Green Synthesis and Characterization of Gold Nanoparticles Using Dayak Onion (Eleuthrine bulbosa) Extract

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Abstract. The green synthesis of gold nanoparticles (AuNPs) was achieved by introducing Dayak onion extract to a hydrogen tetrachloroaurate ($HAuCl_4$) solution under controlled conditions. To optimize the synthesis process, various parameters were examined, including the volume of $HAuCl_4$, synthesis duration, and concentrations of both Dayak onion extract and $HAuCl_4$, in order to identify the most favorable conditions for nanoparticle formation. The optimization results revealed that the ideal reaction time and $HAuCl_4$ volume were 5 minutes and 8 mL, respectively. Furthermore, the optimal concentrations of $HAuCl_4$ and Dayak onion extract were determined to be 300 ppm and 2000 ppm, respectively. The synthesized AuNPs exhibited a spherical morphology, with an average diameter of 14.37 ± 3.67 nm.

Keywords: Green synthesis, gold nanoparticles (AuNPs), dayak onion extract.

1 Introduction

The synthesis of nanoparticles has gained significant attention due to their diverse applications in various fields, including medicine, electronics, catalysis, and environmental science. Among these, gold nanoparticles (AuNPs) are of particular interest due to their unique physical and chemical properties, such as their optical, electronic, and catalytic activities, which make them valuable in diagnostics, drug delivery, and biomedical applications [1]. Traditionally, the synthesis of AuNPs involves the use of toxic chemicals and harsh environmental conditions, raising concerns about environmental sustainability and human safety [2]. Therefore, the development of eco-friendly, sustainable, and cost-effective methods for synthesizing AuNPs has become a major focus in recent years [3].

Green synthesis, utilizing biological reductor like plant extracts, has emerged as an alternative to conventional chemical and physical methods [4]. This approach is environmentally benign, as it uses non-toxic reducing agents and biocompatible solvents, thereby minimizing harmful byproducts. Various plant extracts have been

S. Hadi et al. (eds.), *Proceedings of the 5th International Conference on Applied Sciences, Mathematics, and Informatics (ICASMI 2024)*, Advances in Physics Research 13,
https://doi.org/10.2991/978-94-6463-730-4_14

for the synthesis of AuNPs, acting as both reducing and stabilizing agents [5]. The bioactive compounds present in these extracts, such as alkaloids, flavonoids, and phenolic acids, facilitate the reduction of gold ions and stabilize the nanoparticles, offering a simple, cost-effective, and scalable synthesis method [6].

Eleuthrine bulbosa, commonly known as Dayak onion, is a medicinal plant traditionally used in Central Kalimantan for its anti-inflammatory, antioxidant, and antimicrobial properties. The plant is rich in bioactive compounds like flavonoids, phenolics, and alkaloids. These compounds have phenolic hydroxyl functional groups that are useful in synthesizing AuNPs [7]. Despite its medicinal applications, there has been limited exploration of its potential in nanotechnology, particularly in the synthesis of AuNPs.

This study aims to optimize Dayak union extract as a reducing and stabilizing agent in synthesizing AuNPs. Variations of synthesis time, volume of tetrachloroauric acid ($HAuCl_4$), concentration of dayak onion extract, and concentration of $HAuCl_4$ were investigated to determine the optimum conditions of AuNPs. The synthesis was carried out using the Turkevnich method, which uses $HAuCl_4$ as the gold source. The synthesized AuNPs will be characterized using UV-Vis spectroscopy and transmission electron microscopy (TEM) to determine the surface plasma resonance (SPR), size, and shape of the nanoparticles. This research contributes to the emerging field of green nanotechnology by offering a sustainable approach to synthesizing AuNPs using dayak onion extract.

2 Materials and Methods

2.1 Materials

All reagents and materials were used without any further purification. Hydrogen tetrachloroaurate(III) hydrate ($HAuCl_4 \cdot 3H_2O$) was obtained from Sigma Aldrich. Dayak onion bulbs were purchased from the Kahayan market in Palangka Raya, Central Kalimantan, Indonesia, between June and July 2024. Distilled water was utilized for all experimental procedures.

