Effects of synthesis temperature on the size distribution of silver nanoparticles synthesized using *Psidium guajava* leaf extract and its antibacterial activity

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ABSTRACT

Silver nanoparticles have been well known to possess efficient antibacterial properties. In this study, the biological route was used to synthesize silver nanoparticles using Psidium guajava leaves extract mixed with silver nitrate. Syntheses were done at varying temperatures, namely 30oC, 50oC, 70oC, and 90oC, to investigate its effects on the size distribution and the antibacterial properties of the synthesized silver nanoparticles.

Results revealed a blue-shift of surface plasmon resonance peaks were observed. Transmission electron microscopy (TEM) results showed that particle distribution decreases as synthesis temperature increases, with mean sizes of 57.74, 51.12, 45.24, and 33.81 nm. The dynamic light scattering (DLS) hydrodynamic size distribution revealed the same decreasing pattern with increasing synthesis temperature. Fourier Transform - Infrared (FTIR) spectra also showed that the synthesized AgNPs were capped with phenolic compounds from the biomolecules in Psidium guajava leaves. XRD analysis revealed that the obtained AgNPs had a crystallinity index of 79.3% with an average crystallite size of 10.98 nm.

Finally, antibacterial tests via Disc Diffusion Test suggested that the AgNPs synthesized at higher temperatures are more effective bactericides than those synthesized at lower temperatures, as indicated by the increasing trend of the measured inhibition zones as synthesis temperature increases. Antibacterial activity was also more effective on the gram-negative bacteria than on the gram-positive one.

INTRODUCTION

E. coli

-Gram negative bacteria ->
-thinner cell wall
-Can double their number in just 20 minutes
-Cause diarrhea and vomiting
-Fecal contamination in water
-Optimum growth at 37-49 degrees Celsius

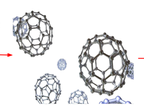
S. aureus

-Gram positive bacteria ->
-thicker cell wall
-Cause cellulitis, eczema,
-multiple skin and soft tissue infection
-Capable of growing within 35-37 degrees Celsius

Chlorine

-Highly corrosive and toxic
-Hazardous to the environment
-Long reaction time
-Health problems have been reported
-Lower effectiveness when used in water decontamination

Alternative

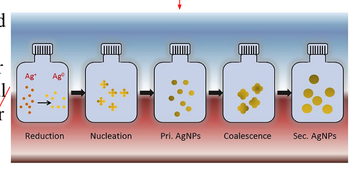


Metallic nanoparticles

-High performance
-Affordable treatment
-Designed and manufactured in nanoscale
-Applicable as absorbents or catalyst in removing harmful substances from waste water and other surfaces

Guava leaf extract

AgNO3

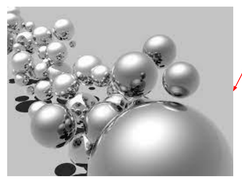


Green synthesis

-Use of nontoxic chemicals
-Cost effective
-Environment-friendly
-Facile and mild
-Large-scale
-Long-term stable
-Less energy is used to synthesize NPs

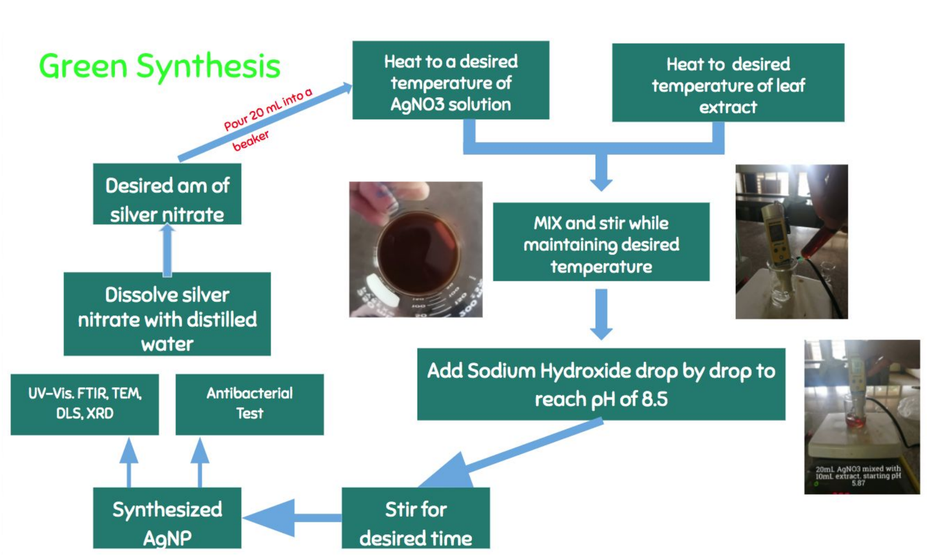
Particle size is inversely proportional with temperature

