ANALYZING THE NANOSCALE PROPERTIES OF GOLD NANOPARTICLES USING UV-VIS SPECTROSCOPY AND TRANSMISSION ELECTRON MICROSCOPY

Asher David[2], Aidan Dauber[2], Jillian Ketchen[2], Gregory Kwan[2], Xuedan Ma[1], Jillian Mills[2], Jacob Shalabi[2], Erica Strojny[2], Ritul Soni[2], Benjamin Voliva[2]

[1]Argonne National Laboratory, Argonne, IL 60439
[2]Lincoln-Way East H.S., Frankfort, IL 60423

ABSTRACT

The purpose of the experiment is to observe the scattering phenomena that the gold nanoparticles (Au NPs) exhibit and to identify the relationship between NP size and resonance frequency. The Au NPs will be synthesized via the reduction of Chloroauric acid ($HAuCl_4$) by sodium citrate and will adhere to a uniform quasi-spherical shape. Through microscopy and spectroscopy techniques, the metrology and optical characterization of the Au NPs will be determined at the CNM. Data will then be collected on the morphology and resonance frequencies of the substances. The results are anticipated to show a direct correlation between nanosphere diameter and scattering intensity. Furthermore, as nanoparticle size increases, a red shift in the UV-Vis spectrum is expected.

MOTIVATION

Changes in the size and shape of gold nanoparticles (Au NPs) result in the shift of surface plasmon resonance. This observed behavior has been proven effective in a multitude of scientific applications such as discriminating single nucleotide polymorphism and the quenching of various fluorescent dyes. Recently, research has found that Au NPs can be utilized in cancer treatment, because they are non-toxic and safe for injection into the body. Au NPs can gather in large quantities in tumor cells, and due to their unique surface plasmon resonance, they will create an optical scattering around the cell cluster. This can be manipulated into forming a probe that can microscopically detect the tumor cells and advance studies in cancer treatment. With significant results, we hope to discover new innovations in nanoscience that will create a gateway to future discoveries.

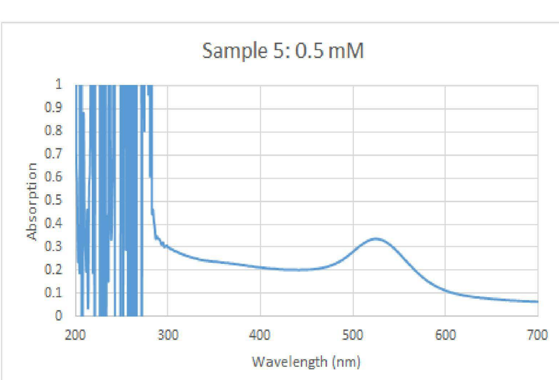
SAMPLE PREP AND TECHNIQUES

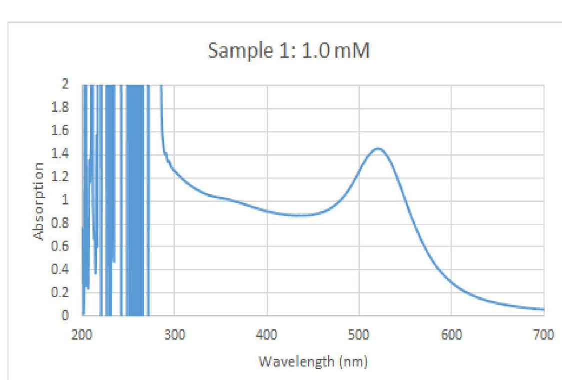
We utilized the Turkevich method to derive prime gold nanoparticle samples, ranging from 20 to 30 nanometers. We first obtained Trisodium Citrate (Na_3Ctr) and Chloroauric Acid ($HAuCl_4$) in the purest qualities available. Then, 20 mL of a 1.0 mM gold chloride ($HAuCl_4$) solution and 2mL of a 1% solution of trisodium citrate (NaCt) were prepared, all with deionized water. The flask containing $HAuCl_4$ solution was heated using a hot plate with vigorous stirring. When the $HAuCl_4$ solution reached its boiling point, the Sodium Citrate solution was rapidly added into the boiling $HAuCl_4$ solution, producing gold nanoparticles. The molar ratio of Sodium Citrate to Chloroauric Acid will be the primary factor utilized to achieve the desired particle size. The mixed solution will be complete once the color changes from yellow to a deep red color. We then changed the concentration of the $HAuCl_4$ solution to achieve a different molar ratio, changing the size and properties of the Au NPs.

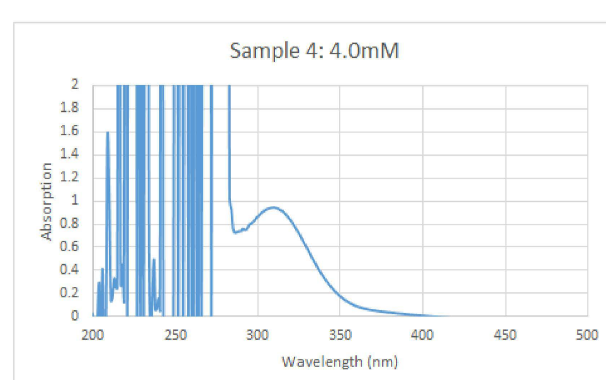
This experiment used a transmission electron microscope (TEM) and UV-Visible spectroscopy to determine the geometry of Au NPs, supplied by the Center for Nanoscale Materials. A transmission electron microscope will supply us with detailed images of the Au NPs and an electron beam will be aimed at the sample to give a higher resolution image.

