Silver nanoparticles (NPAg) using *padina australis* seaweed

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Abstract. The synthesis of silver nanoparticles (NPAg) using Padina australis seaweed as a bioreductor and $AgNO_3$ as a precursor through the green synthesis method was successfully achieved. This environmentally friendly approach utilized various concentrations of the seaweed extract and silver nitrate precursor, resulting in the formation of silver nanoparticles at each concentration variation. The stability of these nanoparticles was confirmed by the observable changes in solution color, maximum wavelength, absorbance, and peak length shift. The process exhibited consistent results, with minimal wavelength variation occurring within 1 to 6 hours, particularly at a concentration ratio of 3 mM and 5:10 mL extract to precursor. These findings demonstrate the potential of Padina australis seaweed in the sustainable production of silver nanoparticles, offering a green alternative for nanoparticle synthesis.

1 Introduction

Nanotechnology is an important part in the current latest research field. Nanotechnology is defined as material design technology with nanometer dimensions. Nanotechnology includes more than just creating nanometer-sized materials or particles, but also about creating and understanding new properties that arise from processed nanomaterials [1–3]. Nano-medicine, nanoemulsions and nanoparticles are a number of nanotechnology developments that are increasing rapidly [4,5]. Particles that have a size of 1-100 nm are nanoparticles. Silver nanoparticles have antibacterial properties and are therefore often used in various household and health product applications [6,7].

According to [8,9], in general the silver nanoparticles used are antibacterial. Silver nanoparticles have many uses in daily activities, which is why they have been widely researched [10,11]. Several methods for synthesizing silver nanoparticles that can be used are chemical, biological and physical methods. Although chemical and physical methods obtain pure particles, these methods require a lot of costs and have the potential to pollute the environment [12,13]. Synthesis of silver nanoparticles from plant can reduce excessive use of chemicals which cause environmental pollution [14–16].

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According to Nilavukkarasi et al., (2020) plant extracts used in synthesis of silver nanoparticles can act as bioreductors to obtain silver nanoparticles, which is an economical, easy, stable and nature-friendly synthesis technique. Examples of the synthesis of silver nanoparticles that have been carried out from plant extracts, both extracellularly and intracellularly, are extracts of M balbisiana (banana), A. indica (neem) and O. Tenuiflorum (black tulsi) [16] and leaf extracts. Capparis zeylancia L. [17]. According to Susanti et al., (2021), using natural materials as natural reducing agents obtained through natural materials that store plant substances, for example antioxidants which can reduce silver, is called the green synthesis method.

Seaweed is used for medicine, beauty, compost, raw material for the food industry, animal feed, and can also be used as raw material for textiles [19]. The Riau Islands Province, the majority of which consists of 96% of water, is known for its abundant and diverse marine resources in its waters [20]. Seaweed is an example of the best commodity that is spread in almost all Indonesian waters as an export commodity that has the potential to be developed. Currently, national seaweed production has increased significantly [21].

According to Nursid et al., (2016) Padina australis seaweed is found on almost all rocky beaches in Indonesian waters. Padina australis is a group of seaweed from the Phaeophyta division (brown seaweed) which is usually found in the ocean, both deep and shallow seas. This seaweed is characterized by filaments or wide sheets that are transparent and brown. Biologically, seaweed is classified as a benthic organism which is usually large in size, attached to dead shells and lives in shallow waters (Kemenangan et al., 2017). Based on research by (Maharany et al., 2017) , the composition of padina australis seaweed has 1.05% protein, 87.25% water content, 8.78% carbohydrates, 0.58% fat and 2.34% ash. Apart from that, padina australis contains tannins and saponins.

Thus, the aim of this research is determine the synthesis process of silver nanoparticles (NPAg) via the green synthesis route using the alga Padina australis and determine the appropriate concentration of extract and precursor to produce stable silver nanoparticles.

2 Research Methods

This type of research is experimental research using the green synthesis method, namely a research approach to examine the effect of synthesizing silver nanoparticles using padina australis seaweed.

The sample used was padina australis seaweed (brown seaweed) taken in the sea of Sarang's eye cat, Senggarang, Tanjungpinang city, Riau Islands. Samples were obtained using a non-probability sampling method where brown seaweed from the Riau Islands was taken randomly from a population of brown seaweed Padina australis in the amount of 1 5 kg plastic with a wet weight of ± 5 kg.

