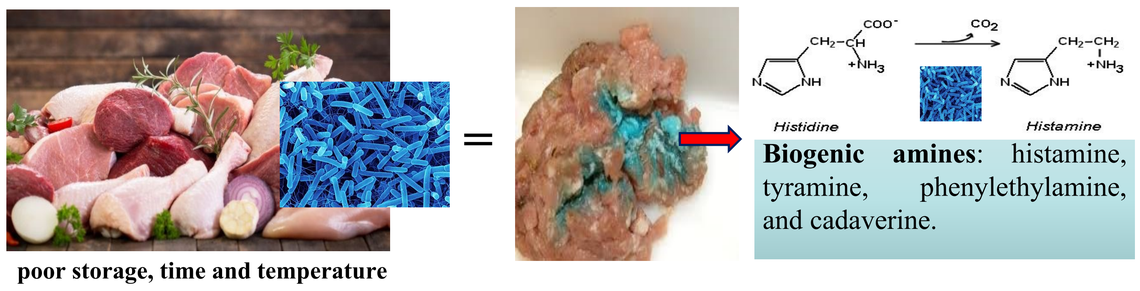
Influence of the Sizes of Gold Nanoparticles on its Colorimetric Sensing for Chicken Meat Spoilage Detection

Rolen Brian P. Rivera*, Noel Lito B. Sayson, Arnold A. Lubguban, Roberto M. Malaluan, Gaudencio C. Petalcorin Jr., Rey Y. Capangpangan, Felmer S. Latayada, Arnold C. Alguno

Materials Science Laboratory, Physics Department, Mindanao State University - Iligan Institute of Technology, A. Bonifacio Avenue, Tibanga, 9200 Iligan City, Philippines
Premier Research Institute of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Iligan City 9200, Philippines
*E-mail: rolenbrian.rivera@g.msuiit.edu.ph

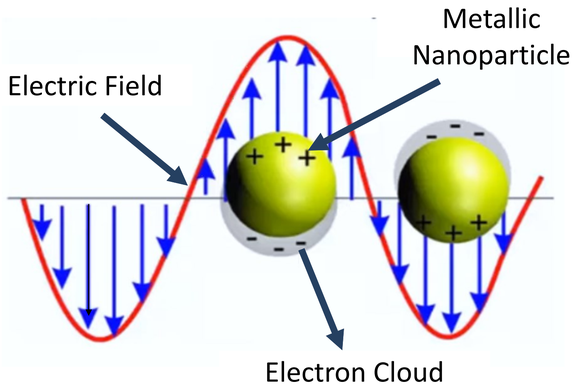
INTRODUCTION

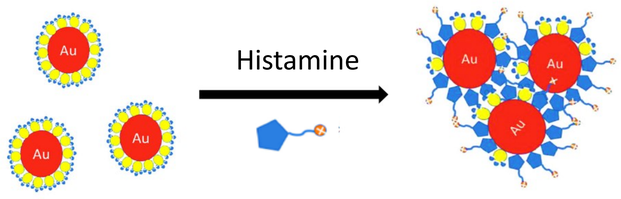


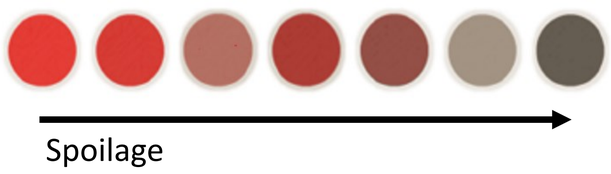
Biogenic amines: histamine, tyramine, phenylethylamine, and cadaverine.

Gold Nanoparticles (AUNPs) as Colorimetric Sensor

Localize Surface Plasmon Resonance(LSPR)







Importance of size:
Controlling the size of metal nanoparticles is technologically important because of the strong correlation between these parameters and optical, electrical, and catalytic properties due to LSPR:

- ✓ Electromagnetic enhancement around the nanoparticle
- ✓ Enhancement has a resonant frequency
- ✓ Resonance shifts based on environment, shape, size and material

Related Studies:

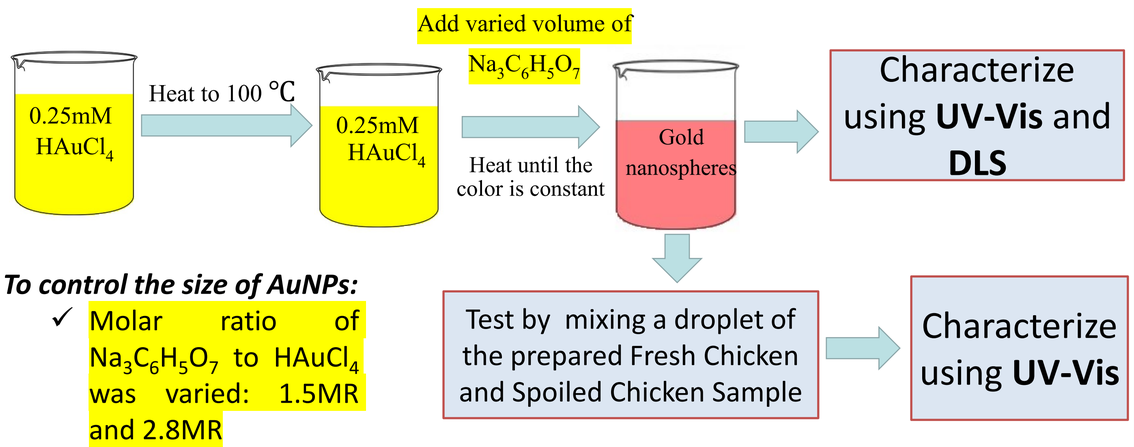
- ❖ AuNPs are utilized as a colorimetric sensor for biogenic amine detection in spoiled food.[1]

