NDnano
Notre Dame Nanoscience and Technology

NDnano Undergraduate Research Fellowship (NURF)
2024 Project Summary

1. Student name & home university:

Irvin Aldair Servin Arredondo
Universidad Nacional Autonoma de Mexico

2. ND faculty name & department:

Aerospace and Mechanical Engineering
College of Engineering

3. Summer project title:

Synthesis of substrate-immobilized gold nanoplates using $NaAuCl_4$

4. Briefly describe new skills you acquired during your summer research:

This summer, I learned a lot of things and used equipment I had never used, like a sputter coater with which I learned to deposit gold and antimony on a sapphire substrate. The synthesis of gold nanoplates was one of the most interesting thing that I learned in professor Neretina's lab. Now, I know how to characterize these nanostructures and how to know their size over time.

5. Briefly share a practical application/end use of your research:

Gold nanoplates are highly studied because of their unique properties like plasmonic response and catalytic activity, bringing a wide variety of applications in a great range of reactions and technological devices. The above is achieved thanks to the possibility of performing functionalizations on the surface of the nanostructure such that they express a specific desired response

6. 50- to 75-word abstract of your project:

Noble metal nanoplates are a unique class of two-dimensional (2D) nanomaterials whose planar geometry serves as one of the most important nanoscale building blocks. Obtaining these attractive gold nanostructures requires the presence of specific conditions and reagents, starting with seeds, a reducing agent and a gold precursor The purpose of this project is to develop a synthesis using $NaAuCl_4$ and Brij S100, thus modifying the pH and optical properties of the growth solution

7. References for papers, posters, or presentations of your research:

(1) Neal, R. D.; Hughes, R. A.; Preston, A. S.; Golze, S. D.; Demille, T. B.; Neretina, S. Substrate-Immobilized Noble Metal Nanoplates: A Review of Their Synthesis, Assembly, and Application. *Journal of Materials Chemistry C*. Royal Society of Chemistry October 14, 2021, pp 12974–13012. https://doi.org/10.1039/d1tc01494c.

(2) Langille, M. R.; Personick, M. L.; Mirkin, C. A. Plasmon-Mediated Syntheses of Metallic Nanostructures. *Angewandte Chemie - International Edition*. December 23, 2013, pp 13910–13940. https://doi.org/10.1002/anie.201301875.

(3) Golze, S. D.; Hughes, R. A.; Rouvimov, S.; Neal, R. D.; Demille, T. B.; Neretina, S. Plasmon-Mediated Synthesis of Periodic Arrays of Gold Nanoplates Using Substrate-Immobilized Seeds Lined with Planar Defects. *Nano Lett* **2019**, *19* (8), 5653–5660. https://doi.org/10.1021/acs.nanolett.9b02215.
(4) Demille, T. B.; Neal, R. D.; Preston, A. S.; Liang, Z.; Oliver, A. G.; Hughes, R. A.; Neretina, S. Epitaxially Aligned Single-Crystal Gold Nanoplates Formed in Large-Area Arrays at High Yield. *Nano Res* **2022**, *15* (1), 296–303. https://doi.org/10.1007/s12274-021-3473-1

Noble metal nanoplates are a unique class of two-dimensional (2D) nanomaterials whose planar geometry serves as one of the most important nanoscale building blocks
The Synthesis of these nanostructures is light-driven where the growth solution and seeds are vital components in their formation. Without one of these components, there is no growth. In Professor Neretina's lab, it has been shown that the synthesis using HAuCl4 and Brij S100 provides an effective method of synthesis.

The objective of this research was to perform a similar synthesis using a similar but different composition of growth solution. The growth solution composition for the syntheses I carried out was NaAuCl4 and Brij S100.
The way to get these nanoplates starts with the deposition of antimony and gold on a sapphire substrate. After, it's necessary to heat it to high temperatures to obtain gold seeds. The seeds are grown in the growth solution under UV light or blue light in a dark room. Finally, nanoplates are characterized by UV-vis spectroscopy and SEM

With different experiments, these results were obtained. Figure 1 shows the absorption spectrum of the growth solution. As you can see, the properties of each solution are different, sodium gold salt absorbs stronger in the UV in comparison to the hydrogen gold salt. For this reason, the growth is done under uv light and blue light.

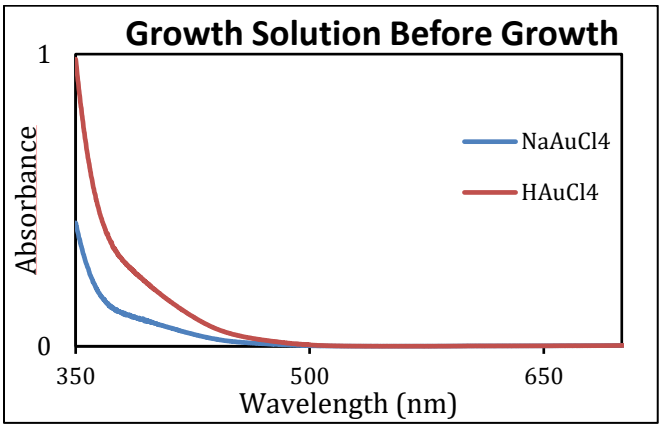

Figure 1. UV-vis spectra of both growth solutions

The growth is carried out using a fresh solution. These graphs show the extinction spectrum of the nanoplates as they grow over time. The more red-shifted it is, the larger the nanostructure will be. It can be observed that it takes longer to reach a certain nanostructure size when growing under blue light.

