Effect of blending ratio of biofuel from used cooking oil with Dexlite

Junety Monde[1], *Prapti* Ira Kumalasari[1], *Akhmad* Fauzan[1], and *Mohammad* Lutfi[2*]

[1]Department of Oil and Gas Processing, STT MIGAS, Balikpapan, 76127, Indonesia
[2]Department of Petroleum Engineering, STT MIGAS, Balikpapan, 76127, Indonesia

Abstract. Indonesia is committed to accelerating the clean energy transition through the biodiesel policy to achieve net zero emission. The commitment to use palm oil as a biofuel base material will support Indonesia in achieving its energy security and energy mix target of 23% in 2025. This article discussed the characteristics of the blended fuel between biofuel from used cooking oil and Dexlite from PERTAMINA products. The blending process is carried out with the biofuel: Dexlite ratio as follows: 5:95, 10:90, 15:85 20:80, 25:75 and 30:70. The results revealed that the best experiments for acid number were obtained at the B5 blending ratio of 0.039 mgKOH/(g sample), saponification number at the B5 blending ratio of 1.066 mgKOH/(g sample), flash point at the B20 blending ratio at a temperature of 101°C, 90% distillation at the B10 blending ratio at a temperature of 213°C, and the density at the blending ratio B15 is 837 kg/m^3. From these results, only the density parameter does not meet the biodiesel quality standards based on SNI 7182:2015. These results indicate that the addition of 30% biofuel to Dexlite can still be used as a fuel for diesel vehicles by applying a better washing method for KOH catalyst residue and unreacted methanol residue.

1 Introduction

The main cause of the increasing emission of greenhouse gases that accelerates the process of climate change is the process of burning fossil fuels [1]. However, most countries still use fossil fuels as the main energy source [2]. The average temperature of the earth's surface has increased by about 1.1°C since pre-industrial era. Therefore, urgent action is needed to limit global warming to 1.5°C [3].

Mitigation efforts around the world have been carried out to reduce economic losses due to disasters caused by global warming [4]. One of the strategies adopted to overcome this problem is to raise public awareness of low carbon society [5] to reduce carbon dioxide emissions without disrupting the continuity of the needs of people who should live in prosperity [6].

Carbon footprint can be reduced by using renewable energy. Biomass has considerable potential as a renewable energy source [7]. The Indonesian government has been pushing for progress in the biodiesel sector to fulfill its commitment to support clean energy [8]. This

*Corresponding author: lutfi_plhld@yahoo.co.id

commitment is realized through the use of renewable energy by 23% in 2025 to achieve national energy security [9].

One of the problems arising from this policy is the increasing waste of palm oil products [10, 11] in the form of used cooking oil which is frying waste. Used cooking oil can cause water and soil pollution if it is disposed of carelessly [12], but it can be used as "an environmentally friendly fuel".

PERTAMINA was given the mandate to implement the 30% biodiesel or B30 program. It is currently available at fuel stations in Indonesia [13]. In general, biodiesel cannot be used directly as fuel in transportation facilities or can be used directly, but engine modifications are needed. The use of pure biodiesel (B100) has a negative impact on several things, such as corrosion of the fuel injectors and tanks, softening of rubber seals, increased demand for pumping power, clogging of fuel injectors, and blockage of fuel pipes/filters due to bacterial growth [14]. One way to overcome this problem is to blend biofuel from used cooking oil with diesel oil from crude oil.

Many studies related to the blending of fossil fuels with biofuels obtained from waste processing have been carried out, for example studies related to the effect of mixing Dexlite with biodiesel obtained from industrial fish canning waste [15] and the mixing of Dexlite with coconut shell oil into biodiesel [16]. In this study, the blending process was carried out between Dexlite and biofuel from used cooking oil. Dexlite Is a diesel fuel variant that has a minimum cetane number of 51 and contains a maximum of 1200 ppm sulfur, meaning that Dexlite is a type of diesel fuel that produces environmentally friendly emissions and is economical in use [17]. The product resulting from this blending process is expected to meet the specifications needed to support national energy security that is environmentally friendly.

2 Methods

The experimental method used to reveal the characteristics of biodiesel produced from the blending process of biofuel and Dexlite with ratios of B5, B10, B15, B20, B25, and B30. The blending process was carried out in two treatments with no replication for each treatment at 30°C for 5 minutes with 500 rpm rotation at 1 atm pressure. Characteristics of biodiesel analyzed are acid number, saponification number, flash point, distillation, and density.

