

Low Conductivity of Green Synthesis Selenium Nanoparticles

Hidayah Mesari¹, Salina Muhamad²

¹Department of Engineering, Faculty Engineering and Life Sciences, Universiti Selangor,
 45600 Bestari Jaya, Selangor Darul Ehsan, Malaysia

¹hidayahmesari@gmail.com

²Department of Engineering, Faculty Engineering and Life Sciences, Universiti Selangor,
 45600 Bestari Jaya, Selangor Darul Ehsan, Malaysia
 msalina@unisel.edu.my

Abstract: Unique properties of Selenium (Se) and its allied nanoparticles are of great interest in the fields of chemistry and engineering. However, widespread applications of nanoparticles, especially Selenium nanoparticles (Se NPs) call for synthesis routes involving eco-friendly procedures as an alternative method to the expensive and toxic chemicals previously used. Thus, this study was conducted to synthesize and analyse Se NPs using *polygonum minus* leaves extract. The produced Se NPs were characterized using Field Emission Scanning Electron Microscope (FESEM), UV-Visible Spectroscopy (UV- Vis), and IV measurement to analyse the electrical conductivity. The morphology of the produced Se NPs was in spherical-shape within the diameter range of 60 nm – 90 nm, while the peak of absorbance was at 2-2.5%, showing the low absorbance of Se NPs. Resistance and resistivity of Se NPs showed 338.4 ohm and 16.92 ohm.cm respectively. The electrical conductivity of Se NPs reached a low conductivity which was 0.059 S/cm. This study successfully showed that Se NPs can be produced through green synthesis and having low conductivity for future electrical and electronic applications.

Keywords: selenium nanoparticles, green synthesis, *polygonum minus*, electrical conductivity

1. Introduction

Nano-materials are miniaturization of materials. Building of machines at the molecular scale that involves the manipulation of materials on an atomic scale were about two-tenths of a nanometre is called nanotechnology. In nanotechnology, a particle is defined as a small object with size ranges between 1 nm and 100 nm that behaves as a whole unit in terms of its transport and properties (Ullah, Wilfred, & Shaharun, 2018)

In this new era with fast-rising field that involved research and technology development, nanotechnology has become one of the most promising approaches for innovations that lead to fulfilment of human needs and also multidisciplinary research area (Anu, Singaravelu, Murugan, & Benelli, 2017) with the potential to revolutionize numbers of research fields. Research on the synthesis of nanoparticles sized material is of great interest because of their unique properties like electrical, electronic, optoelectronic, microelectronic, and electronic component application (Alotaibi, Nama Manjunatha, & Paul, 2017).

Selenium nanoparticles (Se NPs) have increasingly drawn more considerations because of their promising applications in the fields of catalysis, electronics, and sensing (Chaudhary & Mehta, 2014). For most applications, the properties of Se NPs are established by their size, shape, composition, and structure. As an established synthesis process, a chemical reaction has taken place for a long time, which is toxicated and expensive. It is of great significance to prepare the superior quality of Se NPs in a green synthesis environment.

To date, the research on green synthesis Se NPs with local plants is very limited. An existing study indicates that the commonly used plants were coming from outside which is difficult to find in Malaysia. Based on this, *polygonum minus* leaves has been selected, which

also known as kesum leaf. The kesum leaves is reported as a good reducing agent (Abu Samah et al., 2020), whilst can act as an antimicrobial and cytotoxic.

As an alternative method to the existing chemical process, the characteristic of Se NPs is still under great investigations, especially its electrical properties. Thus, this paper presented the green synthesis of Se NPs and their low conductivity behaviour which can be great potential applications, especially in the electrical and electronic field.

2. Methodology

2.1 Preparation of Leaf Extract

The leave selected for this green synthesis is *polygonum minus* leave. Those 3.5 kg leaves were thoroughly rinsed with water to remove dust particles. Then, it was dried using a dry incubator, which took 3 days to complete. The dried leaves were ground using a grinding machine to get the powder form. Leaves extract was then prepared by placing 20 g of the powder with 200 ml of distilled water in the 250 ml beaker.

The temperature of a magnetic mixture with a hot plate was set at 100 °C to boil the mixture. The solution was subjected to cooling at room temperature before it was put into the 50 ml tube. Each tube was filled with the same amount for centrifuging at 10,000 rpm for 30 minutes. After centrifuged, the solution of leaves extract was filtered by using filter paper to removes impurities particles. The leaves extract was stored at 5°C for further experiment.