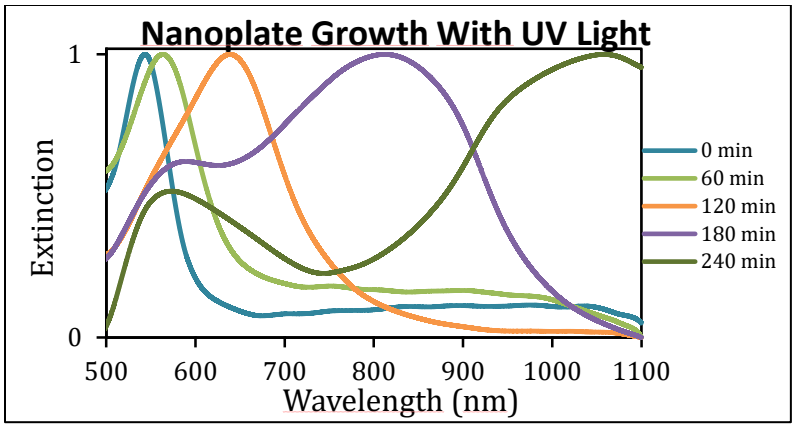

Figure 2. Synthesis under UV light using a fresh growth solution

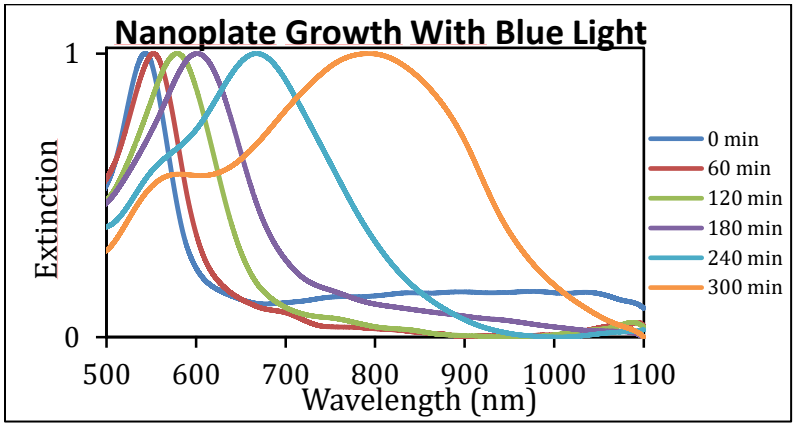

Figure 3. Synthesis under blue light using a fresh growth solution

It can be observe the difference in growth rate between the growth solution compositions in the figure 4. The growth rate using hydrogen gold salt is much higher than using sodium gold salt.

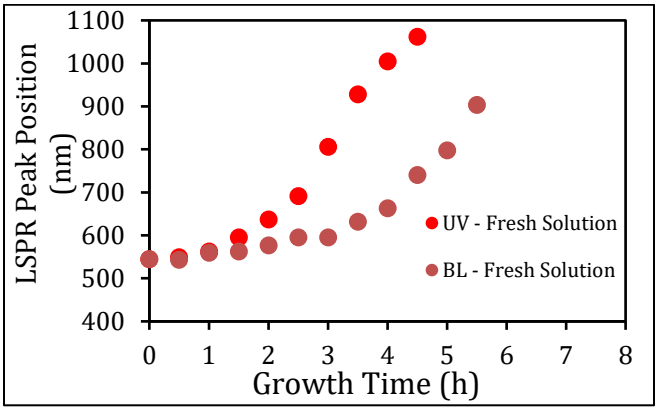

Figure 4. LSPR peak position over time

Finally, in these images, figure 5 and 6, are presented the nanoplates obtained under UV light and blue light. It is possible to say that using UV light yields better hexagons than blue light at the time due to the stronger absorption at this frequency

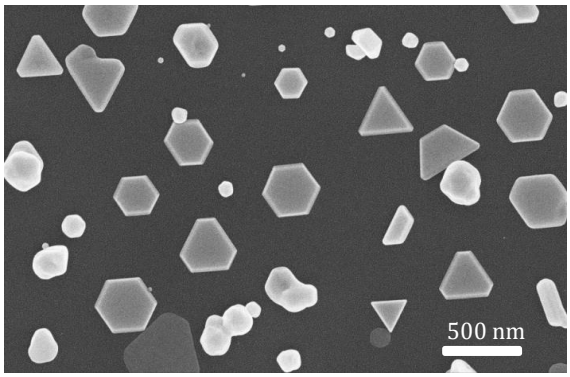

Figure 5. Growth under UV light

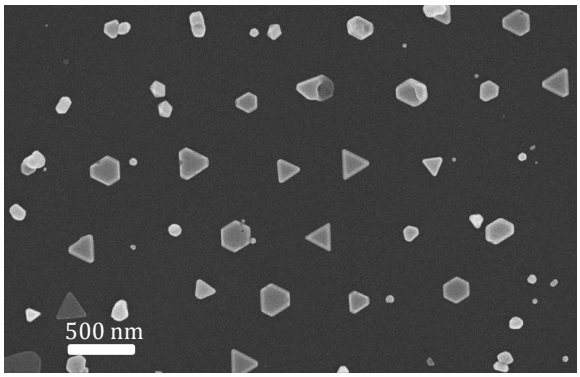

Figure 6. Growth under blue light

In conclusion, both HAuCl4 and NaAuCl4 can be used to grow Au nanoplates but $NaAuCl_4$ results in a slower growth rate because the absorbance is less than HAuCl4. The wavelength of light is a crucial parameter in the growth of nanoplates