Biosynthesis of Silver

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Biosynthesis of Silver Nanoparticles using Banana *Raja* (*Musa paradisiaca Var. Raja*) Peel Extract: Effect of Different Concentrations of the $AgNO_3$ Solution

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Abstract. This study focuses on the biosynthesis of silver nanoparticles using Banana *Raja* (*Musa Paradisiaca Var. Raja*) peel extract. The aim is to determine the effect of concentration differences of silver nitrate ($AgNO_3$) as the precursor on the production of silver nanoparticles. In this study, banana peel extract (BPE) was reacted with $AgNO_3$ solution at several concentrations of silver nitrate solution i.e. 0.125; 0.1; 0.075 and 0.05 M at temperature of 50 °C. The ratio of banana peel extract and $AgNO_3$ solution used was 5:500 (v/v). The stirring was done by using a magnetic stirrer. The reaction took place when the color of the mixture (extract and $AgNO_3$) changed until the color of the mixture became constant. The results of the colloidal silver nanoparticles were characterized using UV-Vis Spectrometer, while the functional groups of the banana extract was analyzed using a Fourier Transform Infra-Red (FT-IR) apparatus. Whereas, the morphology of the silver nanoparticles was studied using a Scanning Electron Microscopy (SEM). The UV-Vis Spectrometer result show that the concentration of $AgNO_3$ which gave the highest absorbance value was at 0.1 M. The SEM micrographs could not clearly show the difference in the morphology of silver nanoparticles samples at different concentrations of $AgNO_3$ solution.

Introduction

Nanotechnology is an emerging field that rapidly growing with the application of science and technology for the purpose of making new materials at the nanoscale level [1]. So it encourages the beginning of chemicals research to synthesize nanoparticle material. Nanoparticle is not only discussed on how it is applied but also on how it is synthesized. The synthesis of nanoparticle can be done in both chemical and physical methods. Synthesis of nanoparticle in physical method has been considered as more difficult technique and also costly [2]. In the other hand, chemical method is a method that often used in the synthesis of nanoparticles. However, recent studies have revealed that some chemical methods were harmful due to the use of hazardous chemicals.

Noble metal nanoparticles such as gold, silver, and platinum have broad applications for humans. One of the metals which has been widely studied is silver. It is because silver is non-toxic and safe metal that can be used as an antibacterial that kills around 650 types of diseases caused by microorganisms [3]. Compared to the regular size, silver particles in nanoscale level (i.e. silver nanoparticles) have more steady properties and potential applications in various science disciplines, such as catalyst, optical sensor detector, and antimicrobial agent. Based on its applications, silver has been mostly used as an antimicrobial agent. The antibacterial properties of silver are also affected by its particle size. The silver in nanosize has a greater effect as antibacterial agent compared to a bigger size [4].

Synthesizing silver nanoparticles requires a friendly process. Therefore, green methods have been developed, such as by using microorganisms, extracts of plants or plant biomass to synthesize the silver nanoparticles [5]. This method can be considered as an environmentally friendly nanoparticle production ("green" synthesis) because it can minimize the use of inorganic hazardous materials. Additionally, synthesis process by utilizing the living organism is known as biosynthesis [6]. Biosynthesis is an alternative method that can replace physically and chemically method. Biosynthesis of nanoparticles can use microorganisms, as well as herbs or plant extracts. There are many types of plants that can be used as the agent in the biosynthesis of silver nanoparticles. Indonesia as a tropical country has many potential plants that contain secondary metabolites compounds (e.g. terpenoids and flavonoids, etc.) that can be utilized in the biosynthesis of silver nanoparticles [5, 7]. However, a recent research study shows that most of the microorganisms used in the biosynthesis of nanoparticles have pathogenic impact on other plant or humans [8].

There are several literatures that reported about the green synthesis of silver nanoparticles using plant extracts. Krithiga, et al [9] have studied green synthesis of nanosilver using *Clitoria ternatea* and *Solanum nigrum* leaf extracts. Pirtarighat, et al. [10] have studied about the green synthesis of nanosilver using Salvia spinosa plant extract and their antibacterial capability. Ahmed, et al. [11] have studied about green synthesis of nanosilver uisng *Azadirachta indica* leaf extract. Banana peels extract (BPE), one of agricultural wastes contains antioxidants (e.g. polyphenols, catecholamine and carotenoids, which can be used as a reducing agent in the synthesis of silver nanoparticles [12]. Ibrahim, et al. [13] have studied about the biosynthesis of nanosilver using banana (*Musa paradisiaca*) peel extract and its antimicrobial activity. Nevertheless, literatures about the biosynthesis of silver nanoparticles using Banana *Raja* peel extract is limited. Therefore, the purpose of this study was to study the effect of concentration differences of silver nitrate ($AgNO_3$) as the precursor on the biosynthesis of silver nanoparticles using Banana *Raja* (*Musa Paradisiaca Var. Raja*) peel extract.