2.2 Synthesis of Se NPs

For the synthesis of Se NPs, 60 ml of *polygonum minus* leaves extract, 6 g of sodium selenite, 4 g of ascorbic acid, and 240 ml of deionized water were prepared. Temperature and speed of hot plate and magnetic stirrer were set at 80 °C and 450 rpm, respectively.

240 ml of deionized water was filled into the 600 ml beaker and was put on the hot plate. The solution was mixed with 6 g of sodium selenite and 4 g of ascorbic acid. Observations on the colour change in the solution of Se NPs were carried out. After temperature reaches 80 °C, the solution was added to the 60 ml leaves extract. The solution of Se NPs remained in 1 hour to observe the reaction of the colour change. Based on the observation, the colour of the solution Se NPs turned into brick-red colour.

The solution was subjected to cooling at room temperature before it was put into the 50 ml tube. For each tube, the solution was filled in the balanced amount for centrifuging at 10,000 rpm for 30 minutes in the first round. The supernatant was carefully discarded and the brick-red sediments were suspended in double-distilled water. This cycle was repeated two times with 10 minutes for each cycle to remove the side products. Fig.1 shows the whole process of the preparation of green synthesis Se NPs.

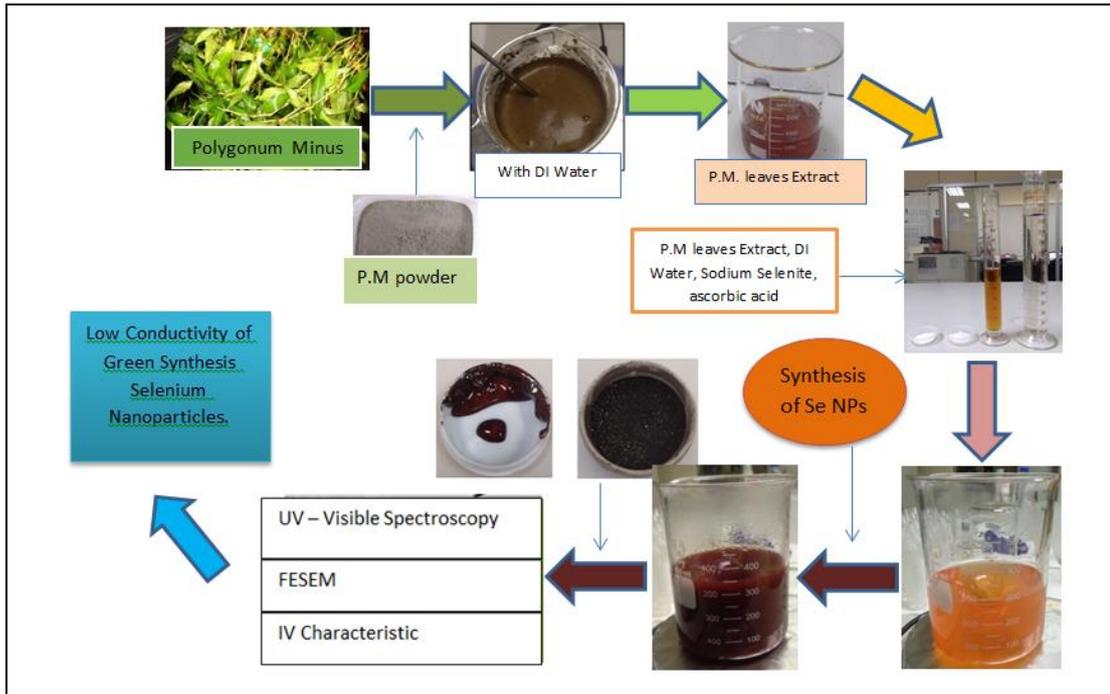


Fig 1: The whole process of the green synthesis Se NPs

2.3 Characterization Techniques

2.3.1 UV-Visible Spectroscopy

UV-Visible spectroscopy was used to measure the absorption of produced Se NPs. The scanning range of the samples was 200–750 nm at a scan speed at 480 nm/min. 2 ml of Se NPs solutions with the temperature of 80 °C was placed into this equipment. The absorbance readings of Se NPs were taken every 15 minutes within 1 hour. The UV-Vis absorption spectra of Se NPs were recorded and Microsoft office (Excel) was used to plot the recorded data of absorbance.

2.3.2 Field emission scanning electron microscopy (FESEM)

The field emission scanning electron microscopy (FESEM) was used to inspect the morphology of the produced Se NPs. The object is scanned by electrons according to a zigzag pattern (Janssen, 2005).

