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Study On Relation Between Gold Nanorattle Core Diameter and Sensitivity to Target Proteins in Solution

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John Cashin

Independent Study Report

Goal

The goal of my independent study project was to research the relation between the core diameters of gold nano-rattles (AuNRTs) and their sensitivity in the detection of target proteins in solution. While keeping the size and shape of the AuNRTs uniform, and varying only the diameters of the gold nano-particle (AuNP) cores, I hoped to utilize two separate methods of determining AuNRT sensitivity to quantify a distinct difference in relation to AuNP diameter.

Progress/Results

AuNPs of 10, 20, and 30nm diameter were used as the cores of my AuNRTs. As the smaller particles would lead to more gold in solution, I first brought the extinction peaks of the three AuNP batches into close alignment.

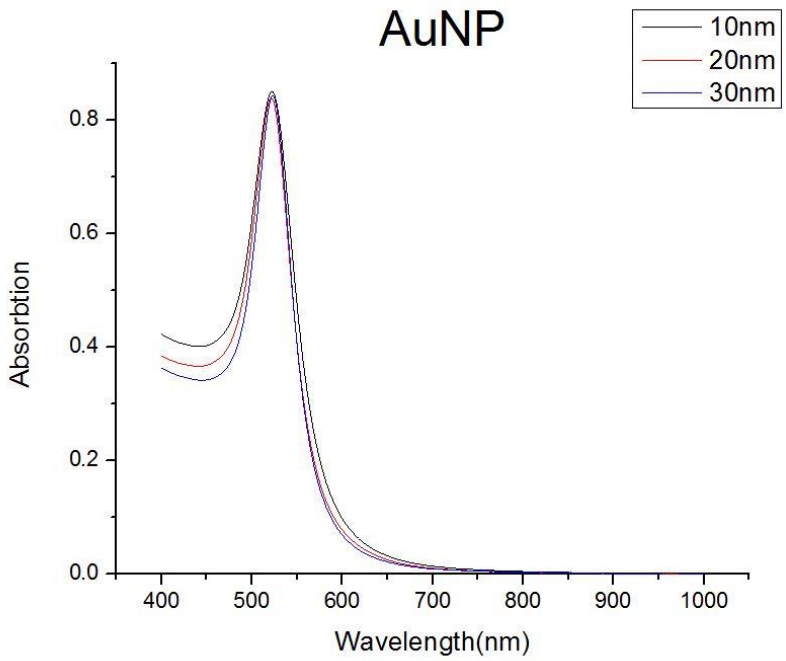


Figure 1: Ultraviolet-Visible (UV) Spectroscopic analysis of AuNP solutions with varying core diameters.

The close relation of the extinction peaks indicated that the overall volume and surface area of gold in solution was uniform. This allowed me to then move forward in coating the AuNP with silver, forming AuAg cubes.

