Characterizing the Effects of Concentration on Protein Adsorption on Gold Model Surfaces using Ellipsometry

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1. Introduction

Adsorption is the adhesion in an extremely thin layer of molecules to the surface of substances with which they are in contact with.[1] A common way of studying and analyzing protein adsorption is by using ellipsometry: an optical technique that determines the thickness and from there we can derive the adsorption .

The study of proteins and their adsorption is important to developments in medicine, where the success of biomaterials, such as drug-delivery systems and implants, depends upon the ability of the surrounding protein to adhere and essentially disguise the foreign object from the subject's immune system so their body doesn't reject it.[2]
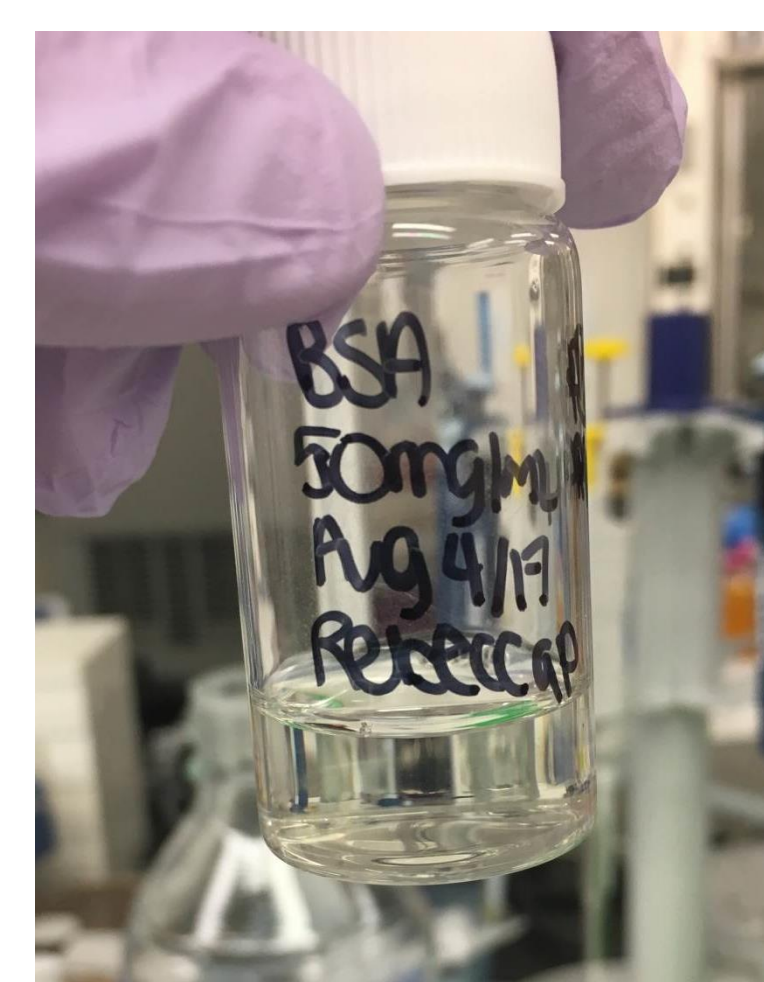