Tools and materials used include: analytical scales, spatulas, watch glasses, chemical flask, funnel, dropper pipette, heating plate with magnetic stirrer, filter cloth, filter paper, filling pipette, Flacon, Volumetrik flask, UV-Vis spectrophotometer, oven, padina australis powder, distilled water and $AgNO_3$.

2.1 Preparation of padina australis seaweed extract

Padina australis seaweed is washed using running water to remove salt and dirt that is still attached, then aired to dry without direct exposure to the sun, which is intended to avoid damage to the active compound Padina australis is susceptible to heat and to avoid contamination from dust. Padina australis which has been dried for 10 days is then put in the oven using a temperature of 50 °C for 20 minutes so that there are no bacteria and fungi

that might be present during drying and then ground using a blender until it becomes powder and placed in a jar.

2.2 Preparation of the Padina Australis solution

The ground padina autralis powder was then weighed using an analytical balance in the amount of 20 grams using a beaker and add 200 mL of distilled water and stirred for 1 hour, then the stirred solution was put into filter cloth and filter paper gradually with the help of funnel, then cover the solution using aluminum foil, this step is carried out 4 times in a row.

2.3 Preparation of $AgNO_3$ solution

Make an $AgNO_3$ solution with concentrations of 1, 3, and 5 mM by weighing 0.017 g, 0.051 g, and 0.085 g of $AgNO_3$ granules using an analytical balance, then add them to a chemical glass and add 100 mL of distilled water to each, stir using a spatula, then Put it in a 100 mL measuring flask and cover with aluminum foil.

2.4 Preparation of green synthesis silver nanoparticles using padina australis seaweed

Green synthesis silver nanoparticles were made by mixing padina australis solution with 1 mM, 3 mM and 5 mM $AgNO_3$ solutions with their respective comparisons of 5:5 (mL/mL) and 5:10 (mL/mL), respectively. Next, the mixture was heated on a Magnetic Stirer Hotplate using time variations of 1, 2, 3, 4, 5 and 6 hours. A UV-Vis spectrophotometer is used to measure absorbance and the wavelength range is 280-700 nm.

3 Results and Discussion

From the research that has been carried out using the synthesis process using the green synthesis method, it has been successfully carried out by paying attention to:

1. Color

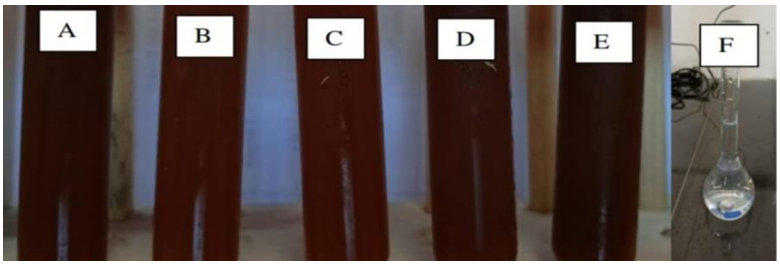

Fig. 1. Differences in Solution Color A) 5 mM 5:10 B) 5 mM 5:5 C) 3 mM 5:5 D) 3 mM 5:10 E) Padina Australis F) $AgNO_3$

Based on Ficture 1, it can be seen that the color change from the padina australis seaweed solution was initially dark brown to light brown and reddish. This is in line with research by Prasetiowati et al., (2018) which states that color changes are a visual indicator of the formation of silver nanoparticles. This color change process is related to the process of nanoparticles formation [12,25]. Haryani et al., (2016) stated that color change indicated the formation of nanoparticles, color changes in the formation of silver nanoparticles occur due to the redox process. Secondary metabolites in the extract are able to reduce Ag+ ions to Ag^0, producing silver nanoparticles which can be seen from the color change. These secondary metabolites, such as terpenoids, flavonoids, biomolecules and phenolics which have amide functional groups, carboxylic acids and aldehydes, are compounds that react to convert Ag+ into Ag^0.

Thus, the change in the color of Padina australis seaweed, which was originally dark brown to light reddish brown, is due to the content of active compounds such as alkaloids,

tannins, triterniods and saponins. The presence of these compounds shows that Padina australis has potential as an antibacterial because it can act as a natural bioreductor (Maharany et al., 2017).

