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INFLUENCE OF BIOADDITIVE TO TOTAL ACID NUMBERS AND VISCOSITY INDEX OF BASED LUBRICANTS MIXED VEGETABLE OIL AND MINERAL OIL

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ABSTRACT

The demands for environmentally friendly products and renewable in lubricant products such as fuels, lubricants, coatings and so on is increasing. This is because the availability of mineral oil is limited, non-renewable, non-biodegradable, and as a consequence, it may pollute the environment. Efforts have been made to reduce the consumption of mineral oil lubricants as well. Mixing mineral oil and vegetable oil is one of the efforts to reduce the use and improve the propertiesof the mineral oil. Vegetable oils generally have a high viscosity and a good lubricity properties. High iodine number indicates the ability of vegetable oil as a lubricant, despite the low oxidation stability. Therefore, the vegetable oil can be used to substitute the use of mineral oil as lubricant base oil, by modifying the oil chemically or physically. Some vegetable oils are widely available in Indonesia and could be used as a base oil and lubricant bioadditive, such as palm oil, coconut oil, castor oil, rice bran oil. This research was conducted with the aim to study the effect of the addition of vegetable oil and bioadditive on a base oil of mineral oil to the oxidation stability. Oxidation stability is measured in terms of its physical and chemical properties of lubricants, namely Total Acid Number (TAN) and viscosity index (IV). The method used in this research was by mixing the mineral lubricating oil with vegetable oils and bioadditive, so that the quality of lubricating oil mixture can be increased. The mixing was done on basis to the ratio % (v/v) of the vegetable oil and mineral oil. The concentration of vegetable oils added to mineral oil lubricants was 20% (v / v) and the addition of epoxidized rice bran oil methyl ester by 1%, 2%, 3%, 4% and 5% (v / v), then the blending was done for 15 minutes with a temperature of 60^0C to 70^0C and allowed to stand for 30 days. Furthermore,the TAN and IV testing were done. The relationship between the epoxidized methyl ester rice bran oil (% v / v), (x) were added to a mixture of vegetable oil and mineral oil to the value of TAN (y) is $y = 0.0357\ x^2 - 0.2543\ x + 0.69$, $R^2 = 0.7874$. The relationship between the epoxidized rice bran oil methyl ester (% v / v), (x) were added to a mixture of vegetable oil and mineral oil to the viscosity index (y) is $y = -0.4083\ x^3 + 5.1857x^2 - 19.977x + 153.2$, the value of $R^2 = 0.9949$.

Keywords: base oil, mineral oil, total acid number,vegetable oil, viscosity index.

INTRODUCTION

There are several advantages of vegetable oil compared to mineral oil as a lubricant base oil. They are non-toxic, biodegradable, renewable, and have a high viscosity index. Vegetable oils is usually much cheaper than synthetic oil, therefore, it has the potentials to be used as the base oil (Talkit, 2012). Nizam and Abdulbari, 2009, stated that the weakness of the vegetable oil lubricant base oil is the low oxidation stability at high temperature and, at low temperature, it has poor lubrication properties. As a matter of fact, modifying the vegetable oil chemically or blending it with additives and mineral oil could overcome the weakness. This shall reduce the consumption of mineral oil as lubricant base oil.

Chemical modification of the vegetable oil can change the physical and chemical properties of the oil. For example, Borugadda, (2014) synthesized epoxidized castor oil methyl ester using ion exchange base catalyst to be used as base oil with high oxidation stability. In addition, Sahoo, *et al*, (2015)used epoxidized soybean oil methyl esters to improve the rheological performance base oil. In reference to the research results of Holser(2008), epoxidized methyl ester can also be used as surfactants, additives and base oil of various industrial products, manufactured by the transesterification reaction of the epoxidized soybean oil.