Experimental

Materials. A local variety of banana (i.e. Banana *Raja*) peel used as a reducing agent was obtained from several stalls that sell banana based snack, such as fried banana, etc. $AgNO_3$ solution used as the precursor to for biosynthesis of the silver nanoparticles was obtained from a local chemical market. Distilled water was used as a solvent to make banana peel extract (BPE).

Preparation of Banana Peel Extract. Prior to the extraction process, the banana peel was washed carefully, weighed for about 100 grams, and then put in a beaker. Afterward, about 300 ml of distilled water was added into the beaker and then heated at 80 °C for 30 minutes. The mixture was then filtered using a clean cloth to obtain the Banana Peel Extract (BPE). The BPE was analyzed using Fourier Transform Infrared (FT-IR), Shimadzu 8201PC (Shimadzu, Japan) to identify functional groups contained in banana peel extracts. The BPE was then stored in a 4 °C cooler for future uses.

Synthesis of Silver Nanoparticles. For the synthesis of silver nanoparticles, the BPE was first diluted in distilled water with a ratio of BPE and distilled water of 5:500 (v/v). The synthesis of silver nanoparticles was carried out using $AgNO_3$ solution as a precursor at predetermined concentration variation of 0.125; 0.1; 0.075; and 0.5 M. This synthesis reaction consisted of 500 ml of aqueous BPE solution and 100 ml of $AgNO_3$ solution. Both of solutions (i.e. BPE extract and $AgNO_3$) were mixed into a one-neck flask, stirred, and heated at 50 °C using a hot-magnetic stirrer. The color of the mixture changed from a clear to a brownish yellow after 30 minutes of stirring, which indicated the formation of silver nanoparticles. The synthesis was stopped when the color of the mixture did not change again (i.e. constant). The synthesized solution was then characterized using a UV-Vis Spectrometer. It was used to measure the absorbance of the synthesized solution containing silver nanoparticles. The sample nomenclature used in this work is shown in Table 1.

Table 1. Sample nomenclature of the biosynthesis of silver nanoparticles.

Sample	Ratio of BPE and Distilled water	Concentration of $AgNO_3$ solution
A	5 : 500	0.125 M
B		0.1 M
C		0.075 M
D		0.5 M

Dry Sample Preparation. About 100 mL of the synthesized solution was taken and then NaOH solution was added dropwise until the pH = 8. Then, the solution was centrifuged and then filtered using Whatman filter paper. Afterward, the filtered sample was washed using distilled water and then dried in an oven at 80 °C for about ten minutes. The sample was dried until constant weight. The silver nanoparticles were ready for further characterization.

Sample Characterization. The prepared silver nanoparticles were then characterized using a Scanning Electron Microscope (SEM-EDX JEOL JSM-6510 LA) with magnification of 20,000X to determine the morphology of the prepared silver nanoparticles.

Results and Discussion

UV-Vis Spectrophotometer Analysis. The synthesized solution was characterized by UV-VIS spectrometer to determine the presence of formed silver nanoparticles. The colloidal silver nanoparticles were detected at wavelengths ranging from 400 nm to 450 nm [14]. The higher the absorbance values, the more the number and the smaller size of silver particles are formed [15]. Fig. 1 shows the UV-Vis Spectrometer analysis results of the synthesized solution using different concentrations of $AgNO_3$ solution as precursor.