2. Wavelength

Wavelength measurements utilize a UV-Vis spectrophotometer with a wave range of 280-700 nm.

Table 1. UV-Vis Spectrophotometer Measurement Results

Time	Concentration							
	3 mM				5 mM			
	Variation				Variation			
	5:5		5:10		5:5		5:10	
	λ (nm)	abs	λ (nm)	abs	λ (nm)	abs	λ (nm)	abs
1	422	0.567	432	0.214	409	0.272	227	4.000
2	433	0.702	432	0.423	424	0.574	223	4.000
3	435	0.819	433	0.588	432	0.671	232	4.000
4	439	0.859	438	0.673	439	0.681	336	3.960
5	443	0.941	439	0.786	336	3.960	253	3.806
6	434	1.403	446	0.938	412	0.920	297	2.544

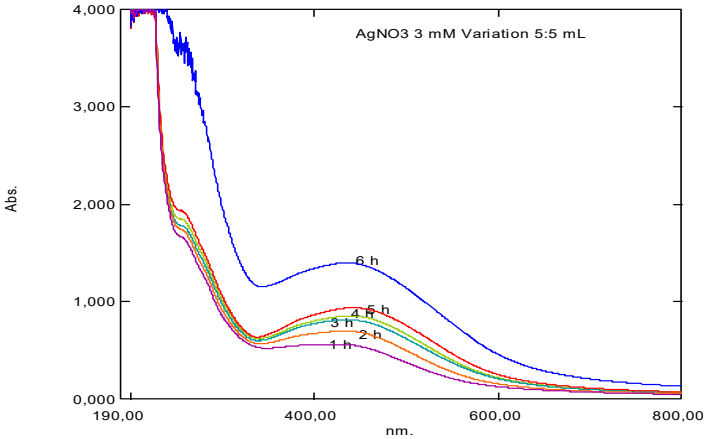

Fig. 2. Graph 3 mM 5:5 mL

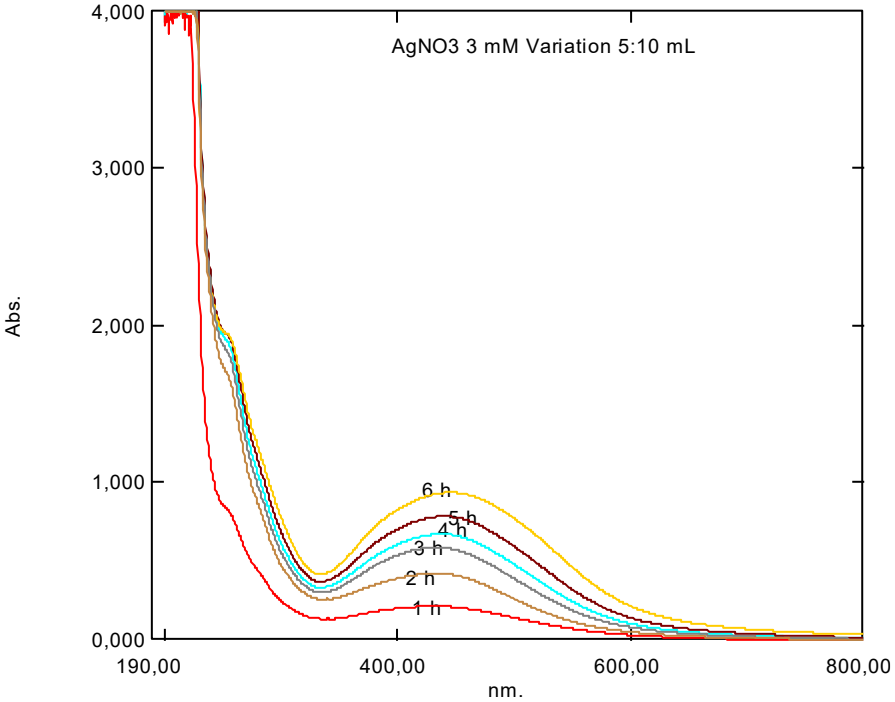

Fig. 3. Graph 3 mM 5:10 mL

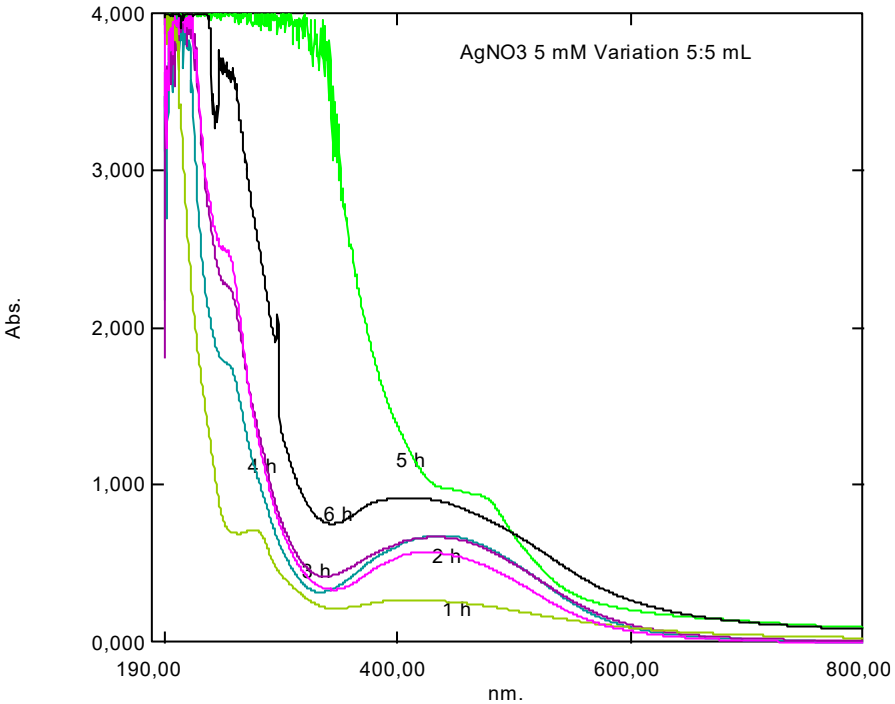

Fig. 4. Graph 5 mM 5:5 mL

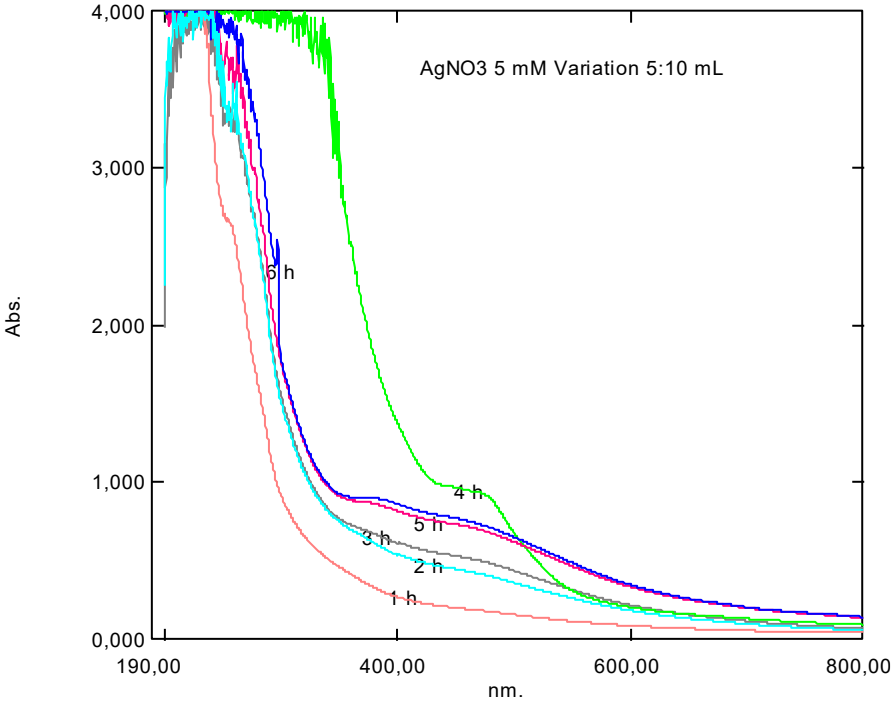

Fig. 5. Graph 5 mM 5:10 mL

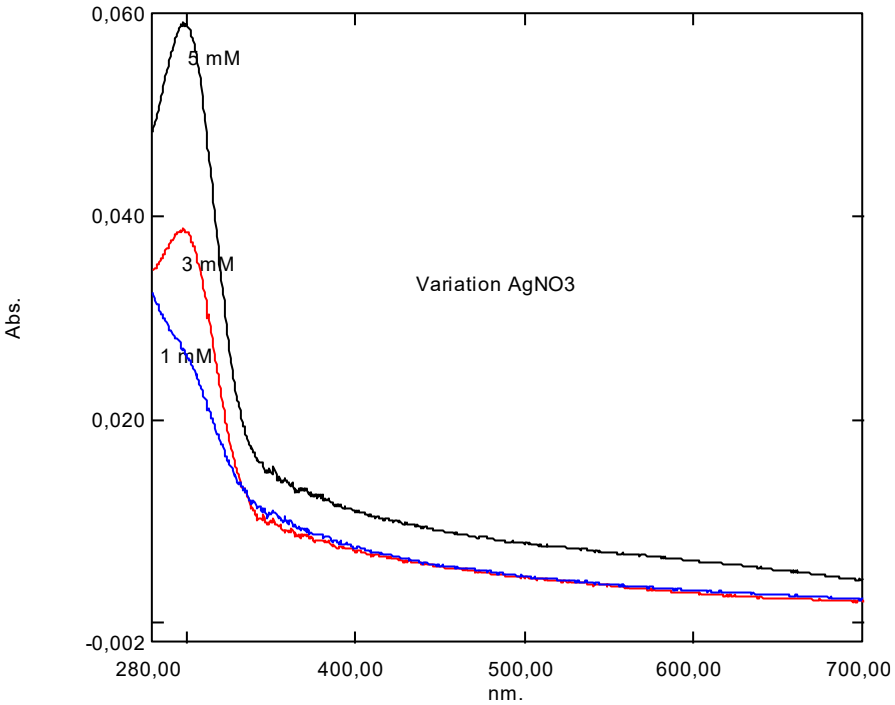

Fig. 6. Graph $AgNO_3$

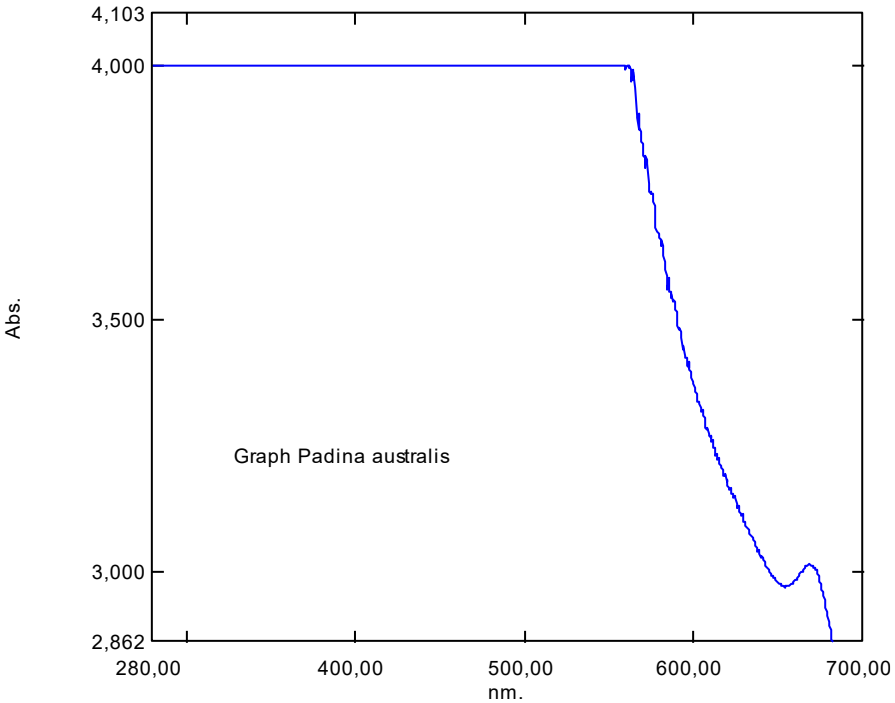

Fig. 7. Graph Padina Australis

Based on Table 1, the maximum wavelength variation in this study ranges from 412-446 nm, and shows the formation of silver nanoparticles at several measured times. The location of the wave peak is influenced by the shape and size of the particle. maximum