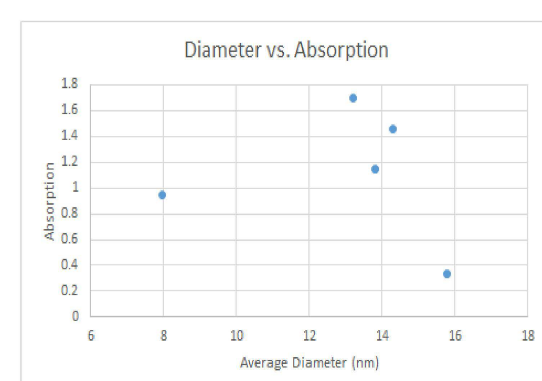
RESULTS

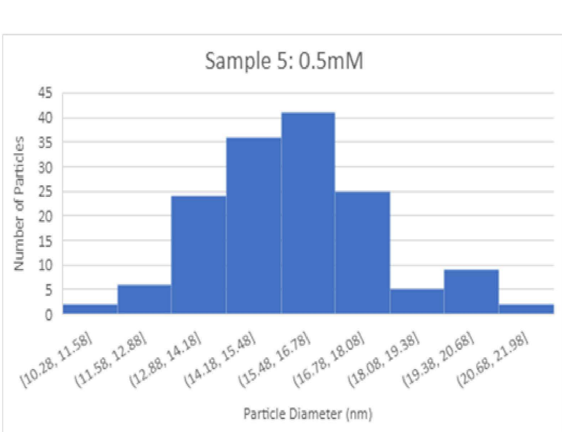
The first set of graphs shows each sample's wavelength in nanometers in relation to the sample's absorbance. Each sample's peak position was calculated which represents the sample's average wavelength. The second set shows each sample's distribution of diameter among Au NPs. The final graphs show the relationship between concentration and diameter and diameter and absorption.