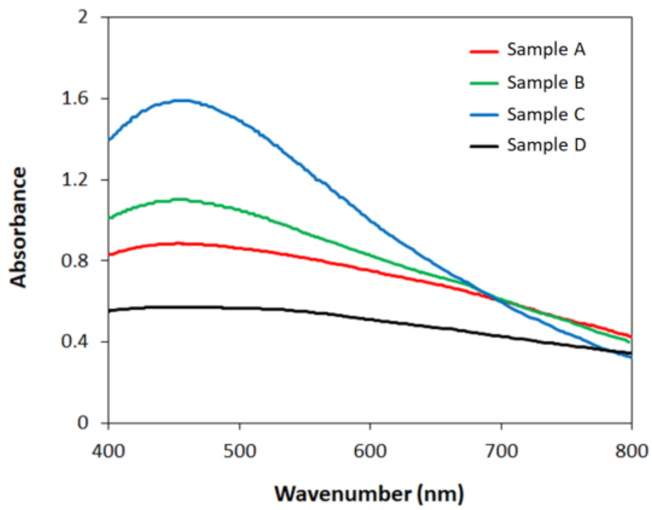

Fig. 1. UV-Vis Spectrometer analysis results of the synthesized solution using different concentrations of $AgNO_3$ solution as precursor (i.e. 0,125; 0.1; 0.075; 0.05 M).

For all the samples, the peak of absorbances occured at a wavelength of 450 nm. Additionally, as noticed in the figure, the highest absorbance value was obtained by a sample with $AgNO_3$ solution concentration of 0.1 M, with an absorbance value of 1.59. From this result, it can be qualitatively suggested that at a $AgNO_3$ concentration of 0.1 M the optimum formation of silver nanoparticles occured. Additionally, it can also be concluded that the precursor concentration greatly influences the formation of nanoparticles. Higher $AgNO_3$ solution concentration could cause the particles formed become large so that the absorbance at 450 nm becomes small. The smaller the size of the silver particles, the more the number and the higher the absorbance of the light by those particles.

Fourier Transform Infra Red (FT-IR) Analysis. The FT-IR spectra of the Banana Peel Extract (BPE) is exhibited in Fig. 2. The uniqueness of the polyphenol compound has an O-H group, while several aromatic rings are characterized by an aromatic C = C group. In Fig. 2, the wavelength of 3402 cm^{-1} indicates the presence of a hydroxyl group specifically for alcohols as phenols. In addition, C-H groups are spread over various wavelengths based on certain types of bonds, e.g. Alkanes C-H at wavelengths 2924 cm^{-1}, alkyl at 1381 cm^{-1} and 926 cm^{-1} for alkenes. The C-H substituted in benzene is located at wavelengths of 771 and 817 cm^{-1}. Whereas, C-O alcohol and phenol groups have wavelengths of 1056 cm^{-1}, C-O-H at 1435 cm^{-1}, and aromatic C-O at 1250 cm^{-1}. These results indicate the possibility of polyphenol compounds. Similar FT-IR test results were also reported by Ibrahim, et al [13].

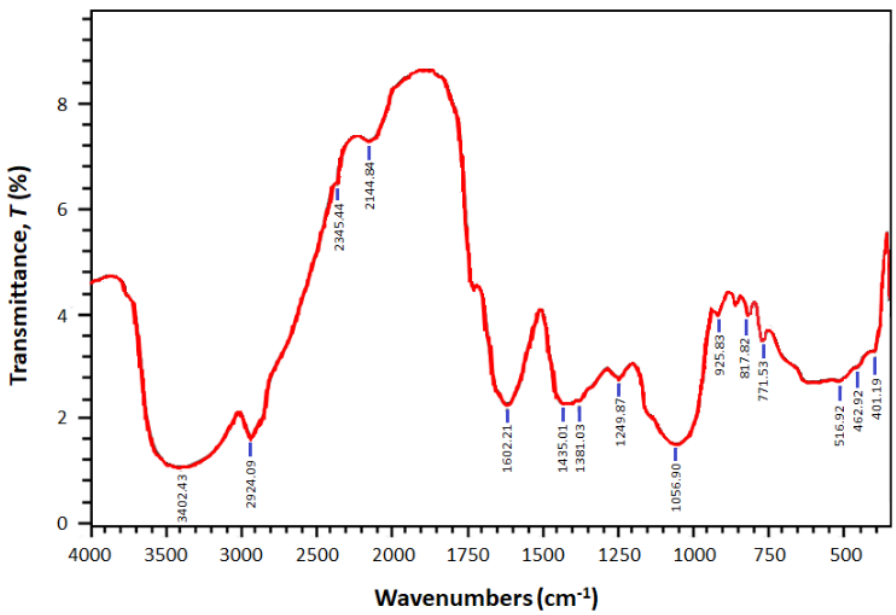

Fig. 2. FT-IR Spectrum from Raja Banana Skin Extract.

