Jurnal Teknologi Informasi dan Pendidikan
Volume 18, No. 1, March 2025
https://doi.org/10.24036/jtip.v18i1.829

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
tip.ppj.unp.ac.id

Combustion Characteristics of Biodiesel Droplets from Nyamplung Seeds with Eggshell Catalyst Using PLX-DAQ Software

Kinanti Wilujeng Sukma[1], Andi Sanata[1*✉], Gaguk Jatisukamto[1], Nurkoyim Kustanto[1], Mahros Darsin[1]

[1]Department of Mechanical Engineering, Universitas Jember, Jember, Indonesia
*Corresponding Author: andisanata@unej.ac.id

Article Information

Article history:

No. 829
Rec. January 12, 2024
Rev. April 29, 2024
Acc. May 14, 2025
Pub. June 01, 2025
Page. 773 – 781

Keywords:

- Biodiesel Droplets
- *Nyamplung Seeds*
- *Eggshell Catalyst*
- *PLX DAQ Software*

ABSTRACT

The purpose of this study was to determine the effect of eggshell catalyst (CaO) on the combustion characteristics of nyamplung oil biodiesel droplets (Calophyllum inophyllum L) on flame visualization, ignition delay, and temperature. At present, Indonesia still uses fossil fuels, namely diesel. However, over time there are alternative fuels using palm oil raw materials. However, palm oil is also used as a source of food so that it will have an impact on the scarcity of palm oil. In this study, we looked for alternative energy using nyamplung seeds (Calophyllum inophyllum L.) with catalyst weight variations of 1%, 3% and 5%. The tested droplet volume of 1 ml was placed in a type K thermocouple. The results of this study showed that the percentage of catalyst weight increased temperature and shortened ignition delay. The highest temperature and lowest ignition delay were found at a variation of 5% with the highest temperature of 679.5 °C and ignition delay of 3000 ms.

How to Cite:

Sukma, K. W, & et al. (2025). Combustion Characteristics of Biodiesel Droplets from Nyamplung Seeds with Eggshell Catalyst Using PLX-DAQ Software. Jurnal Teknologi Informasi Dan Pendidikan, 18(1), 773-781. https://doi.org/10.24036/jtip.v18i1.829

1. INTRODUCTION

Biofuel is one of the alternative energy fuel sources that has great potential to be implemented considering that the potential resources available are very abundant (Directorate General of New, Renewable Energy and Energy Conservation [9]. One way to minimize dependence on fossil fuels is by developing Vegetable Fuels (BBN) or often called biofuels [6]. Biofuel consists of biodiesel, bioethanol and pure vegetable oil Directorate

General of New, Renewable Energy and Energy Conservation [9].

The raw material for making bodysel which has the potential to produce high biodiesel yields is nyamplung fruit (Calophyllum inophyllum L.). The potential of nyamplung (Calophylum Inophyllum L.) as a raw material for making biodiesel is very large because it contains high oil content of around 40-73%. Nyamplung and produces oil (biofuel) whose octane content is quite high.

Biodiesel is a mono alkyl ester of long chain fatty acids containing 12 - 24 carbon atoms which is made from renewable lipid/fat sources, such as vegetable oils and animal fats through a transesterfication process [12]. The transetrication process requires a catalyst which aims to reduce the viscosity and increase the burning power of the oil, so that it can meet the requirements for alternative fuels [15]. A catalyst is a material that can increase process efficiency. The catalysts most often used in making biodiesel are homogeneous base catalysts such as NaOH and KOH [1]. The use of homogeneous base catalysts can become waste that pollutes the environment. . This can be overcome by using a heterogeneous catalyst, an example of a heterogeneous catalyst is CaO. The CaO catalyst can be obtained through the CaCO3 calcination process [16]

The droplet combustion method aims to determine the combustion characteristics of biodiesel [8]. Previous research from Winarko only examined the droplet characteristics of raw nyamplung oil, and it had not yet been processed into biodiesel [20]. This research discusses the characteristics of premix combustion flames. The focus of this research is to determine the differences in flame visualization which are influenced by the weight percentage of the catalyst.