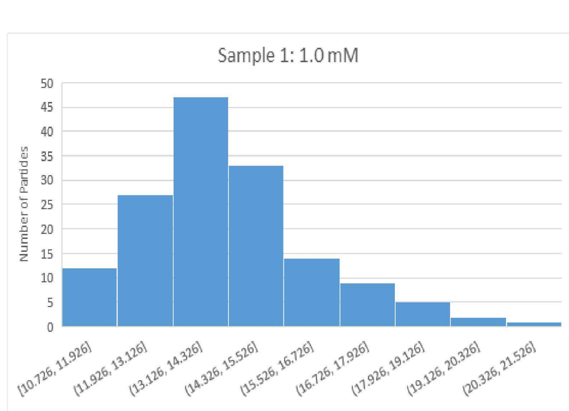


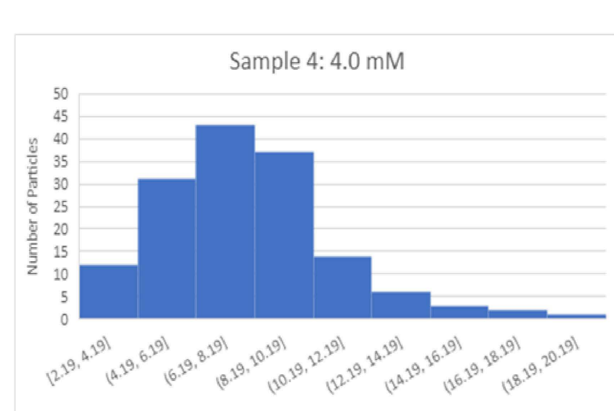


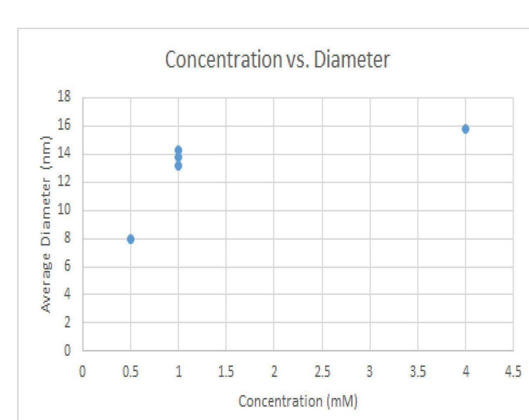




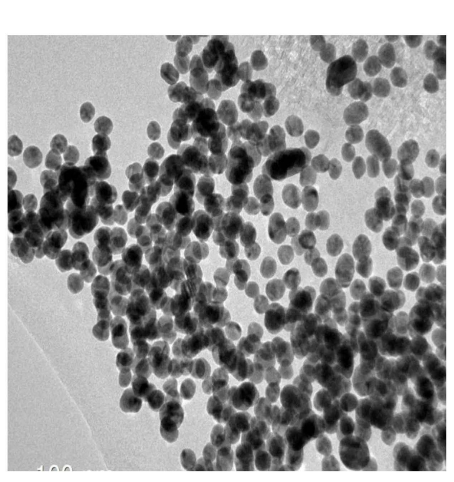




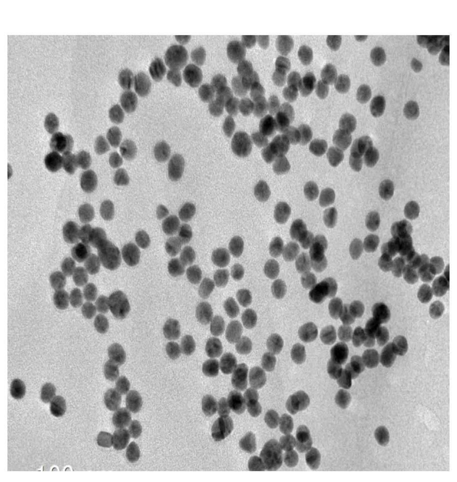




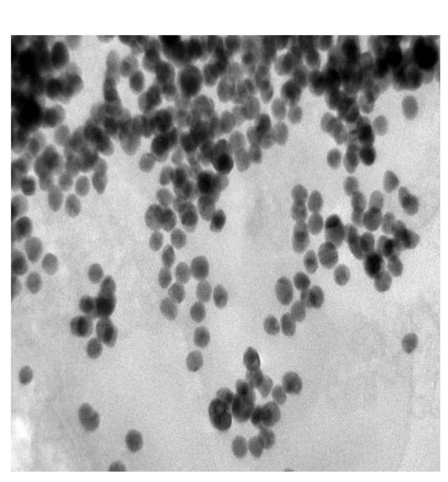
Images were taken of each nanoparticle sample using a transmission electron microscope. Roughly 60 individual nanoparticles per sample were measured then used to calculate an average diameter (in nanometers) using ImageJ.



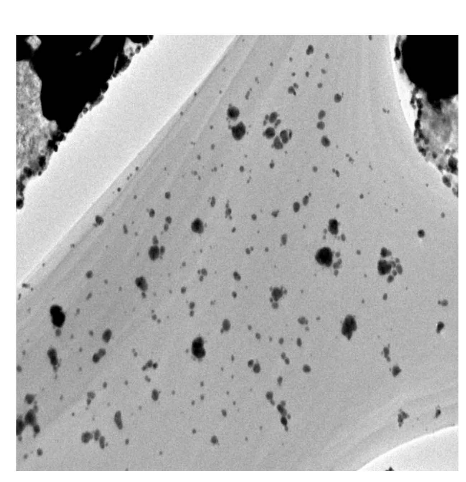
Sample 1.
14.3 nm



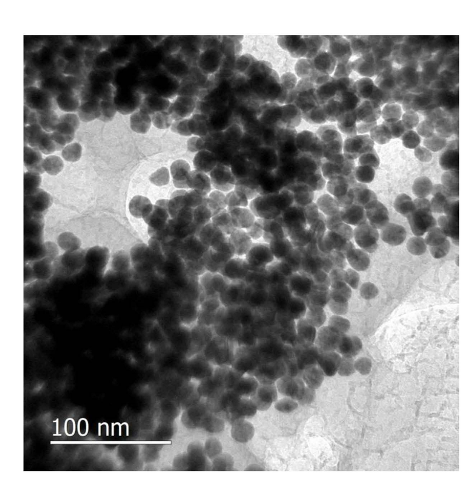
Sample 2.
13.8 nm



Sample 3.
13.19 nm



Sample 4.
7.95 nm



Sample 5.
15.77 nm

CONCLUSION

Our data revealed that as the concentration of the $HAuCl_4$ solution increased from 1.0 mM to 4.0 mM, the average wavelength decreased. However, as the concentration decreased from 1.0 mM to 0.5 mM, no drastic change in average wavelength was found. The data indicated a correlation between concentration and the average diameter of each nanoparticle. As concentration increased, the average diameter increased about 0.57 nanometers per increase of 1 mM. Conversely, the diameter of our 0.5 mM sample was significantly lower than our first three samples made from 1.0 mM $HAuCl_4$ solution. These findings suggest that the relationship between diameter and concentration is not linear and may relate more closely to a logarithmic growth curve, but more tests would be needed to confirm this prediction.

NEXT STEPS

The properties of Au NPs are determined by both the size and shape. Our experiment utilized the Turkevich method to synthesize the Au NPs. Future experiments can include testing different methods of synthesis, such as the seeding growth method, to achieve different geometric properties that will have different applications in nanotechnology, biochemical sensing and imaging. Our results provided here can be applied to fields of solar energy research, as well as medical research to be used in certain cancer treatments.

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