2.1 Acid number

The acid number was obtained by titrating 5 g of the sample which had been dissolved in 50 mL alcohol with 0.1 N KOH using the PP indicator. The volume of KOH used to turn the mixture pink is recorded as the volume of KOH. The acid number is obtained based on equation (1).

$$\%FFA = \frac{V\ KOH \times N\ KOH \times Mr\ Sample}{Mass} \times 100\% \quad (1)$$

2.2 Saponification number

Determination of the saponification number was carried out by adding 50 mL alcoholic KOH (0.5M) to the biodiesel sample. The mixture is boiled using reflux which is connected to the condenser for 1 hour at 400°C. After it cools and forms a jelly-like substance, it is then rinsed with distilled water and titrated with 0.5 N HCl with PP indicator until the pink color disappears. The saponification number is calculated using equation (2).

$$\text{Saponification number} = \frac{56.1 \times (B-C) \times N}{m}\ mg\frac{KOH}{g} \quad (2)$$

where: B = volume of 0.5 N HCl consumed in the blank titration (mL), C = volume of 0.5 N HCl consumed in the sample titration (mL), N = the exact normality of the 0.5 N HCl solution, and m = alkyl ester biodiesel sample mass (g) [18].

2.3 Flash point

The sample is put into the container up to the specified limit mark. The container is placed on the flash point tester. The temperature recorded is when the flash point occurs, which is when the oil vapor contained on the surface of the sample burns in an instant [19].

2.4 Distillation

This test was carried out by inserting a 100 mL sample into the distillation flask on the ASTM D 86 distillation. After the device was turned on, the temperature was recorded when the first drop of condensate was recorded, then an increase in condensate volume by 10 mL to 90 mL is recorded.

2.5 Density

Density is the ratio of the total mass of a substance to a certain volume of a fluid. Density measurement is conducted using a pycnometer. Equation (3) is used to calculate the density of biodiesel.

$$\rho = \frac{m}{V} \tag{3}$$

where: ρ biodiesel = biodiesel density (g/mL), m = biodiesel sample mass (g), and V = biodiesel sample volume (mL) [20].

3 Results and Discussions

Each country generally has standard specifications for each type of fuel. Standard specifications for biodiesel in Indonesia refer to the Indonesian National Standard (SNI) 7182: 2015 [21]. Table 1 shows the characteristics of biodiesel based on the experimental results that have been carried out. The results of blending biofuel from used cooking oil obtained from the transesterification reaction and Dexlite were compared with biodiesel quality standards to determine the quality of the biodiesel produced.

Table 1. Characteristics of biodiesel after blending process

Parameters	Unit	B5	B10	B15	B20	B25	B30	SNI 7182: 2015
Acid number	mgKOH/ (g sample)	0.039	0.048	0.056	0.067	0.078	0.078	Max. 0.5
Density	Kg/m^3	813	820	837	829	832	826	850-890
Saponification number	mgKOH/ (g sample)	1.066	0.898	0.7854	0.7854	0.6732	0.6732	
Flash point	°C	96.11	96.11	98.88	101	104	107	Min. 100
Distillation 90%	°C	245	213	280	260	250	280	Max. 360

3.1 Effect of blending ratio on acid number

The acid number in a sample reveals the amount of free fatty acids contained in biodiesel. The acid number can be an indicator of damage that occurs in biodiesel, which is thought to be due to oxidation activity [22]. Figure 1 shows the acid number analyzed from the six samples with the following results: B5 (0.039 mgKOH/(g sample)), B10 (0.048 mgKOH/(g sample)), B15 (0.056 mgKOH/(g sample)), B20 (0.067 mgKOH/(g sample)), B25 (0.078 mgKOH/(g sample)), and B30 (0.078 mgKOH/(g sample)). These results reveal that the biodiesel produced meets SNI 7182:2015 [21] with a value below 0.5 mgKOH/(g sample). Figure 1 reveals that the greater the blending ratio of biofuel with Dexlite, the acid number value also increases. This is in line with previous studies [23] which stated that the addition of more biofuel in the blending process with Dexlite would increase the free fatty acid content in biodiesel. This is because the esterification process was not carried out prior to the transesterification reaction in used cooking oil [24].