2. RESEARCH METHOD

The method used in this research is a real experiment where the researcher directly knows the results of the experiment, namely the characteristic values in the form of biodiesel fuel characteristics (without and with catalyst) and the combustion characteristics, namely ignition delay, flame temperature, and flame visualization of oil-based biodiesel [17]. The seeds are mixed with an eggshell catalyst [3].

Research will begin in February-October 2023 at the Energy Conversion Laboratory, Department of Mechanical Engineering, University of Jember.

This research used nyamplung oil (Calophylum Inophyllum L.) which was added with 1% calcium oxide (CaO) heterogeneous catalyst. 3% and 5% of the oil volume. The combustion characteristics include flame visualization stability, ignition delay, and temperature [4].

1 ml of biodiesel oil was dripped into a type K thermocouple placed on a ±10 cm 300 watt heater, with a current of 5 A and connected to a data logger connected to a laptop. The data logger is useful for recording droplet temperatures starting when the heater is turned

on until the flame goes out [2]. The camera was turned on and recorded the fire at the same time the heater was turned on. Figure 1 shows the research installation.

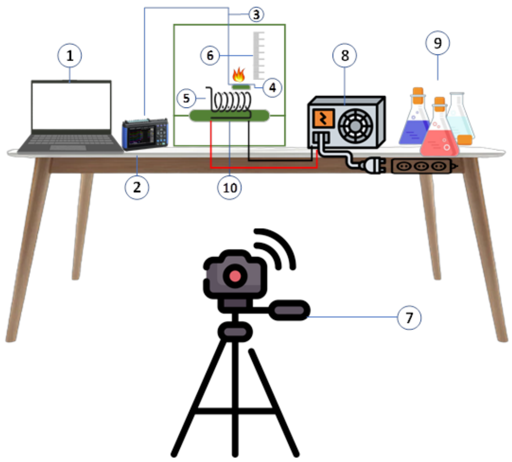


Figure 1. Experimental tools

Information:

1. Laptops
2. Data Logger
3. Thermocouple
4. Thermocouple junction
5. Coil Heater
6. Measuring Scale
7. Camera
8. Power Supply
9. Fuel
10. Coil Heater Support*r*

3. RESULTS AND DISCUSSION

3.1 Biodiesel physical and chemical properties data

Before obtaining research data, fuel properties data are required which are displayed in Table 1.

Table 1. Physical properties of nyamplung oil

Nyamplung Oil Test Parameters	unit	SNI	Test Value
Densitas / density (ϱ)	kg/ m³ (40°C)	840-890	932
Free Fatty Acids (FFA)	%	2%	7,55
Acid Number	mgKOH/g	4	14,2868

Table 2. Physical properties of Nyamplung oil biodiesel

Parameter	Biodiesel Standards	Nyamplung Seed Oil Biodiesel		
		1%	3%	5%
Density (kg/m^3)	840-890	911	886	876
Viskositas (cSt)	2,3-6,0	8,266	7,834	7,1617
Acid Number (mgNaOh/g)	Maks 0,5	3,5904	3,4782	3,366
Free Fatty Acids (%)	Maks 2	1,897	1,83	1,779
Flash point	Min. 40	514	300	275,5

Seen from table 1 and table 2 in the nyamplung oil test, the oil density is still above SNI, namely 932 kg/m3, but after the transesterification reaction the biodiesel density can be reduced to 911 kg/m3 at a 1% variation, then 886 kg/m3 at a 3% variation and the lowest was 876 kg/m3 with a variation of 5%. This test proves that the catalyst can reduce the density. And variations that meet SNI are variations of 3% and 5%.

The viscosity in this test with a 1% variation in viscosity was 8.266 cSt, a 3% variation in viscosity was 7.834 cSt and a 5% variation in viscosity was 7.1617. This is because the catalyst is able to bind free fatty acids. The less catalyst, the less fatty acids are bound [5]. The use of a CaO catalyst has been proven to reduce viscosity.

The acid number and free fatty acids in nyamplung oil are still relatively high, namely 7.55% and the acid number is 14.2868 mgNaOH/g, while the SNI for FFA is <2% and the acid number is 4 mgNaOH/g. Free fatty acids are derived using the help of an acid catalyst, namely H_2SO_4 in the esterification process and a CaO base catalyst in the tranesterification [13] process, which produces data for a variation of 1% FFA 1.897% and an acid number of 3.5904 mgNaOH/g, for a variation of 3% FFA 1.83 % and acid number 3.4782 mgNaOH/g, and with a variation of 5% FFA 1.779% and 3.366 mgNaOH/g.