Due to the concern of reducing the use of mineral oil, substitution or a replacement with other materials should be the alternatives. Talkit *et a*l., 2012 stated that mixing some vegetable oils with mineral oils could not only improve the lubrication properties, but it could be also an attempt to replace them. Several parameters are used as a measure of lubrication properties: the index of viscosity, total acid number, saponification and iodine number. Talkit*et al*., 2012, studied that to increase the oxidation stability, melting point, and viscosity index, soybean oil should be mixed with castor oil, peanut oil, and cotton oil. Mixing soybean oil with coconut oil at ratio 90 : 10 (v/v) showed the highest viscosity and the lowest acid number. Furthermore, vegetable oil can be degraded. Some oil is food grade making it less feasible when used for non-food grade, such as lubricants. On the other hand, the used cooking oil is toxic, discolored and smelly, therefore it has the potentials to be used as a mixture of base oil lubricant (Abdulbari*et al*. 2011).

This research studied the mixing of vegetable oil to the mineral oil with the addition of bioadditive, for the purpose of reducing the use of mineral oil and improves the physical properties and chemical properties. Vegetable

oils used in this study are coconut oil, rice bran oil. The bioadditive used is epoxidized rice bran oil methyl ester. The effect of adding bioadditiveis reviewed by testing the total acid number and the viscosity index of a mixture of vegetable oil and mineral oillubricant.

RESEARCH METHOD

The research flow diagram is shown in Figure-1.

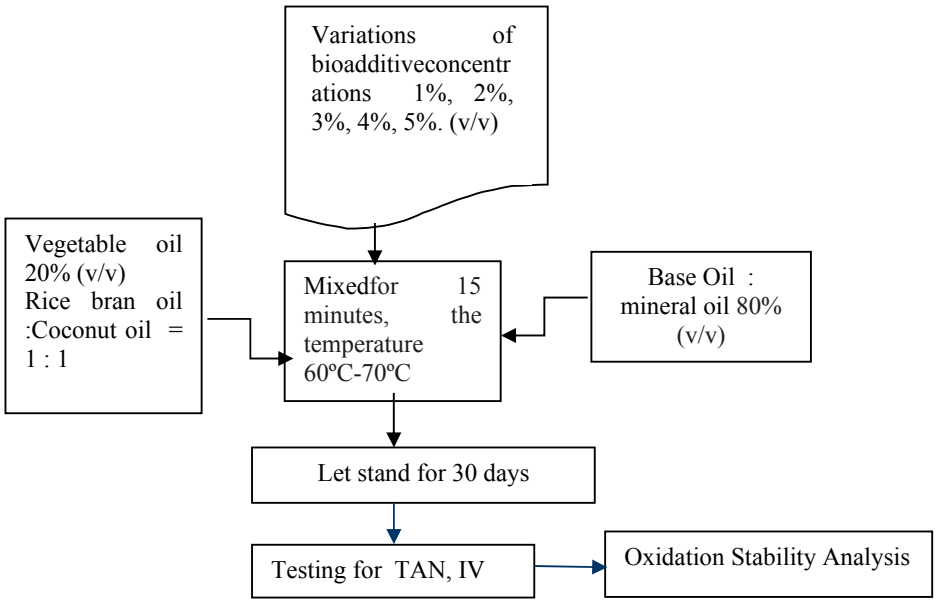

Figure-1. Flowchart of this research.

Research and testing procedures

Preparation of mixed based oil lubricants

Mineral oil, vegetable oil and bioadditive were mixed for 15 minutes at a temperature of 60ºC-70ºC (vegetable oil 20% (v/v) and mineral oil 80% (v/v). The addition of bioadditive(v/v) (epoxidizedrice bran oil methyl ester) varies from 1%, 2%, 3%, 4%, 5%.

Oxidation stability test

The mixture was allowed to stand for 30 days. Tests performed on a mixture of the base oil is a change in the value of its TAN and IV. These tests are performed to determine the improved of oxidation stability of base oil.

Test for Total Acid Number (TAN)

Total Acid Number (TAN) can be calculated by weighing ± 2.5 g sample of the lubricant in a 100 mL beaker, add 25 mLethanol pa. and 3-5 drops of phenolphthalein indicator (pp), and titration using 0.1 N KOH.