Figure 1: BSA 50mg/mL concentrated solution used as basis for dilutions

2. Methods

- Protein solutions of bovine serum albumin (BSA) are made using a phosphate buffer with a pH of 7.4 and are then diluted to the proper concentration, varying from 1mg/ml to 50mg/ml (1, 10, 25, 50)
- After allowing the BSA adsorb onto the gold substrates for 30 minutes, they are rinsed using Milli-Q water, then dried using nitrogen and put into the vacuum overnight.
- Using the ellipsometer, the thickness of the protein layer is measured and is then used in a surface coverage model to determine adsorption.
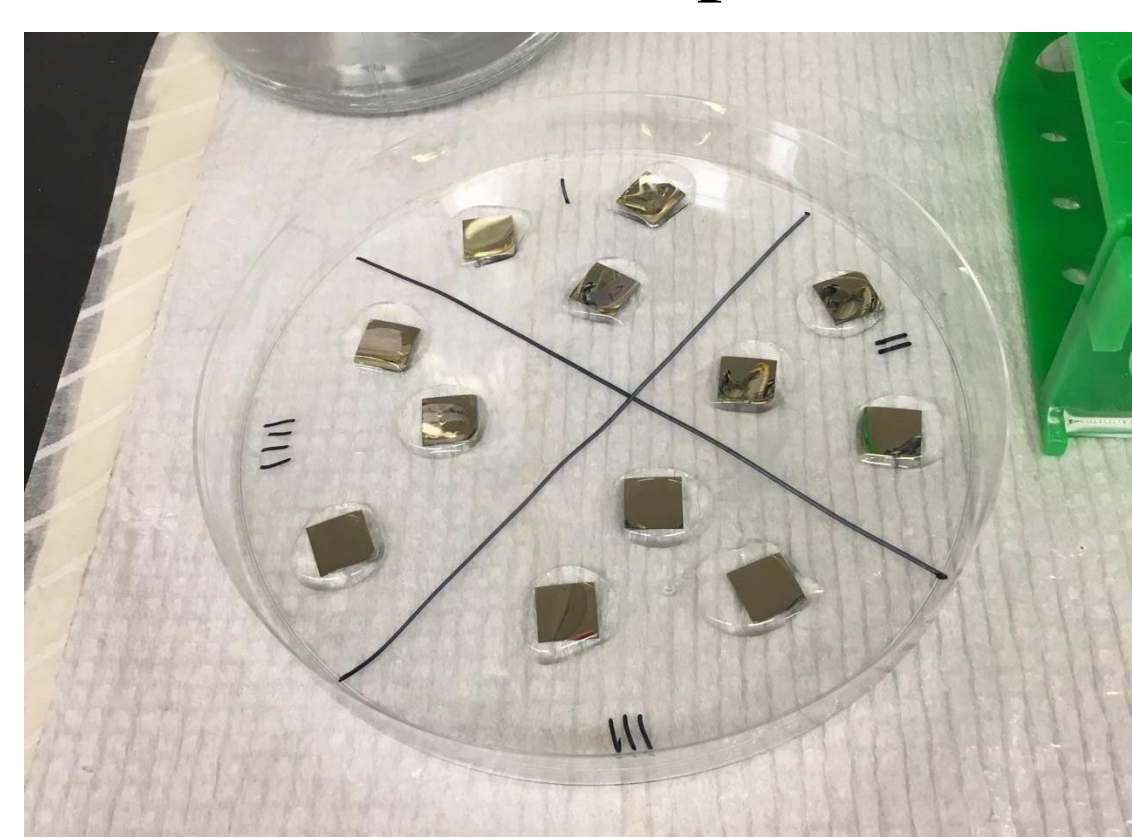

Figure 2: Adsorption process of samples. They are separated based upon concentration in ascending order.
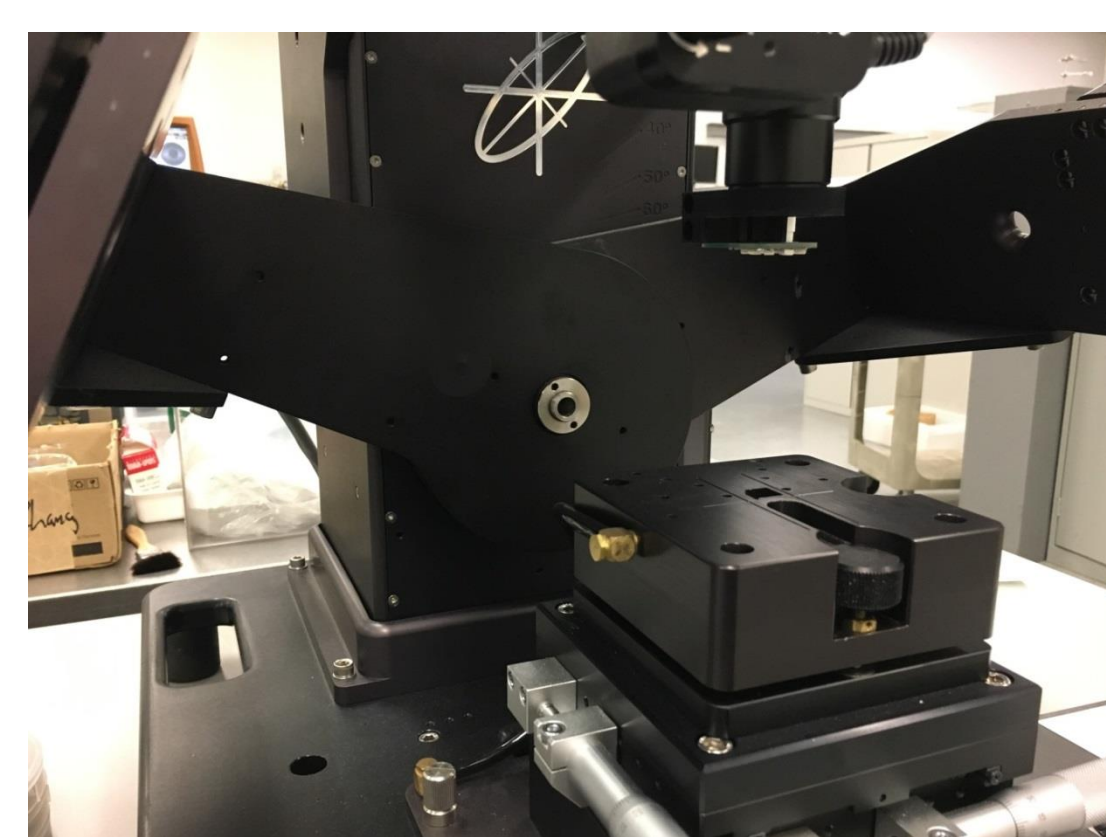

Figure 3: Set up of the ellipsometer, with the light source to the left and the sample holder in the middle.