The flash point or flash point in this test, the flash point at 1% variation is 514℃ at 8000 ms, the flash point at 3% variation is 300℃ at 6600 ms and the flash point at 5% variation is 275.5℃ at 3200 ms. This shows that the use of a catalyst can speed up the reaction. It can be seen that the 5% variation can produce a flame at a temperature of 275.5℃ with a time of 3200 ms, while with the 1% variation the flame is only produced at a temperature of 514℃ and with a long time of 8000 ms [14].

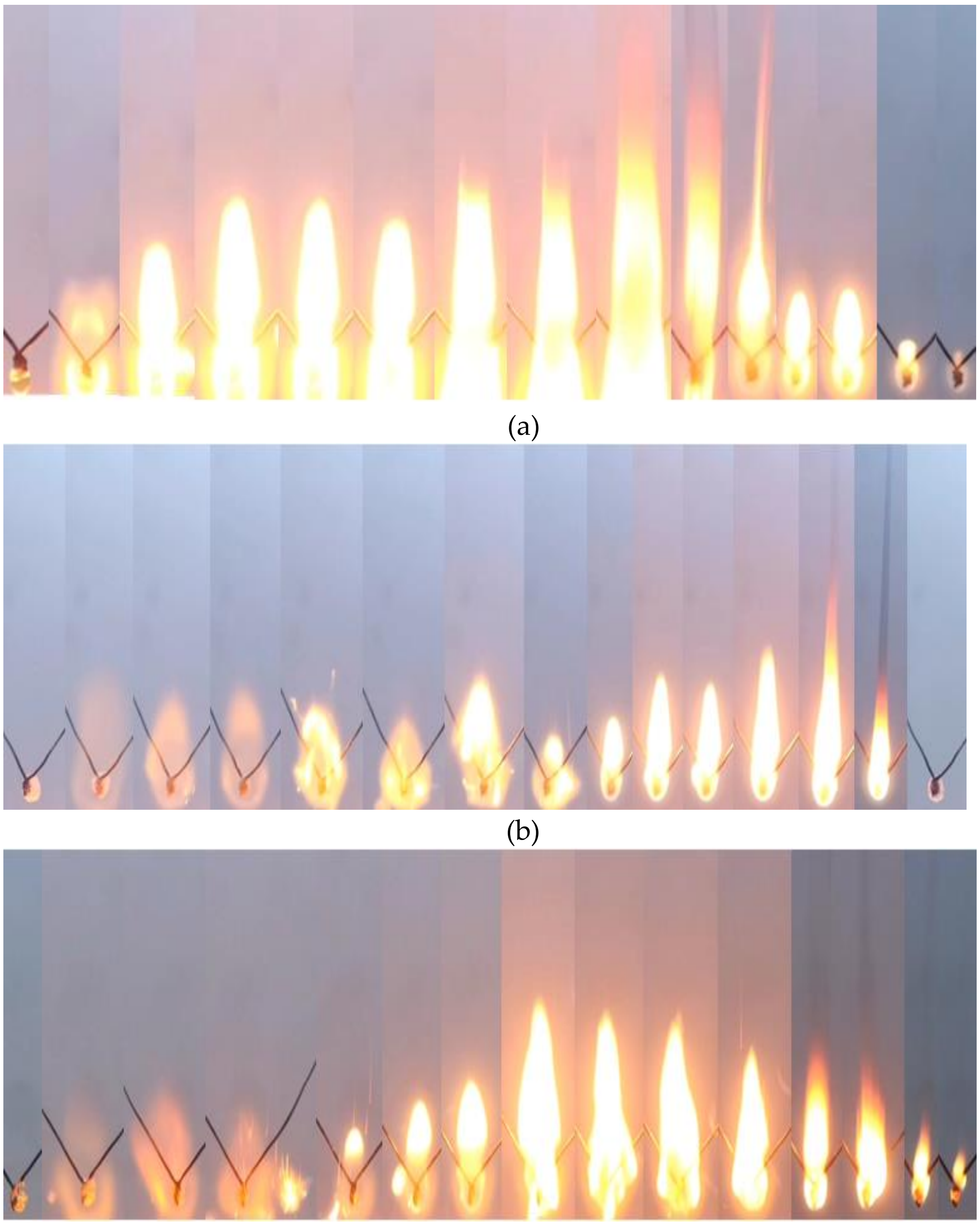
3.2 Flame Visualization

Seen from Figure 2, the weight of the catalyst in biodiesel can influence the stability of the flame. Micro explosions at 5% catalyst weight were seen to be more numerous than 1% and 3% catalyst weights. And the flame with a 5% catalyst weight is longer, namely 3800 ms, while the 1% catalyst has a stable flame and a short flame life, namely 800 ms. And a 3% catalyst has a flame life of 1800 ms [6].

It can be observed that the rapid combustion process can make the resulting flame height smaller. This is because the length of the flame is inversely proportional to molecular

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
tip.ppj.unp.ac.id

diffusivity [19]. The higher the catalyst variation, the higher the combustion rate [7]. The more the burning rate increases, the shorter the flame produced, such as the 5% variation.



(a)

(b)

(c)

Figure 2. Flame stability in biodiesel oil containing variations in catalyst weight, (a) Catalyst 1% (b) Catalyst 3% (c) Catalyst 5%