Test for Viscosity Index (IV)

Viscosity index is an empirical number that shows the effect of temperature changes on the viscosity of the oil at a temperature of 40°C and 100°C. The higher the viscosity index of oil is, the less effect of temperature changes on the viscosity of the oil will be.

Materials

The materials used in this study were mineral oil (*Base Oil*, HVI (High Viscosity Index)), coconut oil, rice bran oil, bioadditive (epoxidized rice bran oil methyl ester), 0.1 N alcoholic potassium hydroxide (KOH), phenolphtalein, methanol, ethanol pa, water.

Equipment

Some of the equipment used in this study are a magnetic stirrer, heater, thermometer, burette, beaker glass, analytical balance.

RESULTS AND DISCUSSIONS

Oxidation stability test results

Total Acid Number (TAN) with the addition of bioadditive

One of the parameters used to test the stability of oxidation is the Total Acid Number (TAN). This is tested on the mixture of mineral oil and vegetable oils with a composition of 80% : 20% (v/v). Temperature and mixing time is 60^0C-70^0C for 15 minutes. In the mixture, bioadditive(epoxidized rice bran oil methyl ester)was added. The mixture was allowed to stand for 30 days. Table-1 shows theTAN test results of the mixture of base oil of mineral oil and vegetable oils.

Table-1. The result of TAN test of mixed mineral oil and vegetable oil (80%: 20% (v / v)) at a temperature of 60^0C-70^0C mixing for 15 minutes with various bioadditive concentrations.

Sample	Bioadditive (%)	TAN Test mg KOH/g oil
1	1	0.5
2	2	0.25
3	3	0.3
4	4	0.25
5	5	0.3

The purpose of adding vegetable oil to mineral oil lubricants is to reduce the consumption of mineral oils. It is expected that the renewable properties and biodegradability of mineral lubricants should increase. Rice bran oil has been selected because of its availability, which is a byproduct of rice processing. Utilizing the rice bran oil as a mixture of mineral oil lubricants is expected to increase its added value. Meanwhile, coconut oil has been selected for the high saturated fatty acids content (C12: 0, lauric acid and C14: 0, myristic acid), as stated by Kumar and Kishna, 2015., Saturated fatty acids tend to have high oxidation stability. In fact, the properties of lauric acid in coconut oil is a natural antioxidant. Table-1 shows that the greater the addition of epoxidized rice bran oil metil ester bioadditive is,the TAN changes tend to decrease. It is because of using of US Patent 20060090393, epoxy esters may reduce the possibility of corrosion on lubricating. Furthermore, the correlation between the additions bioadditive against TAN can be seen in Figure-2.

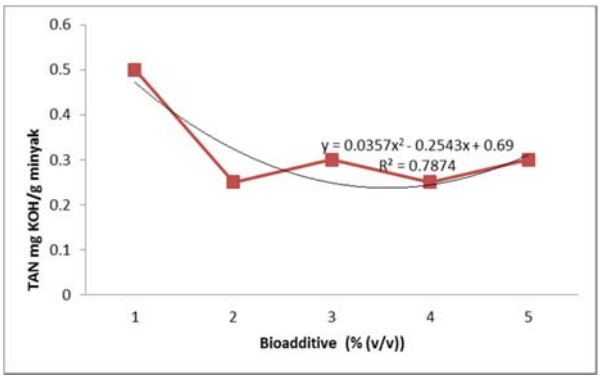

Figure-2. Effect of the bioadditive addition on TAN of the mixture of mineral and vegetable oil lubricant

Figure-2 shows the addition bioadditive on a mixture of mineral and vegetable oils lubricants would affect the TAN. The equation that correlates the x, namely% (v / v) adding bioadditive on a mixture of vegetable oils and mineral oils and y, ie the value of TAN, is $y = 0.0357x^2 - 0.2543 x + 0.69$, $R^2 = 0.7874$. These shows a strong correlation between the bioadditive addition on TAN of the mixture of mineral oil and vegetable oils.The correlation is the quadratic polynomial nonlinear regression equation.