3. Theory

- Ellipsometry is a common optical technique that measures the changes in reflectance and polarization of a light beam upon reflection from a surface.[3]
- The measurements taken in ellipsometry are expressed as ψ (Psi) and Δ (delta), ψ being the amplitude of the light and Δ representing the phase difference between the two components of the polarized light
- From the light source, the light starts off unpolarized, goes through a polarizer to become linearly polarized. It is then reflected off of the sample and analyzed. The polarization is now elliptical – hence the name ellipsometry.
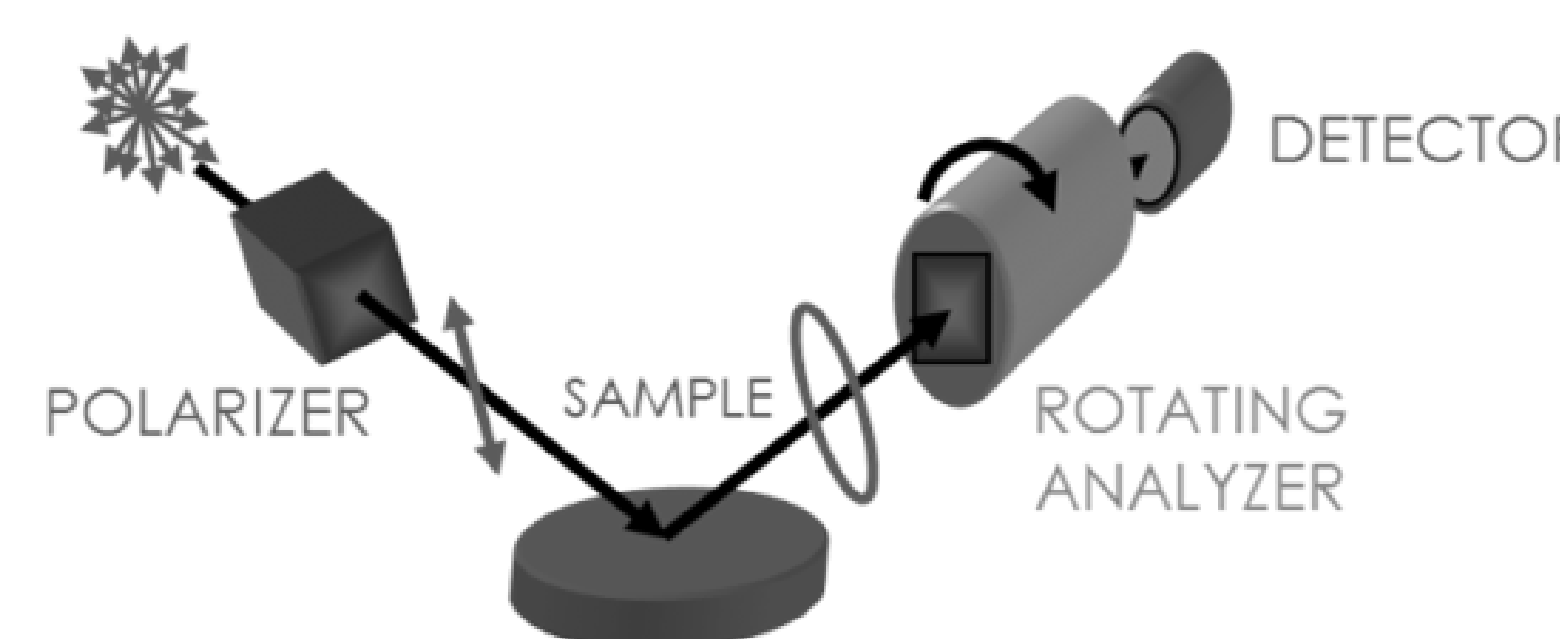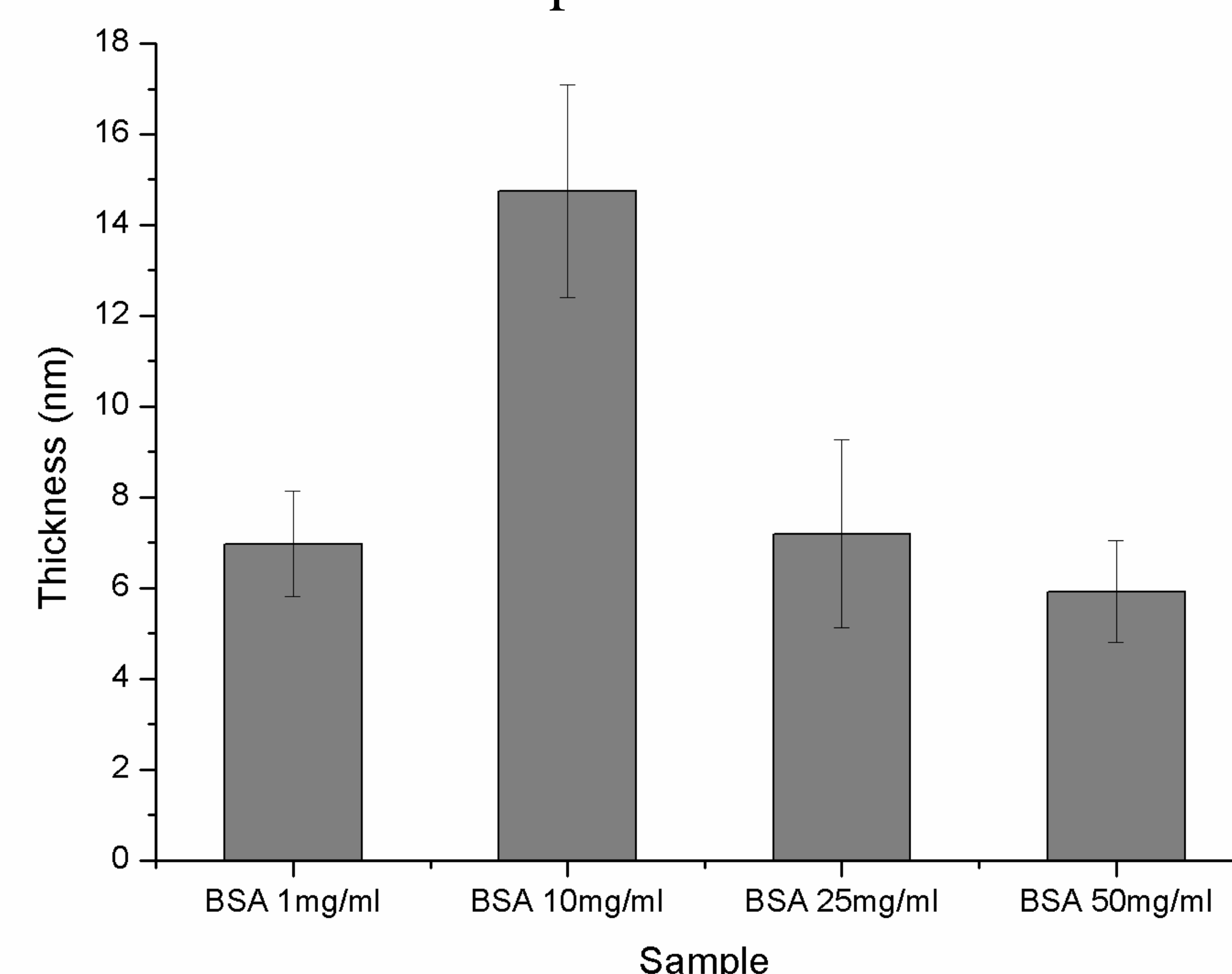

Figure 4: diagram of the main components of an ellipsometer, retrieved from *https://www.jawoollam.com/resources/ellipsometry-tutorial/ellipsometry-measurements*

3. Results

Bar Graph of Averaged Ellipsometry Results per Concentration

Comparative Table of Analyzed Experimental Data Collected via Ellipsometry and Theoretical Values

Sample Concentration of BSA	EXPERIMENTAL		THEORETICAL
	Density (ng/cm^2) Average Thickness	Density (ng/cm^2) Standard Deviation	Density (ng/cm^2)
1mg/mL	887.1961329	147.440424	215.54
10mg/mL	1878.269058	298.4234629	215.54
25mg/mL	916.0083666	263.0316277	215.54
50mg/mL	753.6584329	142.4280621	215.54

4. Conclusions

- Though the results may suggest otherwise, theoretically, the concentration of the protein solutions has no impact on the adsorption of the proteins to the gold substrate.
- A number of sources of error could have contributed to the significantly higher experimental values, as well as the especially outlying data collected for the 10mg/mL samples, including personal judgement and performance of experiments as well as behavior of the protein.

5. Acknowledgements

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6. Literature Cited

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