$$r_{crit} = \frac{-2\gamma}{\Delta G_v} = \frac{2\gamma v}{k_B T \ln S}$$

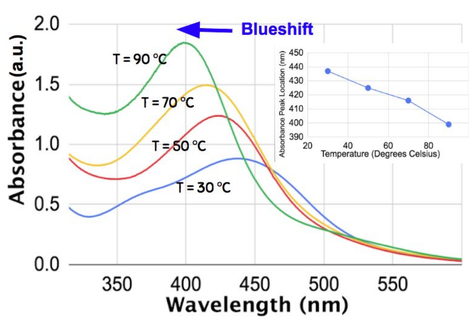


Silver nanoparticles (AgNPs)

METHODOLOGY



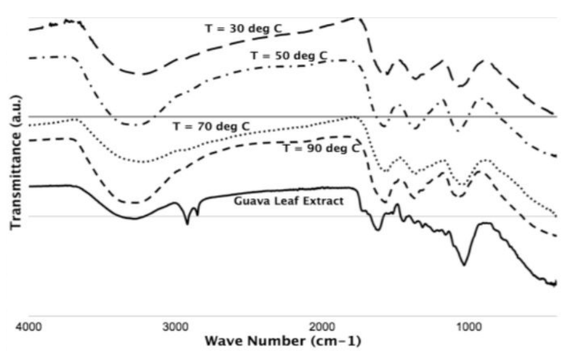
UV-Vis, FTIR



UV-Vis Absorbance Spectra

Synthesis Temperature (deg C)	Absorbance Peak (*nm*)
30	437
50	425
70	416
90	399

Blueshift is observed as synthesis temperature increases, maybe due to reduction in particle size distribution.

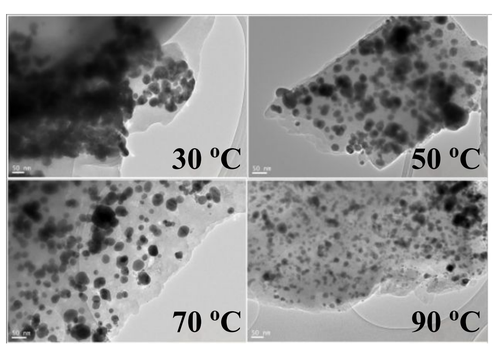


FTIR Spectra

The disappearance of some of the peaks in the extract spectrum in the AgNPs spectra implies that those groups acted as the reduction agents during the synthesis. ==> **glucose moieties and carbonyl groups**

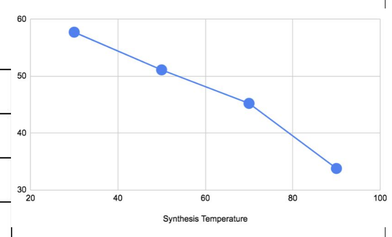
Peaks that are retained means that the biomolecules in those groups coated the final AgNPs as capping agents ==> **phenolic compounds (flavonoids, quercetin, phytochemicals, and other plant antioxidants)**