The viscosity index test results with the addition of bioadditive

Another parameter used to test the stability of oxidation is the Index Viscosity (IV), which was tested in mixed mineral oil and vegetable oils with a composition of 80%: 20% (v / v) and with the addition of epoxidized rice bran oil methyl ester bioadditive as much as 1%, 2%, 3%, 4%, and 5% (v / v). Temperature and mixing time is 60^0C-70^0C for 15 minutes. The mixture was allowed to stand for 30 days. Table-2 shows the IV test result of the mixture of mineral and vegetable oil lubricant.

Table-2. The result of viscosity index test of mixed mineral oil and vegetable oil (80%: 20% (v / v)) at a temperature of 60^0C-70^0C, mixing for 15 minutes with various bioadditive concentrations

Sample name	Bio-additive (%)	Viscosity testing		
		V 40 ^{0}C (cSt)	V 100 ^{0}C (cSt)	Viscosity index
Sample 1	1	6.233	34.57	130.7
Sample 2	2	6.064	33.51	129
Sample 3	3	6.076	33.31	130
Sample 4	4	5.907	31.78	132
Sample 5	5	5.875	31.60	131.8

Based onTable-2, it can be seen that the greater the concentration of bioadditiveis added, the greater the viscosity index will become. This suggests that the addition of bioadditive will increase the viscosity index, thereforethe possibility of oxidation shall reduce.

Furthermore, the correlation between the additions of bioadditiveto the viscosity index can be seen in Figure-3.

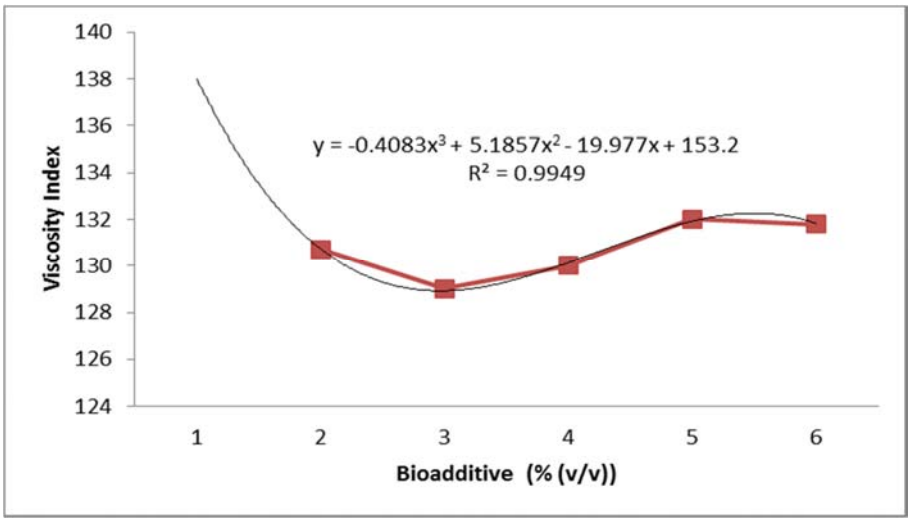

Figure-3. Effect of the bioadditive addition on viscosity index of the mixture of mineral and vegetable oil lubricant

Figure-3 shows the addition of bioadditive on a mixture of mineral and vegetable oils lubricants would affect the viscosity index. The equation that correlates the x, % (v/v) adding bioadditive on a mixture of vegetable oils and mineral oils and y, viscosity index, is $y = -0.4083x^3 + 5.1857x^2-19.977x+153.2$, approaching the value of $R^2 = 0.9949$. This shows a strong correlation between the bioadditive addition on the viscosity index of the mixture of mineral oils and vegetable oils. The correlation is the 3rd order polynomialnon-linear regression equation.