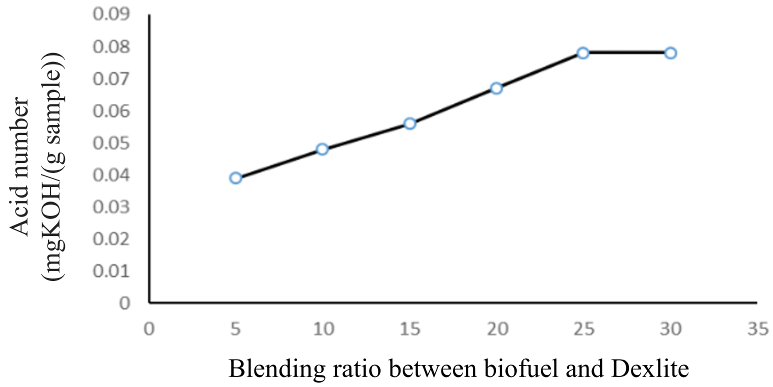

Fig. 1. Relationship between blending ratio and acid number

3.2 The effect of the blending ratio on the saponification number

The saponification number is defined as the number of milligrams of KOH required to completely saponify fat from 1 g of fat or oil. Natural oils and fats are glycerol esters which are usually composed of fatty acids having C atoms between 16 and 18 so that the saponification number of each natural fat or oil does not differ much [25].

Figure 2 reveals that the greater the blending ratio of biofuel to Dexlite, the resulting saponification number decreases. This is because the large biofuel ratio in the blending process has an impact on the average molecular weight of the resulting biofuel. The greater the saponification number contained in an oil, the better the quality of the oil [26]. The results obtained are as follows: B5 (1.065 mgKOH/(g sample)), B10 (0.897 mgKOH/(g sample)), B15 (0.785 mgKOH/(g sample)), B20 (0.785 mgKOH/(g sample)), B25 (0.673 mgKOH/(g sample)) and B30 (0.673 mgKOH/(g sample)).

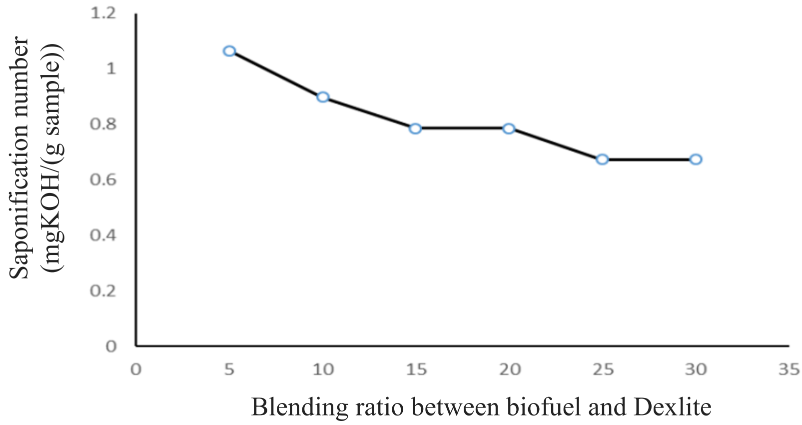

Fig. 2. Relationship between blending ratio and saponification number

3.3 Effect of blending ratio on flash point

The flash point is the temperature when a short flame is seen for less than 5 seconds at a point above the surface of the sample when it is brought close to a fire source [27]. It can be seen in Figure 3 that the flash point increases with increasing the biofuel ratio in blending. The flash point values obtained are as follows: B5 (96.1°C), B10 (96.1°C), B15 (98.8°C), B20 (101°C), B25 (104°C) and B30 (107°C). Based on these results, there were three samples (B20, B25, and B30) that met the standards set [21], namely a minimum temperature of 100°C.