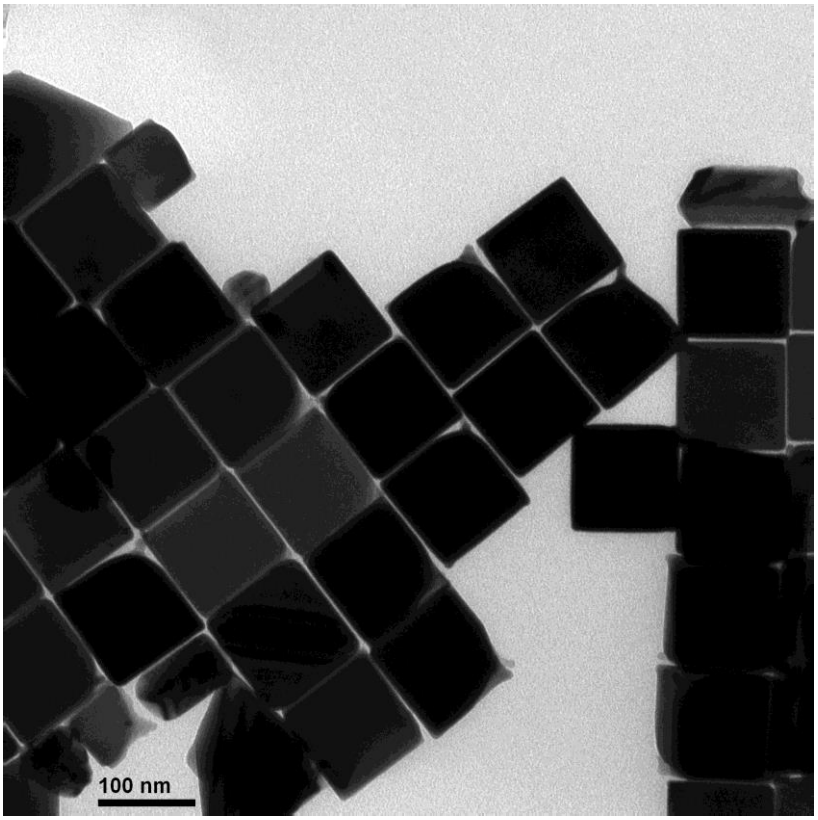


Figure 2: Transmission electron microscope image of silver cubes formed around AuNPs.

The AuNRTs were then formed from the AuAg cubes through galvanic replacement, and the wavelengths of the AuNRT extinction peaks were aligned to best ensure uniformity.

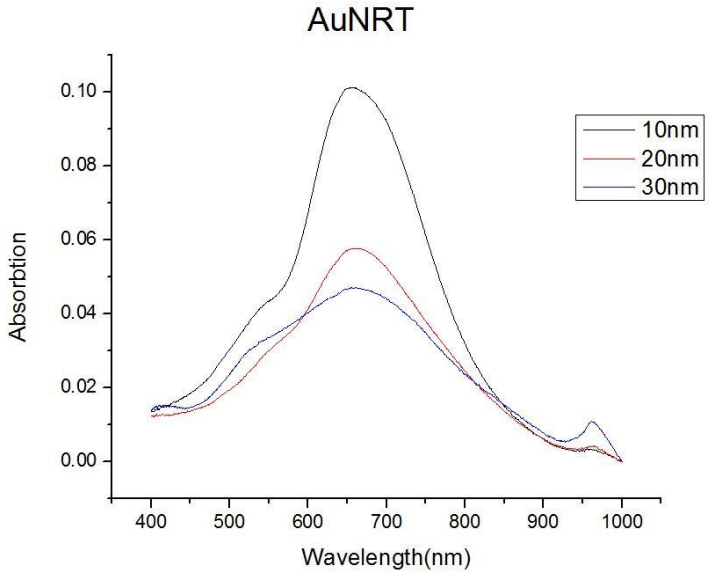


Figure 3: Ultraviolet-Visible Spectroscopic analysis of AuNRT solutions with varying AuNP core diameters.

The AuNRTs were then imaged with a transmission electron microscope (TEM) to verify uniformity.