Present Study:

- ❖ Varied Sizes of AuNPs were synthesized and investigated its influence on the colorimetric detection of chicken meat spoilage.

METHODOLOGY

Citrate Reduction Method



To control the size of AuNPs:

- ✓ Molar ratio of $Na_3C_6H_5O_7$ to $HAuCl_4$ was varied: 1.5MR and 2.8MR

Mie Theory Simulation

provides a simple interface to the classic BHMIE algorithm for Mie scattering from a sphere - as published by Bohren and Huffmann in "Absorption and scattering of light by small particles" (ISBN 0-471-29340-7)[2]

- ❖ Software: MiePlotv4620 [2]
- ❖ Wavelength vs Cross Sections (extinction (C_{ext}) , absorption (C_{abs}) , scattering C_{sca})

Input Parameters:

- ➢ Size (varying parameter)
- ➢ Refractive index (constant)
- ➢ Spectrum (constant)

References:

1. K. M. A. El-Nour, et.al., Gold Nanoparticles as a Direct and Rapid Sensor for Sensitive Analytical Detection of Biogenic Amines, Nanoscale Research Letters 12 (2017) 231.
2. http://www.philiplaven.com/mieplot.htm#Download%20MiePlot

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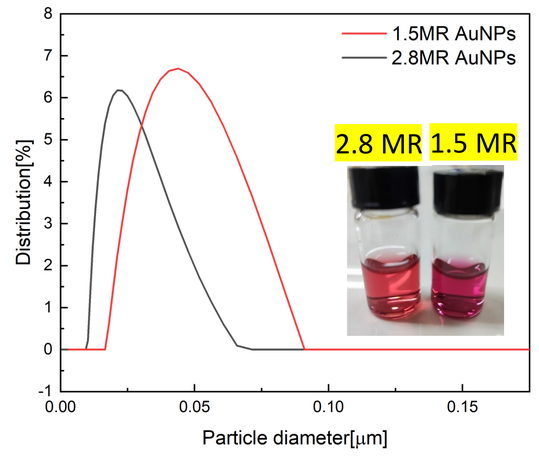
RESULTS and DISCUSSION

Dynamic Light Scattering (DLS)



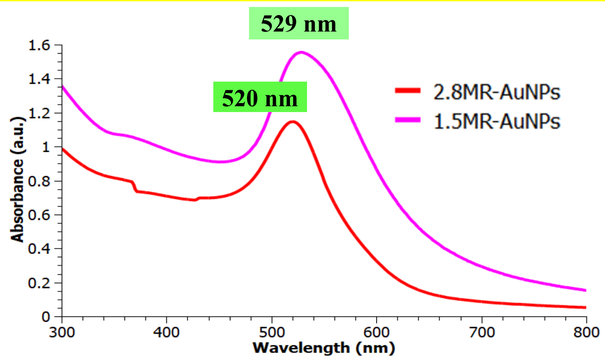
Particle Diameter:
1.5MR – 37.14nm
2.8MR – 23.90 nm

Polydispersity index:
1.5MR – 0.28
2.8MR – 0.24

The figure shows the size distribution of AuNPs of varied $Na_3C_6H_5O_7$ to $HAuCl_4$ molar ratios.

The higher molar ratio (2.8MR) produces smaller nanoparticles sizes around 24nm and a lower polydispersity index while a lower molar ratio (1.5MR) produces larger nanoparticles sizes around 37nm and a higher polydispersity index

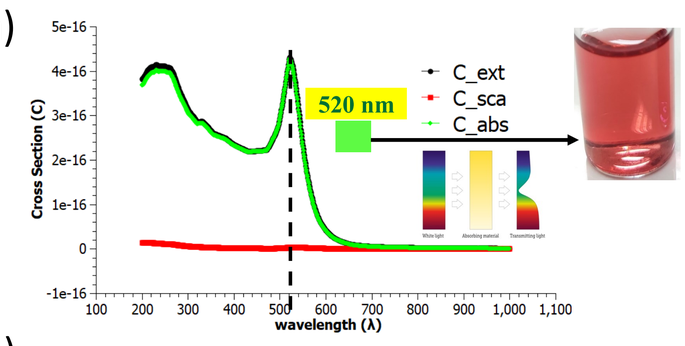
Ultraviolet–Visible (UV-Vis) Spectroscopy



The figure shows the Absorbance spectra of AuNPs of varied $Na_3C_6H_5O_7$ to $HAuCl_4$ molar ratios.

