Green Synthesis and Characterization of Silver Nanopaticles

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Abstract: Green synthesis of silver nanoparticles (AgNPs) was carried out by chemical reduction method. The reduction was carried out in a close and dark condition at 90 ºC for 4 h. Glucose was used as the reducing agent, while starch was used as the stabilizing agent. The reduction of Ag^+ was indicated by color change in the solution from colorless to brown. Synthesized AgNPs were characterized by UV-visible spectroscopy and transmission electron microscopy, which showed that AgNPs had SPR value of 435 nm with spherical shapes. Moreover, the dimension of AgNPs was approximately 9.15 ± 4.15 nm.

1 INTRODUCTION

Silver (Ag) is a promising chemical element to be used in various applications such as medicine, electronics, and household tools. It is classified as a transition metal and has interesting properties. However, the uses of silver are limited because it oxidized spontaneously when exposed to free oxygen molecules (Khorasani *et al.*, 2009)(Zheludkevich *et al.*, 2004). Recently, the production of silver in nanoscale has become highly attractive due to nanoparticles physical, chemical, and biological properties, which are being studied through analytical techniques, i.e. x-ray diffraction, x-ray photoelectron spectroscopy, fourier-transform infrared spectroscopy, UV-vis spectroscopy, transmission electron microscopy, scanning electron microscopy, dynamic light scattering, and localized surface plasmon resonance (Salleh *et al.*, 2020).

Silver nanoparticles (AgNPs) have unique physical and chemical properties with their surface-to-volume ratio, which enable modification of their physical, chemical, and biological properties. These properties have made AgNPs in high demand for various applications such as in health care, as well as for medical and industrial purposes (Morones *et al.*, 2005). The biological activity of AgNPs is the most intriguing property influenced by the particle size distribution, surface chemistry and morphology, chemical composition, agglomeration, capping agents, particle responses in media, the release of ions, and the reducing agents used in the synthesis of AgNPs (Prakash *et al.*, 2017).

Generally, the synthesis of AgNPs through physical, chemical, and biological methods is known as green synthesis. Additionally, the synthesis is classified into top-down (consists of mechanical grinding of silver bulks) and bottom-up method (consists of chemical reduction, sono-decomposition, and electrochemical methods) as shown in Figure 1 (Slepička *et al.*, 2020).

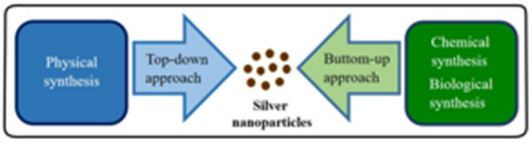

Figure 1. AgNPs preparation method.

Some studies reported green synthesis of AgNPs by using eucalyptus hybrida (Safeda) leaves was able to produce stable AgNPs in solutions with uniform shapes. Moreover, by using chemical reduction method, AgNPs produced had good antimicrobial activity (Landage, Wasif and Dhuppe, 2014). However, no AgNPs dimensions were reported (Dubey, Bhadauria and Kushwah, 2009).

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This study aimed to synthesize AgNPs by chemical reduction process. Chemical synthesis has been widely used as it can easily produce AgNPs with higher yields and lower cost compared to physical approach.

2 EXPERIMENTAL

Materials

$AgNO_3$, starch and glucose were purchased from Merck, Germany.

Chemical reduction of silver nanoparticles

$AgNO_3$ was used as a precursor for the synthesis of AgNPs by chemical reduction method. Firstly, $AgNO_3$ and glucose were mixed under constant stirring with 1:1 ratio in a beaker glass. Then, 80 mL of the mixture were transferred to another beaker glass and 20 mL of starch 1% was added. The mixture was vigorously stirred in a close and dark condition at 90 ℃ for 4 h. After that, the sample was cooled at room temperature and centrifuged at 5000 rpm for 10 minutes. The product was collected for characterization (TEM and UV-visible).

