Green Synthesized Silver Nanoparticles and their Potential Antibacterial Efficacy

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As a result of the COVID-19 pandemic face mask usage has become common in every household. While necessary, this has created an influx of biohazardous waste entering improper waste streams which poses risks to sanitation workers and the environment.
Silver nanoparticles (AgNPs) are a well known antimicrobial, and could improve the efficacy and longevity of face masks (and other personal protective equipment). Traditional syntheses, however, can be both environmentally and personally hazardous with reducing agents such as sodium borohydride. “Green” syntheses utilizing plant matter as both reducing agents could solve this while also simplifying and improving AgNP synthesis.

How do different green synthesized silver nanoparticles compare as antimicrobials for potential uses in personal protective equipment?

Experimental or Approach Taken

Synthesis of a more traditional synthesized AgNP utilizing sodium citrate as both the stabilizing and reducing agent to establish a simple chemically reduced AgNP for comparison.[1]

The final syntheses of each green AgNP followed the same method utilizing 1 mL of the plant extract reducing agent and 2mM AgNO3

The resulting AgNPs were characterized via color change (orange-red-brown) and UV-Vis absorption peak between 415-450 nm.

Final analysis of antibacterial activity using e.coli growth and Kirby Bauer disk-disk diffusion assays.

Figure 1. AgNP synthesis at 60 minutes. *From left to right; Poppy AgNPs, Sodium Citrate AgNPs, and Sword Fern AgNPs*

Kirby-Bauer Disk-Disk Diffusion Assay

This test is designed to evaluate the antibacterial efficacy of an antimicrobial agent by measuring the zone of inhibition surrounding .

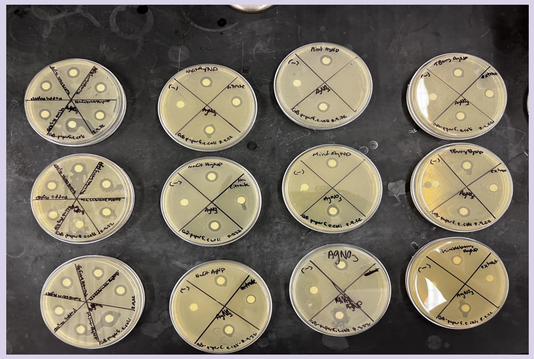

Figure 2. Filter paper disk Kirby Bauer Diffusion Assays of various AgNPs and corresponding controls

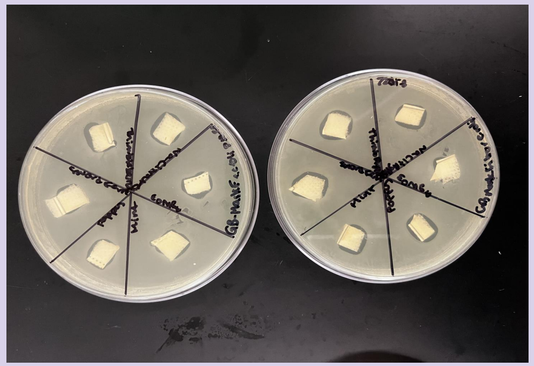

Figure 3. Two trial Kirby Bauer Assays utilizing face mask disks comparing every AgNP and AgNO3.

Each AgNP showed varying degrees of antibacterial activity, however most had only slight increase in efficacy as compared to the AgNO3 control which warrants further testing.

Successful novel syntheses

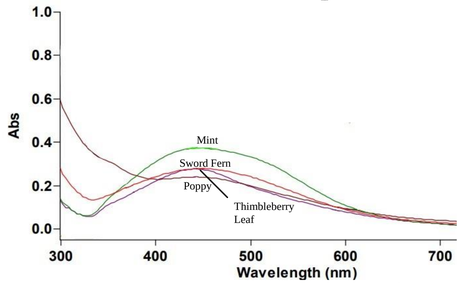

Figure 4. UV-Vis Absorption Spectra of the 4 green AgNPs

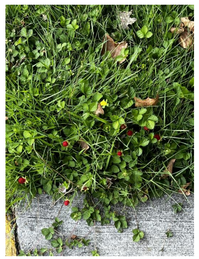

Figure 5. Thimbleberry plants from Outside the Chem Building used for synthesis

Plant Extract	Success	Failure	Existing Literature ?
Garlic		x	Yes
Mint	x		Yes
Poppy	x		Yes
Tall Oregon Grape Leaf		x	No
Sword Fern	x		No
Thimbleberry Leaf	x		No

Table 1. Table detailing the six plant extracts trialed as reducing + stabilizing agents. Four syntheses were successful, two of which are novel syntheses with no previously established literature.

Conclusion

The primary takeaway of this research is the establishment of two novel green AgNP syntheses; the thimbleberry leaf AgNP and the sword fern AgNP. Future research is needed to evaluate different reaction conditions (such as temperature, AgNO3 concentration, Plant extract mg/mL concentration, reducing agent concentration aka final concentration of plant extract, pH) for improved monodispersity and antimicrobial efficacy of the synthesized AgNPs. Additional e.coli growth rate tests are also needed, and could be expanded to include gram-positive bacteria as well. Use of TEM and SEM could give better insight into the size and morphology of the synthesized AgNPs.

Acknowledgments

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Literature Cited

1. Mousavi-Khattat, M., Keyhanfar, M., & Razmjou, A. (2018). A comparative study of stability, antioxidant, DNA cleavage and antibacterial activities of green and chemically synthesized silver nanoparticles. *Artificial Cells, Nanomedicine, and Biotechnology*, *46*(sup3), S1022–S1031. https://doi.org/10.1080/21691401.2018.1527346
2. Loo, Yuet Ying, et al. “In Vitro Antimicrobial Activity of Green Synthesized Silver Nanoparticles Against Selected Gram-Negative Foodborne Pathogens.” *Frontiers in Microbiology*, vol. 9, 2018. *Frontiers*, https://www.frontiersin.org/articles/10.3389/fmicb.2018.01555.