2.2 Preparation of Dayak Onion Extract

Dayak onion bulbs were cleaned and dried at room temperature for 24 hours. The dried bulbs were pulverized into powder. 100 g of dayak onion powder was macerated in 400 mL of ethanol for 24 hours. Then, maceration was carried out twice to obtain more optimal extract results. The extract was filtered with a vacuum funnel and evaporated using a rotary evaporator.

2.3 Green Synthesis of Gold Nanoparticles using Dayak Onion Extract

Hydrogen tetrachloroaurate ($HAuCl_4$) was mixed with Dayak onion extract and synthesized in a water bath for 5 minutes, during which a visible color change indicated the formation of gold nanoparticles (AuNPs). UV-Vis spectroscopy in the range of 400-800 nm was used to investigate the optimization of various reaction parameters, including reaction time (5, 10, 20, 30, 40 minutes), volume of $HAuCl_4$ (1, 2, 3, 4, 5 mL), concentration of Dayak onion extract (2000, 4000, 6000, 8000, 10.000 ppm), and concentration of $HAuCl_4$ (25, 50, 75, 100, 200, 300, 400, 500 ppm). The reduction of Au^{3+} ions by the plant extract increased absorbance within the 530-580 nm range. AuNPs were obtained by centrifugation at 5000 rpm for 5 minutes, followed by drying in an oven at 80 °C. The synthesized AuNPs were characterized using UV-Vis spectroscopy and Transmission Electron Microscopy (TEM).

3 Result and Discussion

The green synthesis of AuNPs was performed by adding Dayak onion extract to an $HAuCl_4$ solution under specific conditions. The optimization of the synthesis process involved varying parameters such as the volume of $HAuCl_4$, synthesis time, concentration of Dayak onion extract, and concentration of $HAuCl_4$ to determine the optimal conditions for nanoparticle formation. The reaction time is a key parameter in the synthesis of AuNPs. Extending the reaction time can increase the maximum absorbance and reduce the maximum wavelength of AuNP colloids up to a certain point. Once the reaction reaches its peak state, further increases in reaction time do not affect the Surface Plasmon Resonance (SPR) peak or the color of the resulting colloids. In this study, the reaction time was varied from 5 to 40 minutes, with intervals of 5 and 10 minutes. A noticeable color change from yellow to brown occurred within the first 5 minutes. The color intensity began to diminish at 10 and 20 minutes. By 30 minutes, the solution had returned to its original yellow color. The color changes of the AuNPs are illustrated in **Fig. 1**.

Fig. 1. The color change observed during different time intervals of the synthesis process

Based on the SPR data in **Fig 2**, it can be observed that after 5 minutes of reaction, the number of nanoparticles increases, as indicated by the higher intensity. However, as the reaction continues, there is a decrease in absorbance intensity. This reduction in intensity correlates with a color change in the nanoparticles formed. **Fig. 1**, taken before measurements were conducted using a UV-Vis spectrophotometer, shows that at 20 minutes, the color of the AuNP colloid was still brown. During the measurement, the colloid became less stable, leading to the formation of AuNP precipitates in the vial. When AuNPs are unstable, they tend to agglomerate, resulting in colloidal precipitation [6]. Consequently, the UV-Vis spectra displayed lower intensity. The highest peak for the AuNPs was observed at a wavelength of 580 nm.

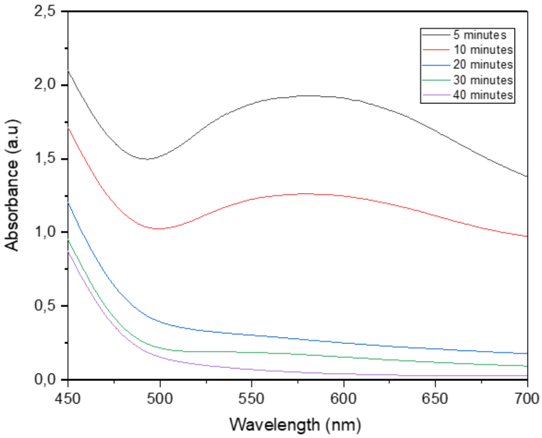

Fig. 2. The UV-Vis spectra of AuNPs synthesized from $HAuCl_4$ and Dayak onion extract were analyzed over different time intervals

Another study examined the effect of $HAuCl_4$ volume (1, 2, 3, 4, and 5 mL), as shown in **Fig. 3**, which displays the UV-Vis spectra of the synthesized AuNPs. The AuNPs were synthesized using Dayak onion extract with a volume of 2 mL and a concentration of 4000 ppm. No plasmon intensity was observed when the volume of $HAuCl_4$ was increased from 1 mL to 2 mL. However, plasmon intensity increased at a wavelength of 580 nm when the volume of $HAuCl_4$ increased from 3 mL to 5 mL. Therefore, the decrease in plasmon intensity can be attributed to the agglomeration of the nanoparticles [8].