2.3.3 IV Characteristics

A simple digital multimeter is used in this experiment to measure the resistance (Ω) of the produced Se NPs. The value of the resistance was then recorded. In order to find the resistivity, it is calculated by using Eq. (1).

$$\rho = \frac{RA}{L}, \Omega.cm \quad (1)$$

where ρ is the resistivity, R is the resistance, A is the area, and L is the length. Then, the electrical conductivity can be calculated by using Eq. (2).

$$\sigma = 1/\rho, S/cm \tag{2}$$

where σ is the conductivity and ρ is the resistivity.

3. Results and Discussions

A green synthesis of Se NPs has been successfully carried out using *polygonum minus* extract. The colour changes from colourless solution to the brick-red colour, which confirmed the formation of Se NPs. The produced Se NPs were then characterized using UV-Visible Spectroscopy and Field Emission Scanning Electron Microscopy (FESEM) to examine, analyse and measure the surface morphology and absorbance ability. Then, the electrical conductivity is measured.

3.1 UV-Vis Analysis

Fig. 2 shows the UV-Visible spectrum at different time interval: 0 minute, 15 minutes, 30 minutes, 45 minutes and 60 minutes. From the plotted spectrum, there was no significant different for all samples. As observed at 200 nm of wavelength, the absorbance of Se NPs was around 0.987% to 1.1%. Then, it increases to reach the highest peak at 2.583% when the wavelength was at 300 nm.

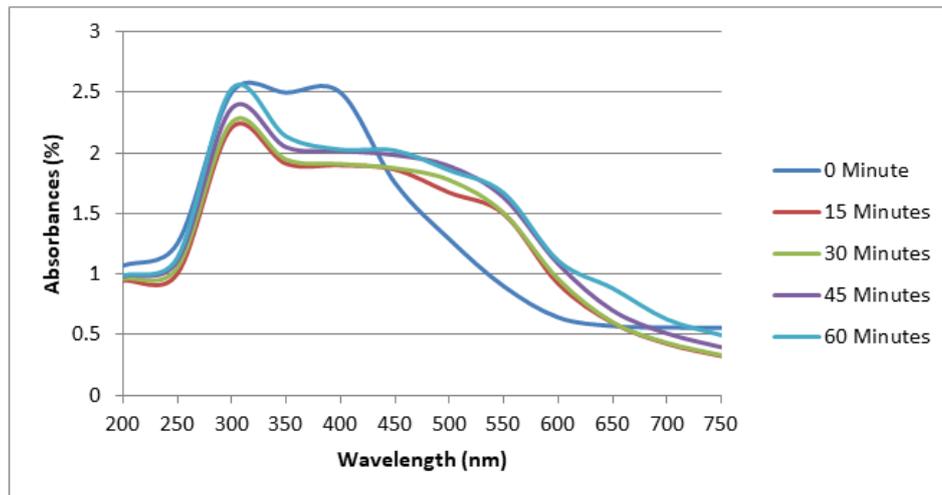


Fig.2: UV-Visible Spectrum at different time interval

This observation revealed that the absorbance maximum (λ_{max}) of produced Se NPs was at 300 nm of wavelength. It concludes that Se NPs produce low absorbance. The low absorbance of Se NPs is not suitable for the condition of high intensity of light. The colour of Se NPs solution also completely turned to brick-red at 60 minutes, resulting in a lower level of absorbance.

3.2 Field Emission Scanning Electron Microscopic Analysis

Field emission scanning electron microscopy is employed to analyse the shape and surface morphology of the produced Se NPs using *Polygonum minus* leaves extract. Fig. 3 shows FESEM images of Se NPs in the form of agglomerated spherical particles within the diameter range of 60 nm to 90 nm. These particles were well distributed with aggregation.

Therefore, it has been suggested that nanoparticle aggregation is dominant over the process of reduction and primary nucleation of reduced atoms (Alagesan & Venugopal, 2019; Kim, Hong, & Park, 2019). This may perhaps be related to the fact that a larger number of functional groups (*Polygonum minus* leaves extract) bind and nucleate sodium selenite with ascorbic acid (Sood, Arora, Shah, Kotnala, & Jain, 2016). The most accessible metal ions are apparently involved in a smaller number of nucleation events, which leads to an agglomeration of the metal (Shankar, Rai, Ahmad, & Sastry, 2004).