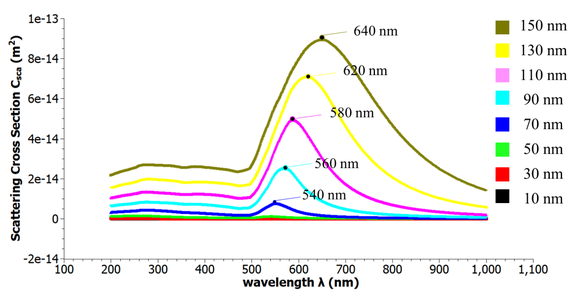
A red shift in the absorbance peak from 520nm to 529nm can be observed as the molar ratio of the precursors was decreased due to the increase in nanoparticle size as supported by the DLS result

Mie Theory Simulation Results

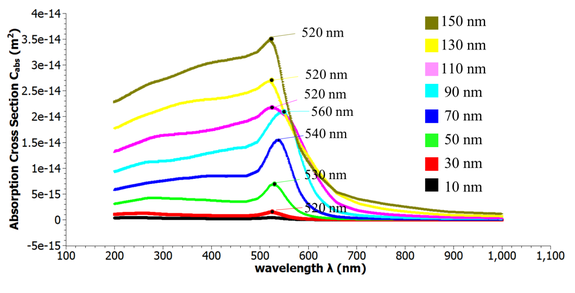


The figure shows the Wavelength vs Cross Section (extinction (C_ext) , scattering (C_sca) and absorption cross section (C_abs)) for AuNPs of particle sizes of:
a) 20nm b) 40nm

- ❖ for smaller-sized nanoparticles the extinction cross-section is dominated by the absorption while the particle equally scatters all wavelengths
- ❖ As the particle size increases, the appearance of scattering cross section peaks can be observed
- ❖ The resulting color of the AuNPs solution is attributed to the absorption and scattering of light by the nanoparticles

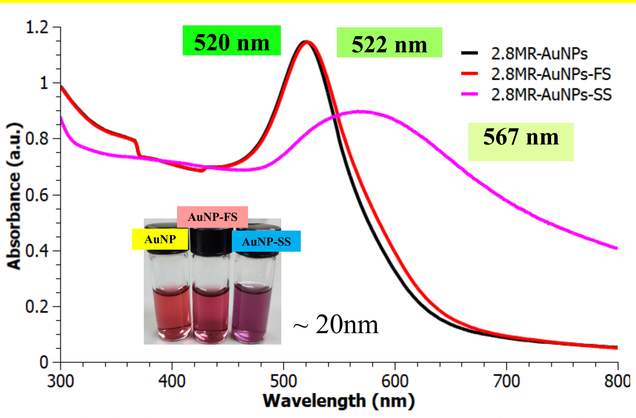


Wavelength vs Extinction Cross Section (C_{ext}) of various sizes of AuNPs

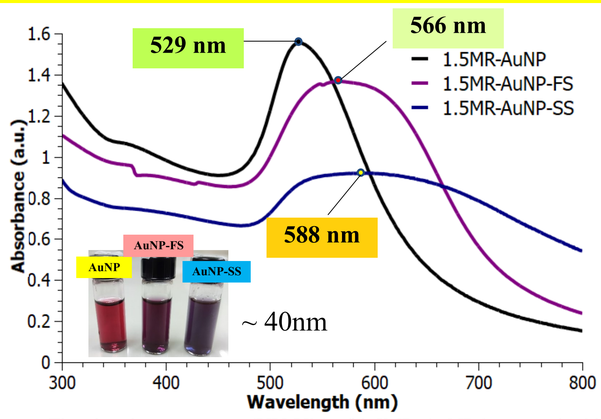


Wavelength vs Absorption Cross Section (C_{abs}) of various sizes of AuNPs

Response of AuNPs to chicken meat spoilage



The absorbance spectra (UV-Vis) of 2.8MR-AuNP interacted with Fresh chicken Sample (FS) and Spoiled chicken Sample (SS)



The absorbance spectra (UV-Vis) of 1.5MR-AuNP interacted with Fresh chicken Sample (FS) and Spoiled chicken Sample (SS)

- ❖ Distinct color change can be observed when interacting with Fresh and Spoiled chicken samples for both sizes of AuNPs, implying that synthesized AuNPs can distinguish fresh from spoiled.
- ❖ The size of AuNPs affects the color response due to the significant change in their Absorbance peaks.

CONCLUSION

Varied sizes of AuNPs were successfully synthesized by varying the molar ratio of $Na_3C_6H_5O_7$ to $HAuCl_4$. to 1.5MR and 2.8MR. Sizes around 20nm and 40nm were produced with absorbance peaks at 520nm and 529nm, respectively. Simulation results confirm that a red shift on the absorbance peak occurs as the AuNPs size increase (10nm-100nm). It is found that the synthesized AuNPs can distinguish fresh from spoiled due to the distinct color change on AuNPs when interacting with the fresh and spoiled samples. The size of AuNPs affects the color response due to the significant change in their Absorbance peaks.