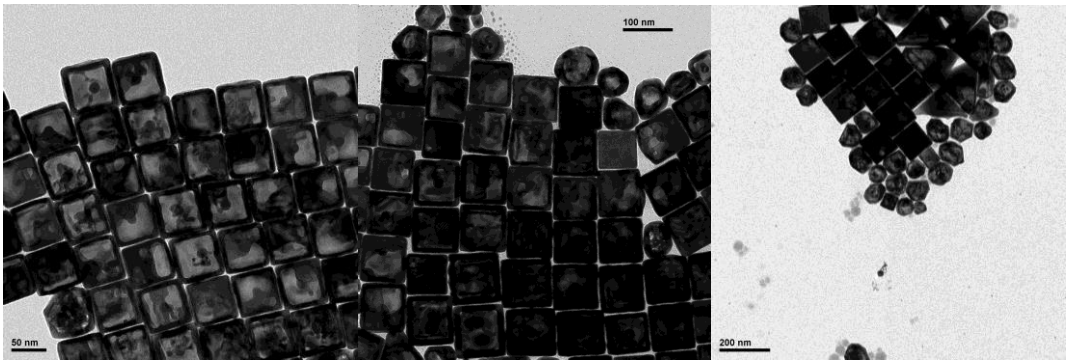
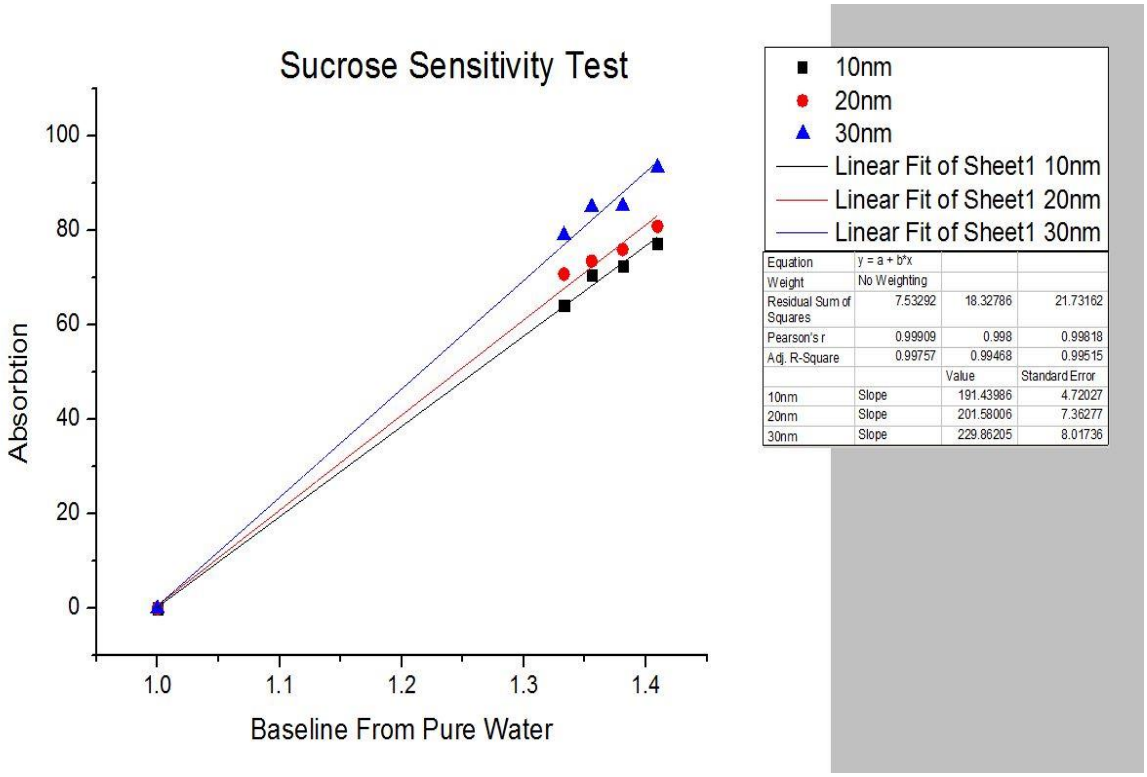


Figure 4: TEM images of AuNRTs with 10, 20, and 30nm diameter AuNP cores respectively.