3.3 Ignition delay time

Figure 3 shows that the ignition delay produced by each variation in catalyst weight is different and very significant. Egg shell catalyst can speed up the combustion reaction and can reduce ignition delay time. From the data obtained, the lowest ignition delay is on the 5% catalyst variation, namely 3000 ms and the longest is on the 1% catalyst, namely 8000 ms. The resulting ignition delay value shows that the catalyst is 5% more effective in reducing ignition delay time [8]. Ignition delay is proportional to flash point, the faster the ignition delay, the lower the flash point. Like the 5% catalyst which has a flash point of 275.5°C and an ignition delay of 3000 ms. Meanwhile, the 1% variation has a high flash point, namely 550.25°C and has an ignition delay of 8000 ms..

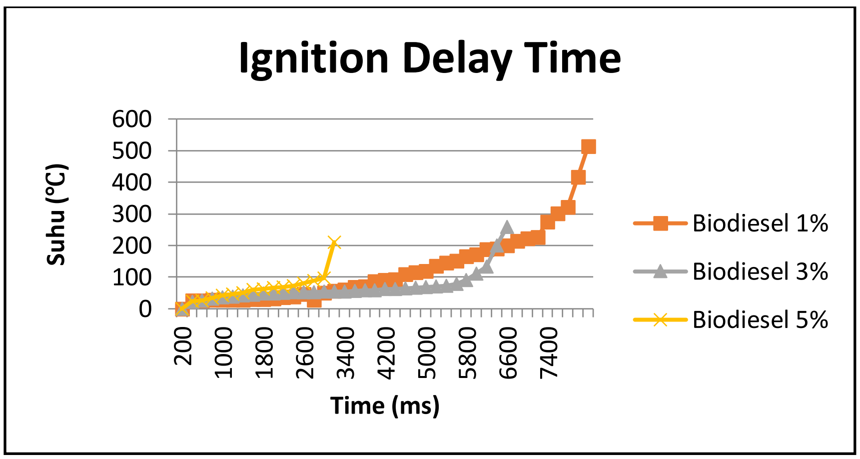


Figure 3. Ignition Delay Time

3.4 Flame Temperature

Seen in Figure 4, it shows that the 5% variation has the highest maximum temperature value compared to the others, namely 679.5 °C, while the lowest maximum fire temperature value is 1% variation with a temperature of 550.25 °C. The higher the catalyst percentage, the higher the flame temperature. The effect of a catalyst is that it can change saturated fatty acids into unsaturated fatty acids [11]. Biodiesel with unsaturated fatty acid content has a higher temperature, such as the 5% variation compared to the 1% variation which has saturated fatty acids.