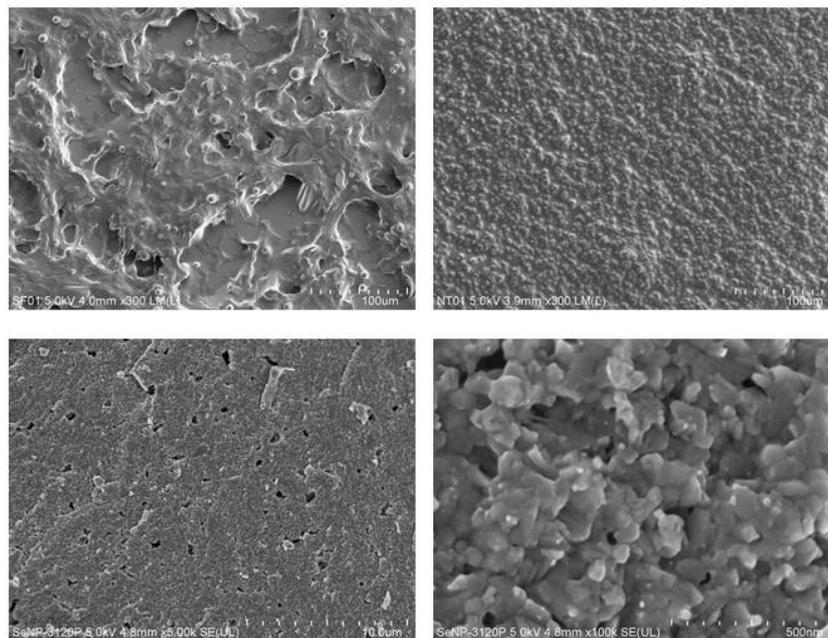


Fig. 3: FESEM images of Se NPs

3.3 Electrical Conductivity of Se NPs

Indium Tin Oxide (ITO) coated glass was used as a template to analyze the electrical conductivity of Se NPs. The resistance was measured using a simple digital multimeter. Table 1 shows the resistance, resistivity and electrical conductivity from the measured sample. It shows that the resistance reached up to 338.4 Ω . Resistivity was then calculated by using Eq. (1), resulted in 16.92 Ω .cm. Then, the electrical conductivity can be found through Eq. (2). It can be seen that the electrical conductivity of Se NPs exhibited lower values than those reported previously (Kalishwaralal et al., 2018). Electrical properties of selenium nanoparticles itself was in low conductivity because Se is one of non-metal category by referring to the periodic table.

Table 1: Electrical Conductivity of Selenium Nanoparticles (Se NPs)

Selenium Nanoparticles (Se NPs)		
Resistance, Ω (ohm)	Resistivity, ρ (Ω .cm)	Electrical Conductivity, σ (S/cm)
338.4	16.92	0.059

4. Conclusion

Low conductivity of 0.059 S/cm Se NPs was successfully produced by using *polygonum minus* leaves extract, which acts as a good reducing agent. The average size of 60 nm to 90 nm was recorded, confirmed the nanosize of the produced selenium. The resistivity and conductivity were recorded as 16.92 Ω .cm and 0.059 S/cm respectively. These characteristics might be useful in electronic devices. The produced Se NPs also exhibited low absorption, as at 300 nm, it only able to reach the peak value of 2.583%.

In conclusion, *polygonum minus* plant extract has supported the eco-friendly process, serve as a good reducing agent, and cost-effective for the synthesis of Se NPs instead of toxic and expensive chemical.