The use of bioadditiveto the formulations of lubricants is to prevent the decline in the lubricant viscosity due to temperature increase, so that the viscosity index lubricant will be higher. High viscosity index lubricant will increase the ability to maintain its viscosity at high temperature. Testing the viscosity index using the ASTM D-2270 is calculated from the measurement of kinematic viscosity lubricant samples at a temperature of 40^{o}C and 100^{o}C, can be seen in Figure-4.

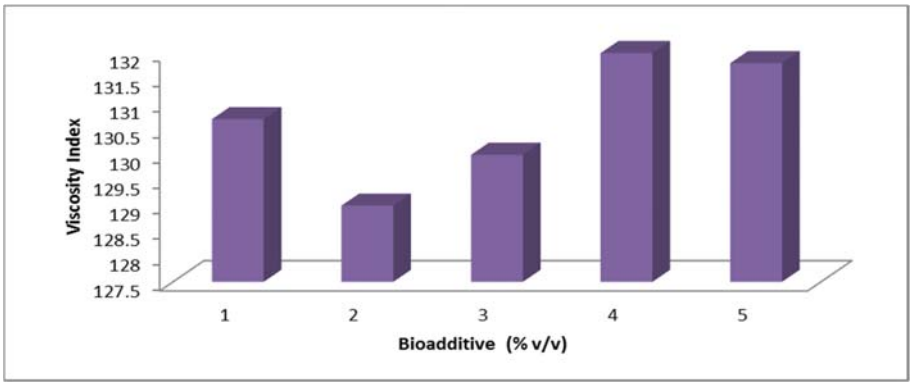

Figure-4. The effect of the bioadditive on the viscosity index.

Figure-4 shows the results of the blending of vegetable oils and mineral oils with the addition of bioadditive. Figure-4 shows that from all five different lubricant products, the lubricant composition no. 4 is the best because it has a viscosity index which is the highest among other compositions on one of lubricant products.

CONCLUSIONS

The results of TAN and viscosity index test of the mixture of lubricant is in the best composition of the vegetable oil addition 20% (v/v) in mineral oil with the addition of bioadditive 4% (v/v).These results indicate the stability oxidation of the mixture of lubricant, which is indicated by the low change of the total acid number and the viscosity index, and the high of viscosity index.

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REFERENCES

Abdulbari H.A., Rosli M.Y., Abdurrahman H.N., Nizam M.K. 2011. Lubricating Grease from spent bleaching cart and waste cooking oil: Tribology Properties, International Journal of the Physical Science. 6(20): 4695-4699.

Borugadda VB. 2014. Epoxidation of Castor Oil Fatty Acid Methyl Esters (COFAME) as a Lubricant base Stock Using Heterogeneous Ion-exchange Resin (IR-120) as a Catalyst Energy Procedia 01/2014; 54:75-84. DOI: 10.1016/j.egypro.2014.07.249.

Holser R.A. 2008, Transesterification of epoxidized soybean oil to prepare epoxy methyl esters.Industrial Crops, and Products.27(1): 130-132.

Kumar P.P.K and Kishna A.G.G. 2015. Physicochemical characteristics of commercial coconut oils produced in India. Grasas Y Aceites. 66: (1).

Nizam M.K., danAbdulbari H.A. 2009. The Use of Vegetable Oil in Lubricant as Base Oil: A Review, Proceeding National Conference on Postgraduate Research (NCON-PGR) Oktober. University Malaysia Pahang.Paten US 20060090393.

Sahoo S.K., Mohanty S.,Nayak S.K. 2015. Toughened bio-based epoxy blend network modified with transesterified epoxidized soybean oil: synthesis and characterization RSC Adv.,5, 13674-13691 DOI:10.1039/C4RA11965G.

Talkit K.M. 2012. Physicochemical Properties of Oil Blend and Their Effects on Lubrication Properties. International Journal of Advanced Engineering Research and Studies. I(III).

Talkit K.M., Mahajan D.T., Masand V.H. 2012. Physicochemical Properties of Soybean Oil and Their Blends with Vegetable oils for the Evaluation of Lubrication Properties. Journal of Chemical, Biological, and Physical Sciences. 3(1): 490-497.