UV-visible

UV-visible spectra were recorded on an ultraviolet/visible spectrophotometer (UV 1800 series, Shimadzu Scientific Instrument). The samples were diluted and measured with wavelengths between 200 and 800 nm.

Transmission electron microscopy

The nanoparticles of AgNPs were investigated by using a LoJeol 1200 EX transmission electron microscope (TEM). The instrument was operated using an accelerating voltage of 80 kV.

3 RESULTS AND DISCUSSION

UV-visible analysis

Surface plasmon resonance (SPR) of the synthesized AgNPs was analyzed by using UV-visible spectra between 200 nm and 700 nm. In this study, the SPR value of AgNPs obtained was 435 nm (Figure 2). Previous study reported AgNPs with SPR value from 410 nm to 425 nm (Handoko *et al.*, 2017). The success in AgNPs synthesis in this study was indicated by the colour change from Ag^+ reduction (Figure 3). The formation of AgNPs is well-known to be indicated by the transformation of solution from colourless to brown. The change occurred in the solution suggested the formation of AgNPs with the excitation of SPR in silver metal nanoparticles (Dubey, Bhadauria and Kushwah, 2009).

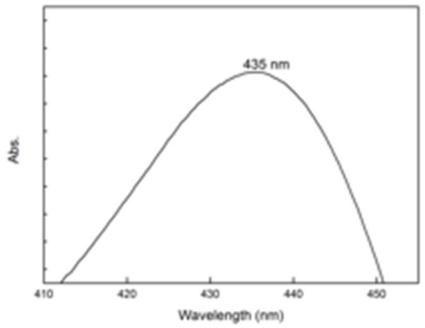

Figure 2 UV-visible spectra of silver nanoparticles.

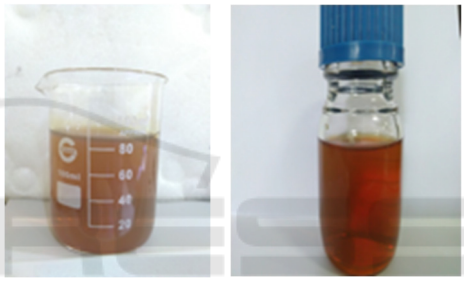

Figure 3 Brown color from Ag^+ reduction.

Transmission electron microscopy

Images from TEM analysis of AgNPs are presented in Figure 4. From the Figure, AgNPs were shown to have formed spherical shapes, which were also reported in other studies (Shanmugam *et al.*, 2018)(Handoko *et al.*, 2017). The dimension of AgNPs produced was calculated by using image J analysis. The average size was approximately 9.15 $\pm$ 4.15 nm. Based on the investigation, AgNPs solution was stable with up to one-month storage.

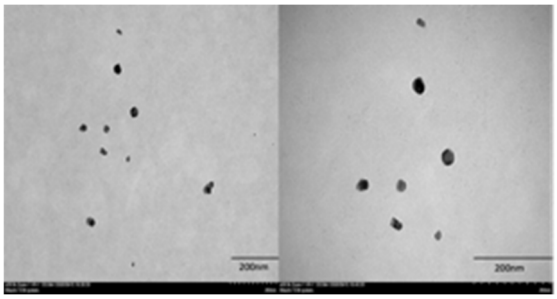

Figure 4. TEM images of AgNPs.

4 CONCLUSION

Green synthesis of AgNPs using chemical reduction was done by using $AgNO_3$, glucose and starch as the precursor and reducing agents. The formation of AgNPs was indicated by the color change in mixing solution from colorless to become dark brown after 4 h of synthesis. UV-visible analysis showed that SPR value of AgNPs was at 435 nm. The spherical shapes of AgNPs were confirmed by TEM analysis. In addition, the dimensions of AgNPs were calculated by using Image J analysis and obtained average diameter at approximately 9.15 ± 4.15 nm.

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