5. References

- Abu Samah, N., Ibrahim, A. L., Muhamad, S., Mahamudin, M., & Alias, R. (2020). Synthesis Of Silver Nanoparticles Using Polygonum Minus Extract And Analysis Of Their Antimicrobial Properties. *Selangor Science & Technology Review (SeSTeR)*, 4(1), 41 - 51.
- Alagesan, V., & Venugopal, S. (2019). Green Synthesis of Selenium Nanoparticle Using Leaves Extract of *Withania somnifera* and Its Biological Applications and Photocatalytic Activities. *BioNanoScience*, 9(1), 105–116. <https://doi.org/10.1007/s12668-018-0566-8>
- Alotaibi, S., Nama Manjunatha, K., & Paul, S. (2017). A study of selenium nanoparticles as charge storage element for flexible semi-transparent memory devices. *Applied Surface Science*, 424, 330–336. <https://doi.org/10.1016/j.apsusc.2017.03.091>
- Anu, K., Singaravelu, G., Murugan, K., & Benelli, G. (2017). Green-Synthesis of Selenium Nanoparticles Using Garlic Cloves (*Allium sativum*): Biophysical Characterization and Cytotoxicity on Vero Cells. *Journal of Cluster Science*, 28(1), 551–563. <https://doi.org/10.1007/s10876-016-1123-7>
- Chaudhary, S., & Mehta, S. K. (2014). Selenium Nanomaterials: Applications in Electronics, Catalysis and Sensors. *Journal of Nanoscience and Nanotechnology*, 14(2), 1658–1674. <https://doi.org/10.1166/jnn.2014.9128>
- Distilled Versus Deionized Water. (n.d.). Retrieved March 12, 2020, from <https://www.thoughtco.com/distilled-versus-deionized-water-609435>
- Effect of a chemical synthesis-based pharmaceutical wastewater on performance, acetoclastic methanogenic activity and microbial population in an upflow anaerobic filter - Ince - 2002 - Journal of Chemical Technology & Biotechnology - Wiley Online Library. (n.d.). Retrieved March 11, 2020, from <https://onlinelibrary.wiley.com/doi/abs/10.1002/jctb.629>
- Janssen, G.-J. (2005). 1.1.What does the word FESEM mean? *Scanning*, 1–5. Retrieved from www.sem.com/analytic/sem.htm
- Kalishwaralal, K., Jeyabharathi, S., Sundar, K., Selvamani, S., Prasanna, M., & Muthukumar, A. (2018). A novel biocompatible chitosan–Selenium nanoparticles

- (SeNPs) film with electrical conductivity for cardiac tissue engineering application. *Materials Science and Engineering C*, 92, 151–160. <https://doi.org/10.1016/j.msec.2018.06.036>
- Magnetic Stirrer - an overview | ScienceDirect Topics. (n.d.). Retrieved March 12, 2020, from <https://www.sciencedirect.com/topics/engineering/magnetic-stirrer>
- Mahmoodi, S. R., Bayati, M., Hosseinirad, S., Foroumadi, A., Gilani, K., & Rezayat, S. M. (2013). AC electrokinetic manipulation of selenium nanoparticles for potential nanosensor applications. *Materials Research Bulletin*, 48(3), 1262–1267. <https://doi.org/10.1016/j.materresbull.2012.12.026>
- Nanoparticles, S. S. (n.d.). *Synthesis, Coating, Characterisation and Stability of Selenium Nanoparticles*.
- Selenium Metal - online catalogue source - supplier of research materials in small quantities - Goodfellow. (n.d.). Retrieved February 19, 2020, from <http://www.goodfellow.com/E/Selenium-Metal.html>
- Shankar, S. S., Rai, A., Ahmad, A., & Sastry, M. (2004). Rapid synthesis of Au, Ag, and bimetallic Au core-Ag shell nanoparticles using Neem (*Azadirachta indica*) leaf broth. *Journal of Colloid and Interface Science*, 275(2), 496–502. <https://doi.org/10.1016/j.jcis.2004.03.003>
- Sood, A., Arora, V., Shah, J., Kotnala, R. K., & Jain, T. K. (2016). Ascorbic acid-mediated synthesis and characterisation of iron oxide/gold core-shell nanoparticles. *Journal of Experimental Nanoscience*, 11(5), 370–382. <https://doi.org/10.1080/17458080.2015.1066514>
- Ullah, H., Wilfred, C. D., & Shaharun, M. S. (2018). Green synthesis of copper nanoparticle using ionic liquid-based extraction from *Polygonum minus* and their applications. *Environmental Technology (United Kingdom)*, 33(30), 1–8. <https://doi.org/10.1080/09593330.2018.1485751>
- Understanding the Benefits and Risks of Deionized (DI). (n.d.). Retrieved March 12, 2020, from <https://theberkey.com/blogs/water-filter/understanding-the-benefits-and-risks-of-deionized-di-water>
- Wadhvani, S. A., Gorain, M., Banerjee, P., Shedbalkar, U. U., Singh, R., Kundu, G. C., & Chopade, B. A. (2017). Green synthesis of selenium nanoparticles using *Acinetobacter* sp. SW30: Optimization, characterization and its anticancer activity in breast cancer cells. *International Journal of Nanomedicine*, 12, 6841–6855. <https://doi.org/10.2147/IJN.S139212>
- Yusuf, S., Ahmad, S., Mansor, H., & Mahmood, M. (2010). Antioxidant activities, Flavonoids, Ascorbic acid and Phenolic contents of Malaysian vegetables. *Journal of Medicinal Plants Research*, 4(10), 881–890. <https://doi.org/10.5897/JMPR10.011>