Optimization of precursor concentration and timing of stirring in the formation of silver nanoparticles with and without polyvinyl alcohol (PVA)

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Abstract. The biosynthesis of silver nanoparticles using plants as reducing agents has been reported. In this study used plant extracts *Myrmecodia pendans* which function as reducing agents and AgNO3 as metal precursors. Silver nanoparticles were successfully synthesized by using plant extracts of *Myrmecodia pendans* by doing them on variations in concentration and stirring time. In this case a variation of 0.5 mM is used; 1mM; 1.5 mM; 2 mM; and 2.5 mM and the time variation used was 120 minutes and 150 minutes. Analysis using UV-Vis spectrophotometer to determine silver nanoparticles formed in a wavelength range of 400-500 nm. From the results of the study, it was obtained that the concentration of 1 mM with 120 minutes stirring time was the best concentration and the time of formation of silver nanoparticles without stabilizer with absorbance of 2.125 at a wavelength of 408 nm and at a concentration of 2.5 mM with 120 minutes stirring time was the best concentration and stirring time formation of silver nanoparticles with a stabilizer at a wavelength of 413.5 nm with absorbance of 2.636.

1. Introduction
Nanometer-sized material has a number of chemical and physical properties that are superior to large (bulk) material [1]. Nanoparticles have been widely studied for various technological applications and in research in material science, chemistry, physics, biology and environmental science [2]. Materials or structures that have nano-size will have different properties from the original material. The specific characteristics of the nanoparticles depend on the size, distribution, morphology, and phase [3]. One of the materials synthesized as nanoparticles is silver. Nanoparticle synthesis means making nanoparticles with sizes less than 100 nm and simultaneously changing their properties or functions.

Nanoparticle synthesis by utilizing living things as biological agents in the synthesis process is known as nanoparticle biosynthesis. The nanoparticle biosynthesis method using plant extracts is an alternative method that is environmentally friendly. Microbes and plants are reported to reduce metal, Ag, Au, and Pd ions to nanoparticles [4]. The use of plant extracts as metal ion reducing agents is relatively shorter compared to the use of microbes to produce metal nanoparticles. Nanoparticles synthesized using plant extracts can be carried out in minutes or hours while microbial-based synthesis methods take longer [5]. Silver nanoparticles tend to aggregate to form large sizes. The stability of silver nanoparticles plays a very important role when it will be characterized and applied to a product. Efforts to prevent aggregate between nanoparticles can be done by adding stabilizers.
The most effective stabilizer used is a polymer that functions to prevent agglomeration. Polyvinyl alcohol is known to be able to stabilize nanoparticles due to their hydrophilic properties by reducing the clumping of nanoparticles so as to produce stable nanoparticles. Things that need to be considered in the synthesis of silver nanoparticles are their size, shape, and morphology [6]. Factors that can influence particle size in synthesis are solution temperature, salt concentration, reducing agent and reaction time [7]. And one of the factors that influence the physical properties of nanoparticles is the time of stirring during the synthesis process. Therefore, in this study, a test was conducted to look for optimization and the effect of variations in concentration, each of which was varied with the time of stirring. This is done to obtain the optimal concentration and stirring time for the synthesis of silver nanoparticles with and without using the PVA stabilizer.

2. Methods

2.1. Instrument
The tools that will be used in the study are an analytic balance (Acculab), UV-Vis spectrophotometer (Shimadzu UV-2600), magnetic stirrer (VWR Scientific), magnetic bar, beaker, Erlenmeyer, measuring flask, spray bottle, dropper pipette and stirring rod.

2.2. Material
Some of the materials used in the research are extracts from powder Myrmecodia pendans which have been separated from their deposits, aquabides, AgNO3 (Intraco), and Polyvinyl alcohol (PVA) as stabilizers.

2.3. Method
2.3.1. Making AgNO3 solution with various concentrations. The AgNO3 solution is made with a variety of concentrations namely 0.5 mM, 1 mM, 1.5 mM, 2 mM, 2.5 mM. For AgNO3 solution with a concentration of 0.5 mM it was made by weighing 0.0212 grams of AgNO3 powder, then dissolving it in 250 mL aquadest and stirring until the AgNO3 powder dissolved. AgNO3 solution with a concentration of 1 mM was made by weighing 0.0426 grams of AgNO3 powder, AgNO3 solution with 1.5 mM concentration was made by weighing 0.0637 grams, and AgNO3 solution with a concentration of 2 mM was made by weighing 0.0845 grams, while for AgNO3 solution with 2.5 mM concentration was made by weighing 0.1056 grams. Each concentration was dissolved in aquadest with a volume of 250 mL.

2.3.2. Making 1 % PVA solution. 1% PVA solution is made by weighing PVA powder weighing 1 gram which is then dissolved in 100 mL aquadest by heating until the PVA powder dissolves. This PVA solution will be used as a stabilizer in the process of biosynthesis of silver nanoparticles.