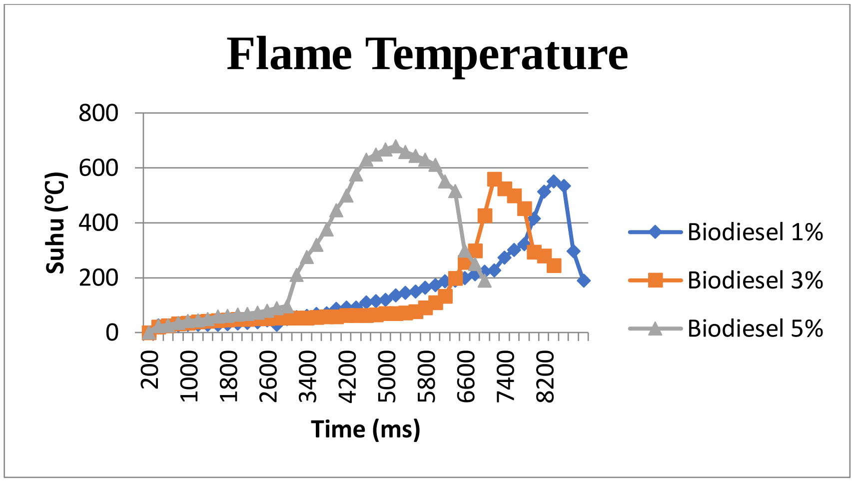


Figure 4. Flame Temperature

3.5 Flame Height

Shown in Figure 4. The highest flame occurs with a 1% variation, namely 4.24 cm, then a 5% variation, namely 4.09 cm, and a 3% variation produces the shortest flame, namely 3.37 cm. This can occur due to the density of the biodiesel produced. The higher the density, the more difficult it will be for air to penetrate the fuel layer, which will slow down the combustion reaction [12].

Apart from that, the difference in flame height is caused by the free fatty acid content. In the 1% variation the flash point is 550.25°C while in the 5% variation the flash point is 275.5°C. A high fatty acid content will speed up the life of the flame and inhibit the rate of flame propagation, so that the resulting flame is small [18].

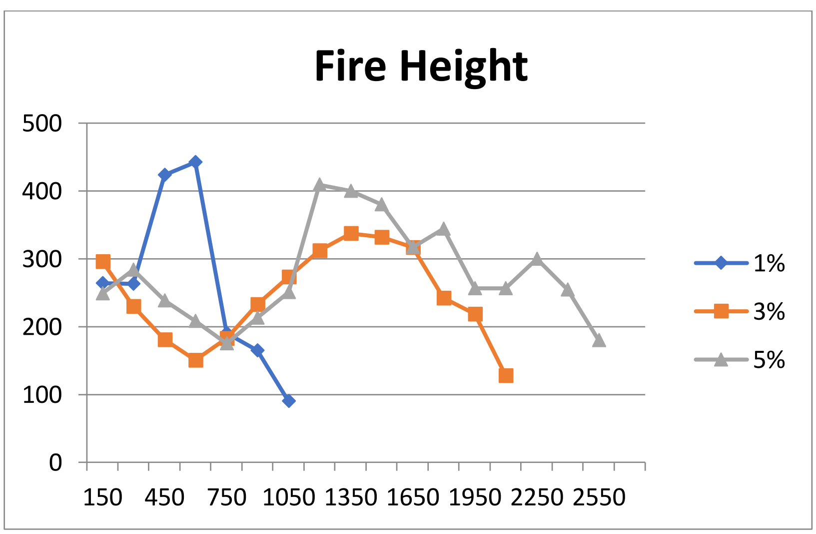


Figure 5. Flame Height Chart

4. CONCLUSION

Research has been carried out on the droplet combustion characteristics of biodiesel oil with varying eggshell catalyst weights. The eggshell catalyst plays a role in improving the transesterification reaction and combustion quality. This effect can be seen in the 5% variation of the catalyst variation which produces the highest temperature, namely 679.5 °C, the shortest ignition delay time, namely 3000 ms, and the lowest flash point, namely 275.5 °C.

REFERENCES

[1] Anwaristiawan, D., Harjito, & Widiarti, N. (2018). Modifikasi Katalis BaO/Zeolit Y pada Reaksi Transesterifikasi Minyak Biji Jarak (Jatropha Curcas L.) Menjadi Biodiesel. Indonesian Journal of Chemical Science, 7(3), 292-298.

[2] Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi (EBTKE), 2019, Inovasi Produksi Biodiesel Berbasis Tanaman Jarak Pagar.