absorption peak of nanoparticles with precursor concentration 1, 3, and 5 mM with variations of 5:5 (mL/mL) and 5:10 (mL/mL) is at a wavelength of 434.00 nm, 446.00 respectively. nm, 412.00 nm, and 336.00 nm in Ficture 2, 3, 4, and 5 while the 1 mM variation was not continued for synthesis because 1 mM $AgNO_3$ did not have the wave peak shown in Ficture 6. Nanoparticles with a concentration of 3 mM were higher. stable compared to concentrations of 1 and 5 mM shown in Table 1. Nanoparticle uptake is unstable due to the faster agglomeration which is influenced by the large concentration (Willian et al., 2020).

3. Absorbance

Absorbance is the ratio of the intensity of the absorbed light to the intensity of the incoming light. The absorbance value depends on the substance content in it. The higher the substance content in the sample, the more molecules that will absorb light in a certain wave range, resulting in a higher absorbance amount. This means that the absorbance value is the same as the concentration of the substance in the sample (Yanlinastuti and Fatimah 2016).

Absorbance measurements in this study used a UV-Vis spectrophotometer to measure in the 280-700 nm wave range. Synthesis with a stirrer was observed every 1 hour for 6 hours. The absorbance results using padina australis seaweed as a bioreductant and $AgNO_3$ as a precursor with variations of 3 mM and 5 mM with a solution ratio of 5:5 (mL/mL) and 5:10 (mL/mL) respectively, obtained a maximum absorbance of 4,000 is shown in Table 1. The longer the reaction time, the absorbance increases until the reaction process stops, that is, when there is no further increase in absorbance (Purnomo et al., 2017).

Variations in precursor and extract concentrations are stable, as seen from the shift in wavelength which is not too significant at 1-6 hours $AgNO_3$ 3 mM variation of 5:10 mL. shown in Ficture 3. This indicates that the silver nanoparticles formed are relatively stable

(Taba et al., 2019). According to Willian et al., (2020) agglomeration occurs more quickly due to the high concentration of $AgNO_3$ which causes nanoparticle uptake to decrease. The higher the $AgNO_3$ concentration, the greater the reduction and the greater the number of silver nanoparticles formed. However, excessive $AgNO_3$ solution results in lower absorption (Willian et al., 2023). Therefore, variations in $AgNO_3$ concentration of 3 mM are more stable than concentrations of 1 and 5 mM.

According to Tapa et al., (2016) the silver nanoparticles obtained tend to be stable if the wavelength obtained during the synthesis of silver nanoparticles does not show significant changes over time. According to Zakir et al., (2016) Stable silver nanoparticles are observed from consistent color changes from light yellow to brownish yellow during the development process without the formation of precipitates due to material clumping, as well as the instability of silver nanoparticles can be seen in the color from initially light yellow to moss green. accompanied by sediment at the bottom of the storage area. This is in accordance with the researchers' synthesis results, which initially turned dark brown into light brown and reddish.

4 Conclusion

The use of padina australis seaweed as a bioreductor and $AgNO_3$ as a precursor using the green synthesis route was successfully carried out, indicated by the formation of silver nanoparticles at each concentration variation and stable concentration variations of the extract and precursor can be seen from changes in solution color, maximum wavelength, absorbance and peak length shift. not very significant waves from 1-6 hours 3 mM variation 5:10 mL.

