in this study is to reduce the amount of oil degrading bacteria on biodiesel. This is evidenced by a decrease in the number of bacterial tanks 2 and 4, respectively by 99.8% and 92.8%. while in the control tank, there was an increase in the number of bacteria as much as 36.7%.

3) In this study, it is known that the composition of the most effective use of silica gel and iron powder in reducing biodiesel degradation rate is in tank 2. This can be proven that the largest increase in acid number was only 39% and a decrease in degradation rate of 46% compared to the control tank.

4) In this study it is known that the use of silica gel and iron powder can better reduce the rate of biodiesel degradation compared to the use of 0.1% TBHQ antioxidant. This is evidenced by a reduction in the degradation rate of tank 2 by 46%, while in tank 6 (0.1% TBHQ) only by 33% when compared with a control tank.

References

[1] Silviana & B. Luqman, “EFEK PENYIMPANAN BIODIESEL BERDASARKAN STUDI KAJIAN DEGRADASI BIODIESEL CPO”, Reaktor, Vol. 15 No. 3, April 2015, Hal. 148-153.
[2] Y. P. Wu, Y. Lin & J. Y. Ye, “The Effect of Storage Condition on Biodiesel”, Department of Chemical and Materials Engineering, National Ilan University Taiwan, 2011.
[3] W. Siegert, “Microbial Contamination in Diesel Fuel – Are New Problems Arising from Biodiesel Blends ?”, Schülke & Mayr GmbH, Robert Koch Straße 2, 22851 Norderstedt, Germany, 2013.
[4] A. Moenyem, “The effect of biodiesel oxidation on engine performance and emissions”, Retrospective Theses and Dissertations. 11950, 1998.
[5] Y.L. Chreng, (2013). Effects of Biodiesel Blend on Marine Fuel Characteristics for Marine Vessels. Department of Marine Engineering, National Taiwan Ocean University, Keelung 202, Taiwan.
[6] A. Anggraini, “PENGARUH JENIS DAN KONSENTRASI ANTIOKSIDAN TERHADAP KETAHANAN OKSIDASI BIODIESEL DARI JARAK PAGAR (Jatropha Curcas, L.)”, Skripsi, Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian IPB, Bogor, 2007.
[7] J. WÄRING & S. KRISTER, “Characterisation of Chemical Decomposition of Biodiesel with a Focus on B10, B30 and B100 Blends”, Bachelor of Science Thesis Department of Chemical and Biological Engineering CHALMERS UNIVERSITY OF TECHNOLOGY Gothenburg, Sweden, 2012.

[8] A. B. Al-Hawash, A.D. Maytham, L. Shue.,A. Ahmad, A.A. Hayder, Z. Xiaoyu & M. Fuying, “Principles of Microbial Degradation of Petroleum Hydrocarbons in The Environment”, College of Life Science and Technology, Huazhong University of Science and Technology, Wuhan 430074, China, 2018.

[9] V. Grishchenkov,R. Townsend, T. McDonald, R. Autenrieth, J Bonner & A.Boronin, “Degradation of petroleum hydrocarbons by facultative anaerobic bacteria under aerobic and anaerobic conditions”, Process Biochem 35 (9), 2000, 889–896.

[10] P.P.Coppen, “The Use of Antioxidants. Di dalam Allen, J. C. dan R. J. Hamilton (eds.)”, Rancidity in Foods. Applied Science Publisher, London, 1983.

[11] G S Dodias, Zanikos, E. Fanouris, S. Loinos, T. Konstantakos, T, “ Effects of Microbiological Contamination In The Quality of Biodiesel Fuels”, Laboratory of Fuel Technology and Lubricants School of Chemical Engineering National Technical University of Athens, Greece, 2012.

[12] I. M. R.Fattah, H.H. Masjuki, M. A. Kalam, M. Mofijur & M.J. Abedin. Effect of Antioxidant on The Performance and Emission Characteristics of a Diesel Engine Fueled With Palm Biodiesel Blends. Centre for Energy Sciences, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia. 2013.

[13] N. Marlina. MASA PEMAKAIAN SILIKA GEL SEBAGAI DESIKAN PADA PENENTUAN KADAR AIR. Balai Penelitian Ternak Po . Box 221, Bogor. 2006.

[14] J. Pullen & K.Seed .An overview of biodiesel oxidation stability. Renewable and Sustainable Energy Reviews. 2012.

[15] Rozana . APLIKASI PENYERAP OKSIGEN (OXYGEN SCAVANGERS) DALAM TEKNOLOGI PENGEMASAN. Review Jurnal SEKOLAH PASCASARJANA INSTITUT PERTANIAN BOGOR BOGOR. 2013.

[16] J. W.Tukey .Exploration Data analysis, Readings : MA Addison Wesley. 1977.

[17] J.A. Waynick, Characterization of biodiesel oxidation and oxidation products,. Subcontractor report, National Renewable Energy Laboratory,SwRI Project No.08-10721,2005.

[18] H.Zakaria, K.Amir, F. S. Muhammad, M. Norrizal & B.Manshoor . Effect of storage temperature and storage duration on biodiesel properties and characteristics. Trans Tech Publications, Switzerland. Applied Mechanics and Materials Vols. 465-466 (2014) pp 316-321.