[3] Gormantara, A., & Elisabeth. (2022). Evalutation of the Success of the Academic Information System (SIAMIK) with the DeLone and McLean Model. Jurnal Teknologi Informasi dan Pendidikan. Vol. 15, No. 2

[4] Handayani, P. A., Wulansarie, R., Husaen, P., & Ulfayanti, M. I. (2018). Esterification of Nyamplung (Calophyllum Inophyllum) Oil with Liquid Catalyst of BMIMHSO4 adn Microwave-Assisted. Jurnal Bahan Alam dan Terbarukan, 7, 59-63.

[5] Hasibuan, S., Sahirman, & Yudawati NMA. (2013). Karakteristik Fisiokimia dan Antibakteri Hasil Purifikasi Minyak Biji Nyamplung (Calophyllum Inophyllum L.). Agritech, 33(3), 311-319.

[6] Howarth R.W., and Stefan Bringezu (2009), Biofuels: Enviromental Consequences and Interactions with Changing Land Use, SCOPE Rapid Assessment, New York, Cornell Ithaca

[7] (P3HH), P. P. (2005-2008). Penelitian Pembuatan Biodiesel dari Biji Nyamplung (Calophyllum Inophyllum Linn). Retrieved from http://www.litbang.pertanian.go.id/

[8] Hoxie, A., Schoo, R., & Braden, J. (2014). Microexplosive combustion behavior of blended soybean oil and butanol droplets. Fuel, 120. https://doi.org/10.1016/j.fuel.2013.11.036

[9] Naveenkumar, R., & Baskar, G. (2019). Biodiesel Production from Calophyllum inophyllum Oil Using Zinc Doped Calcium Oxide (Plaster of Paris) Nanocatalyst. Bioresource Technology, 280, 493-496.

[10] Nasution, I.H., Helmiah, F., & Sudarmin. (2022). Dseign of Internet E-CRM System on CV. AHyein Pratama Mandiri Air Joman. Jurnal Teknologi Informasi dan Pendidikan.

[11] Nurhidayanti, N. (2018, Desember). Studi Reaksi Pembuatan Biodiesel dari Minyak Nyamplung Menggunakan Iradiasi Microwave. Jurnal Tekno Insentif, 12, 1-12.

[12] Ma, F., and Hanna, M.A., 1999, Biodiesel Production: a Review, Bioresource Technology, 70(1), 1-15.

[13] Maharrani, R.H., Supriyono A.R., Syarifullah L., & Purwanto R. (2022). Usability Test for The User Centered Design-Based Industrial Internship Management System. *Jurnal Teknologi Informasi dan Pendidikan*. Vol. 15, No. 2.

[14] Musta, R., Haetami, A., & Salmawati, M. (2017). Biodiesel of The Transesterification Product of Calophyllum Inophyllum Seed Oil From Kendari Using Methanol Solution. 4(2), 394-401.
[15] Susilo, Bambang, 2006, "Biodiesel; Pemanfaatan Biji Jarak Pagar Seabagi Alternatif Bahan Bakar", Trubus Agrisarana, Surabaya
[16] Stadelman, W.J., 2000, Eggs and egg product. In: Francis, F.J. (Ed.), Encyclopedia of Food Science and Technology, 2nd ed., John Wiley and sons, New York, 593-599
[17] Trisnaliani, L., Fatria, & Sari, I. M. (2018). Proses Produksi Biodiesel dari Minyak Jelantah Menggunakan Microwave Hydro Distillation dan Separasi Tegangan Tinggi. 9, 25-30.
[18] Veronica, S., Putri, R. H., Fitriani, F., Ramadhan, M. L., Riki, M., Reynaldo, S., Imran, F. A., & Nugroho, Y. S. (2017). Effect of density on forward and upward smoldering combustion of cellulosic material. AIP Conference Proceedings, 1826. https://doi.org/10.1063/1.4979249
[19] Wardana, I.N.G. (2008). Bahan Bakar dan Teknologi Pembakaran. Malang: PT. Danar Wijaya-Brawijaya University Press
[20] Winarko, W.A., Ilminnafik, N., Kustanto, M. N., & Perdana, D. (2022). Peran Orientasi Medan Magnet Pada Karakteristik Nyala Api.