The reduction reaction by polyphenol compounds to form silver nanoparticles can be explained as follows. Initially, polyphenol compounds in the extract of plantain peels mixed with $AgNO_3$ solution form radical compounds, compounds that have free electrons. Polyphenols in radical form will adsorb Ag^+ from $AgNO_3$ solution, and then Ag^+ adsorbed will experience a reduction reaction by polyphenols, which causes to form Ag^0.

Scanning Electron Microscopy (SEM) Analysis. Fig. 3 shows the SEM micrographs of silver nanoparticles produced using different precursor (i.e. $AgNO_3$ solution) concentrations. As seen in the figures, there were no clear difference in morphology among the silver particles produced using different concentrations of $AgNO_3$ solution. Nevertheless, the silver particles formed were in size of nanometer, as exhibited in the figures. However, the dispersion and size distribution of the produced silver particles were not able to be achieved. Therefore, more advanced electron microscopy technique is required, such as a Transmission Electro Microscoy (TEM). This will be a good recommendation for the future research study.

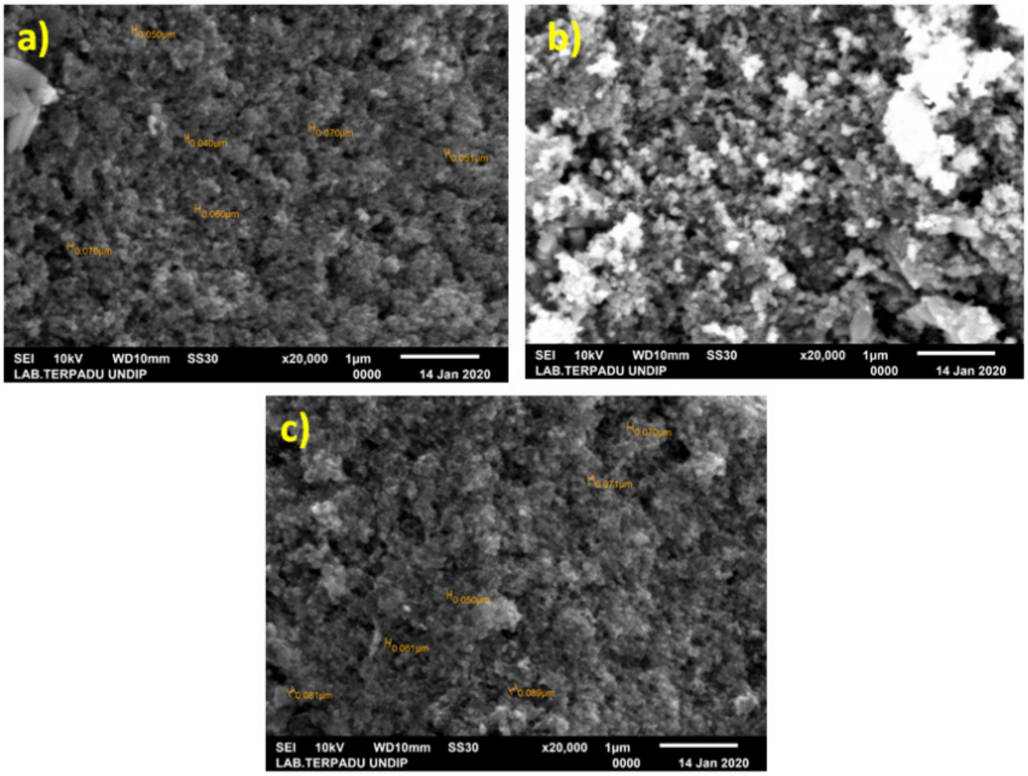

Fig. 3. SEM micrographs of silver nanoparticles produced at different $AgNO_3$ solution concentrations of **a)** 0.1 M; **b)** 0.075 M; and **c)** 0.05 M.

Conclusions

From the results of this study, it can be concluded that banana peel extract can be used to synthesis silver nanoparticles. Additionally, it was also found that the precursor concentration greatly influenced the formation of nanoparticles. Based on the UV-Vis Spectrometer analysis results, the highest absorbance value was obtained by a sample with AgNO3 solution concentration of 0.1 M, with an absorbance value of 1.59. This result was considered as the most optimum formation of silver nanoparticles in this study.

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