References

1. 1. Y. Rilda, K. Khairu Ummah, U. Septiani, S. Syukri, A. Agustien, H. Pardi, and N. Sofyan, Mater. Sci. Eng. B **298**, 116910 (2023)
2. H. A. Ariyanta, MKMI 36 (2014)
3. Y. Rilda, A. Meranti, Y. Citra, R. Refinel, Y. E. Putri, A. Agustien, and H. Pardi, Mater. Res. Innov. (2020)
4. Y. Rilda, D. Dwiyanti, S. Syukri, A. Agustien, and H. Pardi, J. Dispers. Sci. Technol. **42**, 784 (2021)
5. G. A. Duncan and M. A. Bevan, Nanoscale **7**, 1 (2015)
6. Y. Rilda, P. V. P. Ayuni, I. S. Tursiah, S. Syukri, Refinel, Y. E. Putri, A. Agustien, and H. Pardi, Rasayan J. Chem. **14**, 1028 (2021)
7. V. A. Fabiani, F. Sutanti, D. Silvia, and M. A. Putri, Pure Appliied Chem. **1**, 68 (2018)
8. Y. Rilda, P. V. P. Ayuni, R. Refinel, A. Armaini, A. Agustien, A. Almurdi, and H. Pardi, Rasayan J. Chem. **15**, 402 (2022)
9. I. Fadillah, Ris. Farm. **1**, 141 (2021)
10. Y. Rilda, R. Rinaldi, S. Syukri, A. Armaini, R. Refinel, A. Agustien, and H. Pardi, ChemistrySelect **7**, 1 (2022)
11. I. N. Oktavia and S. Sutoyo, Chemistry (Easton). **10**, 37 (2021)
12. N. Willian, H. Pardi, and S. Arief, Rasayan J. Chem. **15**, 2570 (2022)
13. D. M. Rahim, N. Herawati, and Hasri, Chemica **21**, 30 (2020)
14. Y. Rilda, F. Puspita, R. Refinel, A. Armaini, A. Agustien, H. Pardi, and N. Sofyan, South African J. Chem. Eng. **47**, 91 (2024)
15. Y. Rilda, A. Valeri, S. Syukri, A. Agustien, H. Pardi, and N. Sofyan, South African J. Chem. Eng. **45**, 10 (2023)
16. A. N. Nalawati, N. E. Suyatma, and D. I. Wrdhana, Teknol. Dan Ind. Pangan **32**, 98

(2021)
17. M. Nilavukkarasi, S. Vijayakumar, and S. P. Kumar, Mater. Sci. Energy Technol. **3**, 371 (2020)
18. Susanti, F. Ramadhani, M. Soraya, and F. Afriani, Semin. Nas. Penelit. Dan Pengabdi. Pada Masy. 2021 174 (2021)
19. N. Riska, S. W. A. Suedy, and M. Izzati, Pro-Life **6**, 171 (2019)
20. F. Alfayed, O. Adhayanto, and N. Winarti, Pendidikan, Sos. Dan Hum. **3**, 124 (2023)
21. F. Maharany, Nurjanah, R. Suwandi, E. Anwar, and T. Hidayat, JPHPI **20**, 10 (2017)
22. M. Nursid, E. Marraskuranto, K. B. Atmojo, T. M. P. Hartono, M. D. N. Meinita, and Riyanti, Squalen Bull. Mar. Fish. Postharvest Biotechnol. **11**, 59 (2016)
23. F. R. Kemenangan, G. D. Manu, and F. B. Manginsela, Ilm. Platax **5**, 243 (2017)
24. A. L. Prasetiowati, A. T. Prasetya, and S. Wardani, Indones. J. Chem. Sci. **7**, 160 (2018)
25. N. Willian, S. Syukri, Z. Zulhadjri, and S. Arief, F1000Research **10**, 768 (2021)
26. Y. Haryani, G. F. Kartika, Yuharmen, E. M. Putri, D. T. Alchalish, and Y. Melanie, Chim. Nat. Acta **4**, 151 (2016)
27. N. Willian, Syukri, Zulhadjri, A. Labanni, and S. Arief, Rasayan J. Chem. **13**, 1478 (2020)
28. Yanlinastuti and S. Fatimah, Pus. Tenologi Bahan Bakar Nukl. 22 (2016)
29. S. R. Purnomo, N. N. Sumadiyasa, and M. Sumadiyasa, Bul. Fis. **18**, 6 (2017)
30. P. Taba, N. Y. Parmitha, and S. Kasim, Indo. J. Chem. Res **7**, 51 (2019)
31. N. Willian, Syukri, Zulhadjri, A. Laban, and S. Arief, Rasayan J. Chem. **13**, 1478 (2020)
32. N. Willian, S. Syukri, Z. Zulhadjri, H. Pardi, and S. Arief, F1000 Res. **10**, 1 (2023)
33. F. La Tapa, E. Suryanto, and L. I. Momuat, Chem Prog **9**, 8 (2016)
34. M. Zakir, I. R, and P. Budi, Indo. J. Chem. Res **4**, 356 (2016)