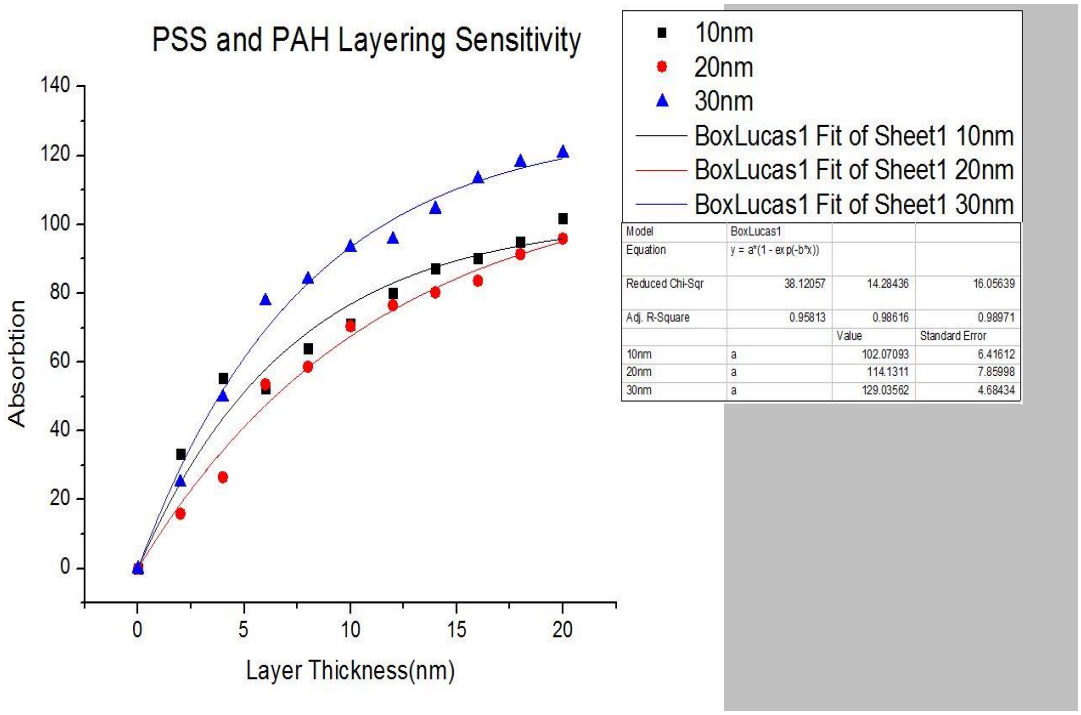
With the size and shape of the particles having been confirmed as roughly uniform, their respective sensitivity was quantified and compared using two alternative methods. First, the AuNRTs were bound to glass substrate, and immersed in varied concentrations of sucrose while being tested for their extinction peaks. The slope of the linear fit to the resulting data was an indicator of the particle's sensitivity. The three peaks in relation to one another displayed an increase in sensitivity in association with increasing core diameter.



Equation	y = a + b*x		
Weight	No Weighting		
Residual Sum of Squares	7.53292	18.32786	21.73162
Pearson's r	0.99909	0.998	0.99818
Adj. R-Square	0.99757	0.99468	0.99515
		Value	Standard Error
10nm	Slope	191.43986	4.72027
20nm	Slope	201.58006	7.36277
30nm	Slope	229.86205	8.01736

Figure 5: Determination of particle sensitivity using increasing concentrations of sucrose in solution.

The potential issue with the use of this method for AuNRTs is that the galvanic replacement forms more of a cage than a solid cube. It is possible for the sucrose molecule to enter the interior of the cage, which is not possible for the target proteins. The second method of determining particle sensitivity, which did not have this potential issue, was the layering of the AuNRT bound glass substrates with ten 2nm thick layers of Poly(sodium 4-styrenesulfonate) (PSS) and Poly(allylamine hydrochloride) (PAH). The extinction peak was determined after each layering, with the resulting data fit to a Box Lucas equation.



Model	BoxLucas1		
Equation	y = a*(1 - exp(-b*x))		
Reduced Chi-Sqr	38.12057	14.28436	16.05639
Adj. R-Square	0.95813	0.98616	0.98971
		Value	Standard Error
10nm	a	102.07093	6.41612
20nm	a	114.1311	7.85998
30nm	a	129.03562	4.68434

Figure 6: Sensitivity test using varying layers of PSS and PAH.

Both sensitivity tests indicate the same conclusion, that the sensitivity of the AuNRTs increased with the increase in AuNP diameter.

Future Direction

Future tests should improve the quality of the AuNRTs with 30nm diameter cores, and include larger core diameters as well.