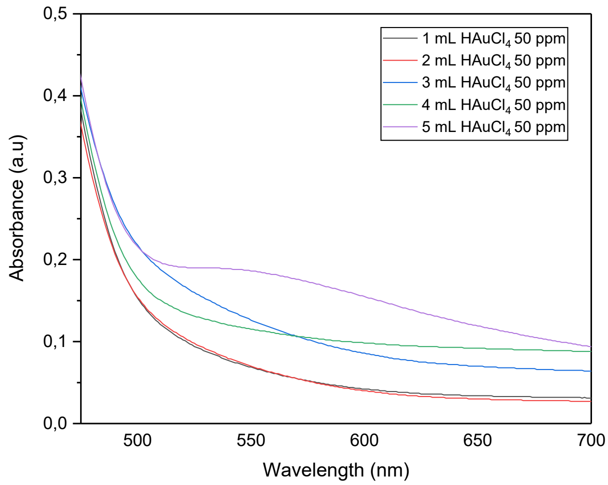

Fig. 3. The UV-Vis spectra of synthesized AuNPs between different volumes of $HAuCl_4$ (1 to 5 mL) and Dayak onion extract

We also investigated the effect of gold ion concentration on forming AuNPs by varying the concentration of the $HAuCl_4$ solution (**Fig. 4**). The results show that when 75 ppm $HAuCl_4$ is added, the spectra show an absorption peak around 580 nm. This shows that the concentration of gold ions greatly affects the formation of AuNPs. An increase in gold ion concentration corresponds to higher UV-Vis absorbance. However, at gold ion concentrations exceeding 300 ppm, a slight shift in the maximum wavelength to a larger value is observed, accompanied by a broadened peak. This broadening occurs because the concentration of free Dayak onion extract decreases, leading to insufficient stabilizing and capping action by the reducing agent. Consequently, various edges form on the surface of the nanoparticles, which produce larger and inhomogeneous nanoparticles [6,9]. Therefore, a gold ion concentration of 300 ppm was selected as the optimal condition for forming more stable AuNPs.

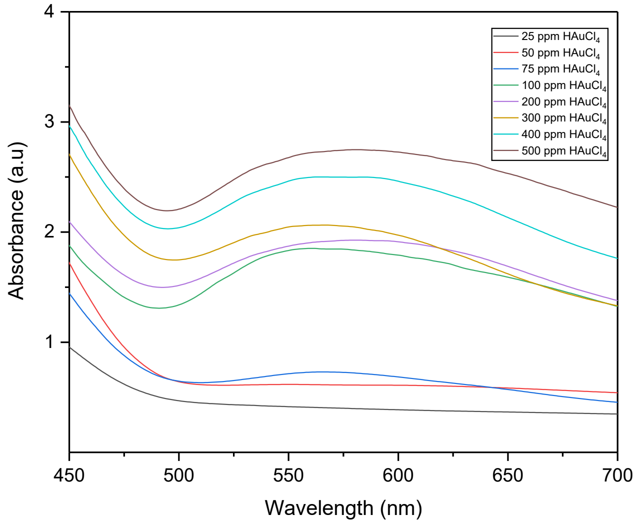

Fig. 4. UV-Vis spectra of synthesized AuNPs between HAuCl4 (25, 50, 75, 100, 200, 300, 400, 500 ppm) with dayak onion extract

When the reaction was conducted using various concentrations of dayak onion extracts, the resulting suspensions exhibited distinct colors, ranging from brown to yellow (**Fig. 5**). The SPR band was observed at a wavelength of 575 nm. Notably, increasing the amount of extract decreased the absorbance peak of the AuNPs. This reduction in absorbance can be attributed to the higher extract concentration, which may trigger the aggregation of AuNPs, resulting in more unstable nanoparticles and subsequent precipitation [10].