TEM, DLS

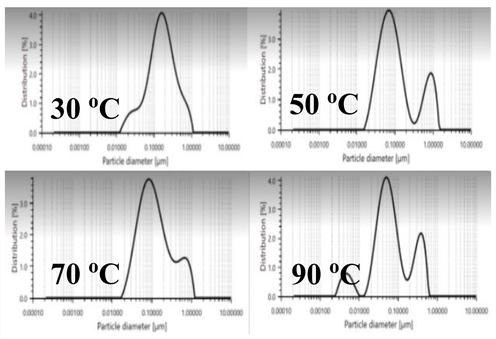


TEM Images of the obtained AgNPs

Temperature	Mean Size (*nm*)
30	57.74
50	51.12
70	45.24
90	33.81

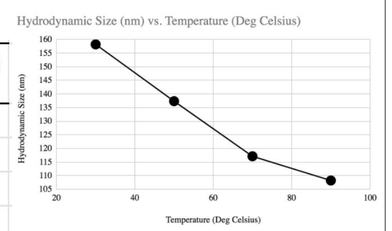


Synthesis Temperature vs Mean Particle Size



DLS Hydrodynamic size distribution

Synthesis Temperature (deg C)	Hydrodynamic Size (*nm*)
30	148.2
50	137.3
70	117.1
90	108.2

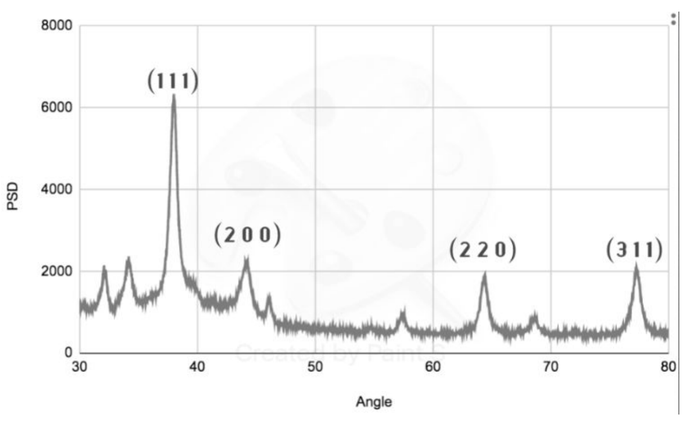


Synthesis Temperature vs Hydrodynamic Size

Both particle size and hydrodynamic size decrease as synthesis temperature increases consistent with the equation below

$$r_{crit} = \frac{-2\gamma}{\Delta G_v} = \frac{2\gamma v}{k_B T \ln S}$$

XRD

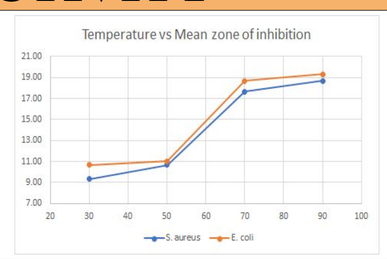


Diffraction Peaks, 2θ (deg)	Lattice Planes (*h*, *k*, *l*)
37.99225	(1 1 1)
44.11121	(2 0 0)
64.34026	(2 2 0)
77.27804	(3 1 1)

Mean Crystallite Size: 10.98 nm
Crystallinity Index: 79.3%

ANTIBACTERIAL ACTIVITY

Synthesis Temperature (C)	Zone of Inhibition (ZOI), mm	
	S. aureus (gram-positive)	*E. coli* (gram-negative)
30	9.33	10.67
50	10.67	11.00
70	17.67	18.67
90	18.67	19.33



ZOI increases with increasing synthesis temperature indicating increase in antibacterial efficacy.

AgNPs synthesized at 90 degrees have better efficacy compared with those synthesized with lower temperatures, due to their smaller size

CONCLUSION

- Increasing synthesis temperature causes the AgNPs' SPR absorbance to blueshift due to the decrease of particle size distribution.
- Zone of inhibition, which is a measure of the effectiveness of the obtained AgNPs, increases with increasing synthesis temperature.
- For antibacterial applications, AgNPs synthesized at higher temperatures are more effective bactericides than those synthesized with lower temperatures.

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