Green Synthesis of Silver Nanoparticles using Lemon Extract, Characterization, and Antimicrobial Properties

[1]Kelly Biv; [1]Ryan Nolan; [2]Paul Kelly, PhD; [1]Christine MacTaylor, PhD; [1]Mustafa Yatin, PhD
[1]Department of Chemistry & Physics, [2]Department of Biology, Salem State University

Abstract

In this study, silver nanoparticles (AgNPs) were synthesized using lemon extract. A color change was observed during the synthesis process. The synthesized AgNPs were characterized using the ultraviolet – visible (UV–Vis) spectrometer and the scanning electron microscope (SEM) machine. Both the UV–Vis spectra and SEM images indicated the presence of AgNPs and metallic silver particles. The antimicrobial properties of AgNPs were tested using the disk diffusion agar method on four different bacteria: *E. coli, P. aeruginosa*, *S. aureus*, and *V. parahaemolyticus;* zones of inhibition were observed.

Introduction

Silver nanoparticles (AgNPs) are known for its antimicrobial activity. Usually, the process to synthesize AgNPs involves sodium citrate, as a reducing agent.[1] A greener alternative is to use lemon extract as it contains citric acid, which can act as the reducing agent and stabilizer.[2,3] The benefit of using lemons is that they are cheap, commercially available, and environmentally safe.

A benefit of working with AgNPs is its observable color change as its properties change. A yellow/orange color depicts smaller AgNPs size as opposed to the purple/greenish blue color, which depicts a larger size.[1]

Experimental Design

Preparation of the Lemon Extract:
Two fresh lemons were cut and squeezed through a combination of cheese cloth and coffee filter. Then, the lemon juice was put inside a centrifuge for 10 minutes at 10,000 rpm.

Experimental Design

Synthesis of AgNPs from Lemon Extract:[2]
A 0.065 M silver nitrate solution was mixed with the lemon extract at a 1:4 ratio. The solution was heated in a water bath at 90℃ for 30 minutes. Color changes were observed.

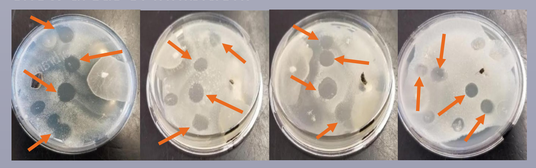
Figure 1: AgNPs solution in the water bath. The color at the start was yellow-orange, but it quickly changed to brown during the process, and ended with a deep black color.

Characterization of AgNPs using the UV-Vis Spectrometer:
The AgNP solution was centrifuged and diluted with distilled water to 0.0019 M. Then, it was run in the spectrometer at different wavelengths around the range of 250 nm to 590 nm.

AgNP Observations through the SEM:
The AgNPs was centrifuged and freeze-dried for 24 hours, before running them in the SEM machine for observations.

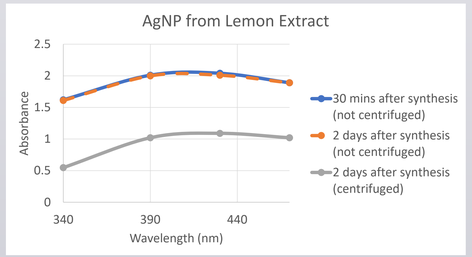
Antimicrobial Testing:
AgNPs at different concentrations were tested against *E. coli, P. aeruginosa*, *S. aureus*, and *V. parahaemolyticus.*

Figure 2: Photographs of the AgNP solutions at different concentrations after 48 hours, measuring against (left to right): *E. coli, P. aeruginosa*, *S. aureus*, and *V. parahaemolyticus*. The clear spots show areas of inhibition.



Results & Discussion

Characterization Data from UV-Vis:



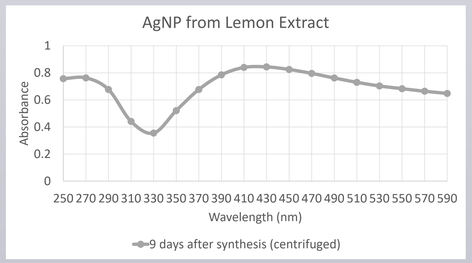
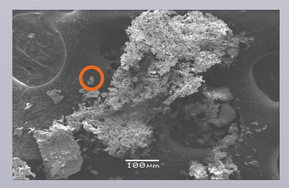
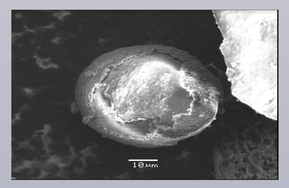


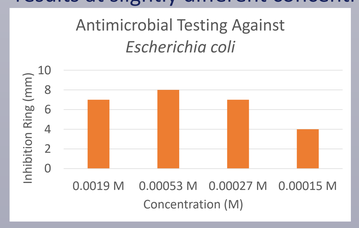
Figure 3: Characterization of AgNP on UV-Vis, showing the highest peak of absorbance to be ~420 nm. AgNPs are known to show a high absorption in the UV-Vis at around 400 – 500 nm.[3]

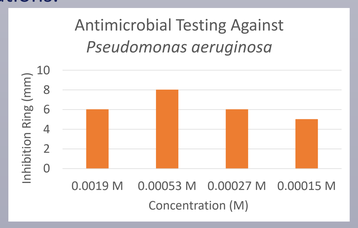
SEM Data: Photo on the left shows potential AgNPs agglomerating at 100 µm circled in orange, and on the right, a photo of potential metallic silver at 10 µm.

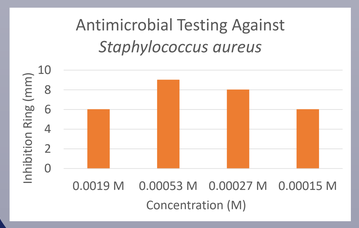


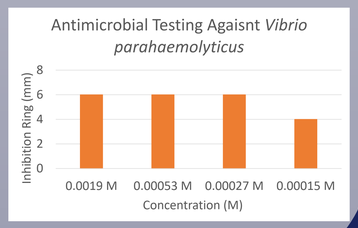


Antimicrobial Results: Bar graphs of the antimicrobial results at slightly different concentrations.









Conclusion

Although the UV-Vis data seems to support that AgNPs were successfully synthesized, there is a very high chance that the AgNPs synthesized quickly agglomerated as shown at the end of the synthesis with the black color and the clumps seen in the SEM machine. This color change may also be due to the oxidation of metallic silver to silver oxide.

In future studies, to limit the AgNPs from agglomerating, the synthesis will be conducted at room temperature, as heat affects the AgNPs to come together into clusters. Other instrumental methods, such as the Fourier transform–infrared (FT–IR) spectroscopy will also be performed to further characterize the AgNPs.

References

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Acknowledgements

We wanted to thank:
- Dr. Jayashree Ranga for her support and help on the AgNP images interpretation.
- Jessica Christel for providing us with the materials and equipment.