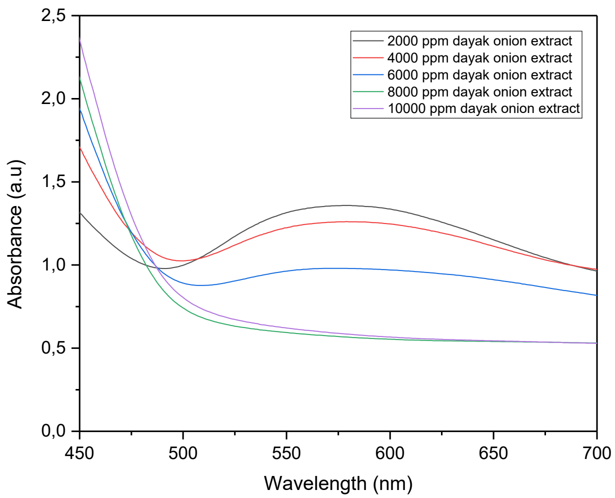

Fig. 5. UV-Vis spectra of AuNPs synthesized between $HAuCl_4$ with dayak onion extract at various concentrations

The ideal conditions for synthesizing AuNPs using dayak onion extract as a reducing agent were determined based on the optimization conducted. The optimization results indicated that the optimal reaction time and volume of $HAuCl_4$ were 5 minutes and 8 mL, respectively. Additionally, the optimal concentrations of $HAuCl_4$ and dayak onion extract were found to be 300 ppm and 2000 ppm, respectively. The UV-Vis spectra of AuNPs obtained under these optimal conditions are presented in **Fig. 6**

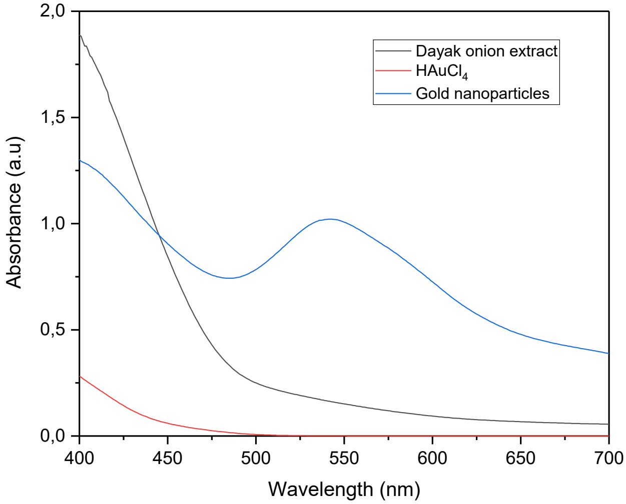

Fig. 6. UV-Vis spectra of AuNPs at optimum condition

Under optimal conditions, the synthesized AuNPs were characterized using transmission electron microscopy (TEM). The AuNPs were obtained in powder form, exhibiting an average diameter of 14.37 ± 3.67 nm, as illustrated in the histogram (**Fig. 7**). A thin layer of Dayak onion bulb extract surrounds the AuNPs, serving as a nucleation site. TEM observations revealed that most particles exhibit a spherical or near-spherical morphology [11].

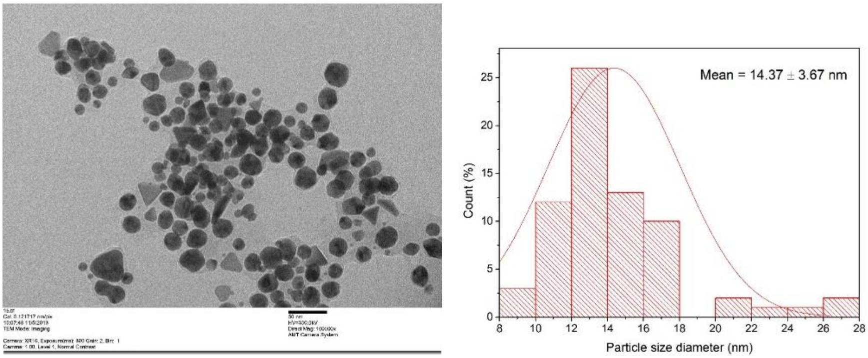

Fig. 7. TEM observation results and histogram of particle size distribution of AuNPs under optimum condition

4 Conclusion

In conclusion, spherical gold nanoparticles (AuNPs) with a small TEM particle size of 14.37 ± 3.67 nm were successfully biosynthesized using a green, single-step method that did not require expensive commercial reductants or stabilizers. The formation of AuNPs was primarily indicated by a color change in the solution, and UV absorption spectra showed a maximum absorbance peak at 540 nm. This study highlights the effectiveness of Dayak onion extract in reducing gold ions and stabilizing AuNPs.