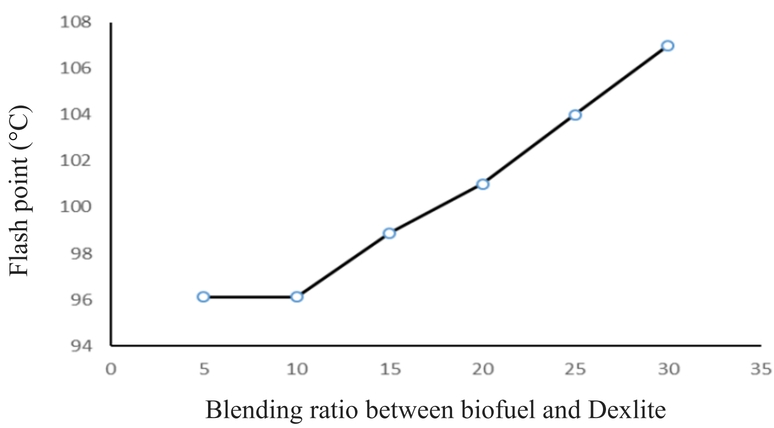

Fig. 3. Relationship between blending ratio and flash point

3.4 Effect of blending ratio on distillation

The distillation process carried out in this study refers to the ASTM D-86 method. This procedure is carried out to provide information about the contents of the light and heavy fractions presented in boiling points. The distillation process is carried out at a volume of 100 mL, the temperature of the initial dripping steam (Initial Boiling Point) and the final dripping steam (Final Boiling Point). The distillation temperature of 10 mL volume of biodiesel produced by blending biofuel with Dexlite is shown in Table 2. Based on the results, the inspection of biodiesel met the requirements of biodiesel [21], where the maximum temperature is 360°C.

Table 2. Distillation results

Volume (mL)	B5 (°C)	B10 (°C)	B15 (°C)	B20 (°C)	B25 (°C)	B30 (°C)
10	205	220	225	206	230	225
90	245	213	285	260	250	280

3.5 Effect of blending ratio on density

Density is the ratio of mass per volume, this characteristic is related to the calorific value and power produced by a diesel engine per volume of fuel [28]. Figure 4 shows the densities resulting from the blending process, namely B5 (813 Kg/m^3), B10 (820 Kg/m^3), B15 (837 Kg/m^3), B20 (829 Kg/m^3), B25 (832 Kg/m^3) and B30 (826 Kg/m^3). Based on these results, the density value does not meet the biodiesel quality standards [21]. This is because compounds such as soap, alkaline catalysts, and methanol are still suspected to be present in biodiesel due to imperfect separation [29]. Therefore, to obtain a good density, it is necessary to wash the compounds repeatedly.

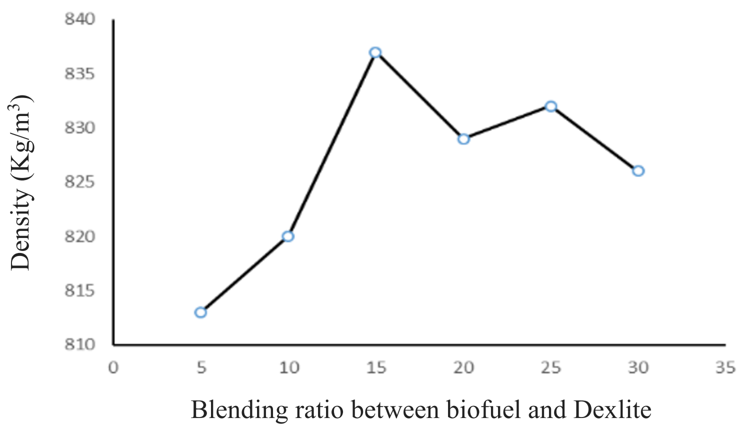

Fig. 4. Relationship between blending ratio and density

4 Conclusion

The best blending ratios were obtained as follows: The acid number was obtained at the B5 blending ratio of 0.039 mgKOH/(g sample), the saponification number at the B5 blending ratio was 1.066 mg/(g sample), the flash point was at the B20 blending ratio when the temperature reached 101°C, 90% distillation at the blending ratio of B10 at 213°C, and the density at the blending ratio of B15 is 837 Kg/m^3. From these results, only the density parameter does not meet the biodiesel quality standards based on SNI 7182:2015. To get a good density, it is necessary to apply a better washing method for KOH catalyst residue and unreacted methanol residue. Based on these results, the addition of 30% biofuel to Dexlite can still be used as fuel for vehicles with diesel fuel. However, testing of other parameters such as sulfur content, water, glycerol, cetane number, smoke point, etc. need to be carried out to obtain comprehensive results. Further research is needed to get more accurate results by conducting many replications in each treatment.

Acknowledgement

This research was funding by Kemenristek Dikti. The authors would like to thank for the support of LPPM STT Migas, Balikpapan.