2.3.3. Variation in stirring time. Each AgNO3 solution with variations in concentration was stirred using a time variation of stirring ie, 120 minutes, and 150 minutes. Each concentration of AgNO3 with a volume of 20 mL for biosynthesis of silver nanoparticles was made by mixing 2 mL of available Myrmecodia pendans plant extract (optimization without stabilizer) and added with 2 mL of PVA 1% (optimization with stabilizer). Each solution with a variation of the concentration of the distiller with a variation of the stirring that has been determined. And then to determine the optimization of the concentration and time of stirring a UV-Vis spectrophotometer was conducted to provide information about the formation of silver nanoparticles.

3. Results
In the process of the formation of silver nanoparticles can be characterized by a change in color from time to time, namely from yellow to brownish. The color characterization of the solution was carried out to determine the effect of stirring time on the formation of silver nanoparticles. Silver nanoparticles that are synthesized with varying stirring times plus varying concentrations can also produce different physical colors. Silver nanoparticle colloids have wavelengths of 400 - 500 nm.
synthesized sample formed at a wavelength of 400 nm to 450 nm is silver nanoparticles (Ag0) while the samples formed at a wavelength of 370 nm to 400 nm are silver ions (Ag+).

**Figure 1.** Color changes during the stirrer process

The stability of silver nanoparticles can be determined by measuring using a spectrophotometer by looking at changes in the absorption peak. If there is a shift in the absorption rate to a larger wavelength, it indicates that agglomeration occurs because the stability of the silver nanoparticles is still low [8].

From the results of this study found the formation of different physical colors, namely from pale yellow, clear yellow to brownish. These colloid nanoparticles showed different colors based on the absorption of light and emission in the visible light region, as well as the frequency of electron-electron conduction vibrations which are responses to the electric fields resulting from electromagnetic radiation that only occur in metals such as Ag, Au, Cu, and metals alkali because in these metals there are free electrons that have Plasmon resonance in the visible light spectrum that can give good color.

### 3.1 Optimum condition

Control of size distribution during particle synthesis is an important criterion in the biosynthesis of silver nanoparticles. The reaction conditions can be optimized by changing experimental factors, such as pH, incubation time, precursor concentration, reaction temperature, stirring time, presence of light sources, and composition of culture media. This optimization will change the chemical composition, shape and size, and monodisperse of particles [9].

Experimental factors optimized in this study include precursor concentration and stirring time to determine the precursor concentration and the best stirring time in the biosynthesis of silver nanoparticles which were analyzed using a UV-Vis spectrophotometer where the maximum wavelength of the signal response is at a maximum good and low detection limits and reduce measurement errors [10].

#### 3.1.1 Precursor concentration and stirring time without stabilizer

The results of the analysis using UV-Vis spectrophotometer at precursor concentration and stirring time formed on silver nanoparticles according to the results of Zuas, et al [11]. Which states that the solution of synthesized colloid nanoparticles has a nanometer-scale size. In fig.2, it can be seen that the best concentration is formed at a concentration of 1 mM with the absorbance of 2.125 at wavelength 408 with a stirring time of 120 minutes. Compared to fig.3, the concentration formed at a concentration of 1.5 mM with a stirring time of 150 minutes formed silver nanoparticles at a wavelength of 436 nm and absorbance of 1.250. The absorbance value determines the number of nanoparticles formed in a solution.
3.1.2. Precursor concentration and stirring time with 1% PVA stabilizer

The addition of 1% PVA produces silver nanoparticles which are quite stable because of the small maximum wavelength shift compared to those who do not use stabilizers. This happens because stabilizers play a role in controlling the size of silver nanoparticles. Stabilizers with a concentration of 1% are used because according to Zhao, et al [12], in the synthesis of silver nanoparticles with variations in the concentration of stabilizers, that the use of stabilizers can control the size of silver nanoparticles if they are in optimal concentration. If the concentration of the stabilizer is above the maximum condition, it can cause the stability of the silver nanoparticles to be disrupted. In Fig. 4 it can be seen that silver nanoparticles were formed at the best concentration of 2.5 nm with 120 minutes stirring time formed at a wavelength of 413.5 nm and absorbance of 2.636. While in Fig. 5 the formation of silver nanoparticles at a wavelength of 416 nm and absorbance of 2.440 is seen. There is a significant difference in wavelength and absorbance value for the formation of silver nanoparticles using stabilizers.
Figure 4. Stirring for 120 minutes with stabilizer

Figure 5. Stirring for 150 minutes with stabilizer

4. Conclusion
Optimization of precursor concentration and stirring time in the biosynthesis of silver nanoparticles was formed at a concentration of 1 mM AgNO3 with the best stirring time of 120 minutes on the formation of silver nanoparticles without stabilizer with a wavelength of 408 nm and absorbance of 2.125. While the concentration of 2.5 mM with 120 minutes stirring time is the best time for the formation of silver nanoparticles with stabilizers with a wavelength of 413.5 nm and absorbance of 2.636.

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