Acknowledgments. The authors wish to express their gratitude for the financial support received from the Directorate General of Higher Education, Research and Technology through fundamental research schemes.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Hosny, M., Eltaweil, AS., Mostafa, M., El-Badry, YA., Hussein, EE., Omer, AM., et al.: Facile Synthesis of Gold Nanoparticles for Anticancer, Antioxidant Applications, and Photocatalytic Degradation of Toxic Organic Pollutants. ACS Omega **7**(3), 3121–33 (2022)
2. Suriyakala, G., Sathiyaraj, S., Babujanarthanam, R., Alarjani, KM., Hussein, DS., Rasheed, RA., et al.: Green synthesis of gold nanoparticles using Jatropha integerrima Jacq. flower extract and their antibacterial activity. J King Saud Univ - Sci [Internet] **34**(3), 101830 (2022). Available from: https://doi.org/10.1016/j.jksus.2022.101830
3. Dang, KPT., Nguyen, TTG., Cao, TD., Le, VD., Dang, CH., Duy, NPH., et al.: Biogenic fabrication of a gold nanoparticle sensor for detection of Fe3+ ions using a smartphone and machine learning. RSC Adv **14**(29), 20466–78 (2024)

4. Saad, N., Abdullah, CAC., Zainal, NAA., Albert, EL.: Characterization, Antibacterial and Toxicity Evaluation of Biosynthesized Zinc Oxide Nanoparticles utilizing Eleuthrine bulbosa Bulb Extract. Sains Malaysiana **52**(10), 2907–18 (2023)
5. Hosny, M., Fawzy, M., El-Badry, YA., Hussein, EE., Eltaweil, AS.: Plant-assisted synthesis of gold nanoparticles for photocatalytic, anticancer, and antioxidant applications. J Saudi Chem Soc [Internet] **26**(2), 101419 (2022). Available from: https://doi.org/10.1016/j.jscs.2022.101419
6. Doan, VD., Thieu, AT., Nguyen, TD., Nguyen, VC., Cao, XT., Nguyen, TLH., et al.: Biosynthesis of Gold Nanoparticles Using Litsea cubeba Fruit Extract for Catalytic Reduction of 4-Nitrophenol. J Nanomater **2020**, 4548790 (2020)
7. Rahayu, N., Gusrizal, G., Nurlina, N.: Ekstrakk umbi bawang dayak (Eleutherine palmifolia (L.) Merr.) sebagai pereduksi ion perak dalam sintesis nanopartikel perak. Indones J Pure Appl Chem **3**(3), 17-24 (2021)
8. Al-Radadi, NS.: Facile one-step green synthesis of gold nanoparticles (AuNp) using licorice root extract: Antimicrobial and anticancer study against HepG2 cell line. Arab J Chem [Internet] **14**(2), 102956 (2021). Available from: https://doi.org/10.1016/j.arabjc.2020.102956
9. Kumari, Y., Kaur, G., Kumar, R., Singh, SK., Gulati, M., Khursheed, R., et al.: Gold nanoparticles: New routes across old boundaries. Adv Colloid Interface Sci [Internet] 274, 102037 (2019). Available from: https://doi.org/10.1016/j.cis.2019.102037
10. Bezares, B., Jaña, Y., Cottet, L., Castillo, A.: Effect of ph and leaf extract concentration of pittosporum undulatum on gold nanoparticles synthesis. Mater Express **8**(5), 450–6 (2018)
11. Liu, B., Xie, J., Lee, JY., Ting, YP., Paul, Chen J.: Optimization of high-yield biological synthesis of single-crystalline gold nanoplates. J Phys Chem B **109**(32), 15256–63 (2005)