References

1. F. Perera and K. Nadeau, New. Engl. J. Med. **386**(24), 2303-2314 (2022)
2. F. Martins, C. Felgueiras, M. Smitkova, N, Caetano. *Energies*, **12**(6), 964 (2019)
3. V. Masson-Delmotte, P. Zhai, H.O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Pean, Pidcoc R, (2018). Available online: https://www. ipcc. ch/sr15/ (accessed on 21 June 2023)
4. M. Lutfi, JESTEC. **15**(4), 2309-2323 (2020)
5. B. Sulaiman, A.N. Bambang, H. Purnaweni, M. Lutfi, E.M. Mohammed, JPII. **8**(4), 561-569 (2019)
6. W. Iriyanto, *The 3rd International Conference on Energy, Environmental and Information System (ICENIS 2018)*. E3S Web Conf. **73**, 08028 (2018)
7. S. Yana, M. Nizar, D. Mulyati, A rev. Renew. Sust. Energ. Rev, **160**, 112268 (2022)
8. A. Sahara Dermawan, S. Amaliah, T. Irawan, S. Dilla, J. Econ. Struct, **11**(1), 22 (2022)
9. V.S. Husada, N.A. Fathurrahman, C.S. Wibowo, I.E. Joesoef, *International Conference on Biomass and Bioenergy,* IOP Conf. Ser. Earth Environ. Sci. **1187**, 1, 012036 (2023)
10. M. Yamin, A. Lisnawati, M. Lutfi, *The 4th International Conference on Rehabilitation and Maintenance in Civil Engineering (ICRMCE 2018),* MATEC Web Conf. **195**, 01022 (2018)
11. M. Lutfi, M. Yamin, M. Rahman, E.G. Popang, *The 4th International Conference on Rehabilitation and Maintenance in Civil Engineering (ICRMCE 2018),* MATEC Web Conf. **195**, 01019 (2018).
12. W.H. Foo, W.Y. Chia, D.Y.Y. Tang, S.S.N. Koay, S.S. Lim, K.W. Chew, J. Hazard. Mater **417**, 126129 (2021)
13. A. Setiyawan, A. Novianto, N.B.A. Afkar, F. Chabib, F.R. Amelia, I. Pratiwi, *10th Engineering International Conference*, IOP Conf. Ser. Earth Environ. Sci. **969**, 1, 012034 (2022)
14. O. Sidjabat, A. Haris, H. Purnomo, The 7th Asian Petr. Tech. Symp. Ho Chi Minh, 18-19 February (2009)
15. A.R.A. Udin, A.T. Zain, IOP Conf. Ser. Earth Environ. Sci. **672**, 1, 012102 (2021)
16. A. Nugroho, F. Lumela, R.D. Ratnani, J. Polimesin, **20**(2), 117-120 (2022)
17. M.A. Kodir Jaelani, *Uji konsumsi bahan bakar mesin pencacah plastik* (2021)
18. L. Laila, JTPII, **2**(1), (2017)
19. M.R. Harahap, AMINA, **3**(1), 13-17 (2021)
20. J. Monde, P.I. Kumalasari, D. Aryani, M. Lutfi, A. Alfandy, J. Chemurgy. **6**(2), 80-85 (2022)
21. B.S. Nasional, *SNI 7182: 2015, "Syarat Mutu Biodiesel"* (Badan Standarisasi Nsasional, 2015)
22. S. Suyono, N.U. Hartanti, A. Wibowo, N. Narto, BIOSFERA A Sci. J. **34**(3), 123-130 (2017)
23. H. Haryono, M. Marliani, Eksergi **11**(2), 24-29 (2014)
24. D.A. Setyawardhani A.T.Y. Widiasri, M. Rahman, J. Integ. Pros. **10**(2), 68-76 (2021)
25. I. Aziz, S. Nurbayti, A.R. Hakim, J. Kim. VALENSI, **2**(5), 541-547 (2012)
26. G. Gunawan, M.T.M Aloysius, A. Rahayu, J. Kim. Sains. Apl. **6**(3), 13-16 (2003)
27. Y. Lawa, Sem. Nas. Pend. Sains Kim. 60-64 (2018)

28. G.N.I.P. Pratama, A.M. Yusuf, Inersia: J. Tek. Sip. Ars. **15**(1), 62-73 (2019)
29. A.K. Makalalag, D.P. Silaban, J. Pen. Tek. Ind. **12**(1), 31-40 (2020)