Optimizing shell thickness in plasmonic –TiO_2 core-shell nanoparticles

Morales Valenzuela Luis Germàn[1,3], Paulina Segovia Olvera[2] and José Manuel Romo Herrera[1]

[1]Universidad Nacional Autónoma de México, Centro de Nanociencias y Nanotecnología (UNAM-CNyN)

[2] División de Física Aplicada, Centro de Investigación Científica y de Educación Superior de Ensenada (FA-CICESE)

[3]Posgrado en Nanociencias, CICESE / CNyN-UNAM.

Abstract

The direct conversion of solar energy into chemical energy through photocatalysts has gained significant attention over the last decade due to its potential to generate alternative fuel in an eco-friendly manner. Semiconductors-based materials are commonly employed in heterogeneous photocatalysis, where light absorption induces electron-hole pairs generation, enabling the production of reactive oxygen species (ROS). These ROS play a crucial role in transforming molecules into valuable fuels.

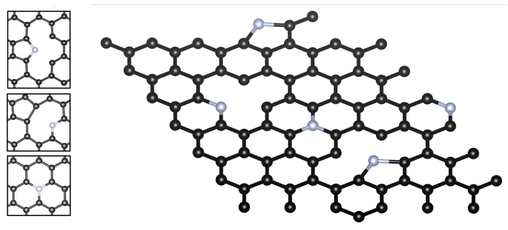
Group Lab

AG&P group

Assembly Graphene & Plasmonics

We like to Assembly Graphitic & plasmonic nanostructure into functionals materials for alternative energy, Environmental or bio applications

Graphitic structure dope with nitrogen



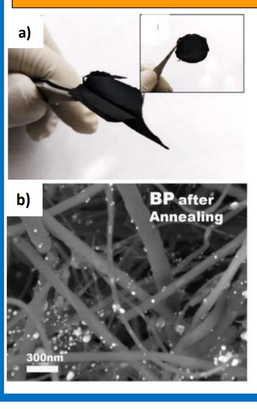
Doping graphitic structures (e.g., graphene and carbon nanotubes) with nitrogen

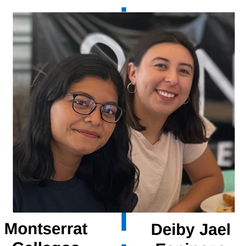
Plasmonic Gold/Silver morphologies

Synthesizing plasmonic morphologies of gold and silver, including spheres, cubes, rods, stars, and bipyramids.

Some graduate students

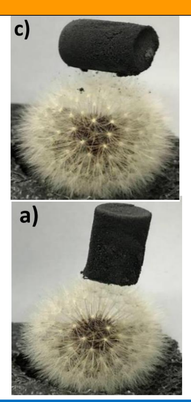
Bucky paper made of CNTs with embedded gold nanoparticles





Montserrat Gallegos Ph.D. Student

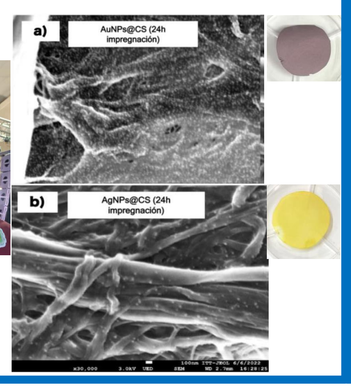
Aerogel composed of CNTs.



Deiby Jael Espinoza Master Student

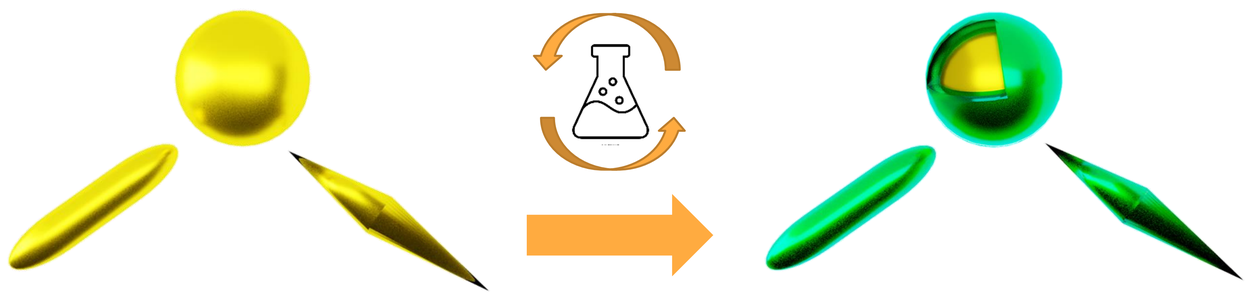
Paper functionalized with Au/Ag nanoparticles

Erick Toledo Master student

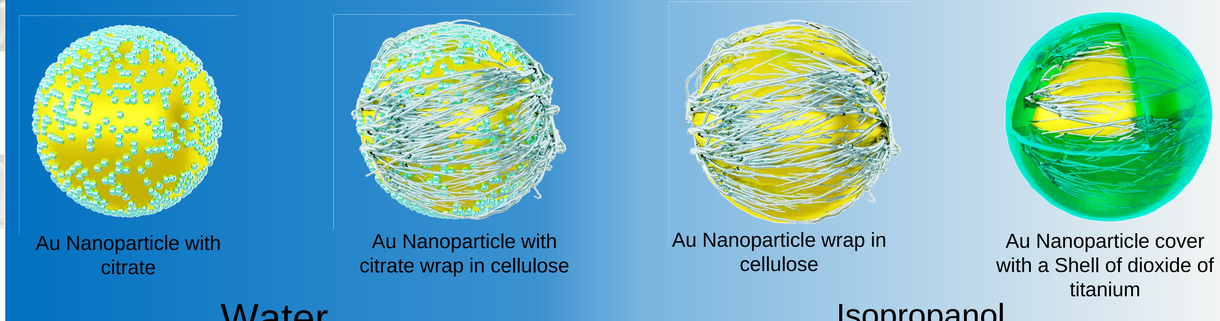


Ph. D. Proposal

It is possible to coat plasmonic gold NPs regardless of their morphology, with different thicknesses of titanium dioxide, to obtain core-shell type nanostructures and monitor the thickness of the titanium dioxide shell by UV-vis spectroscopy, without the need to use TEM.

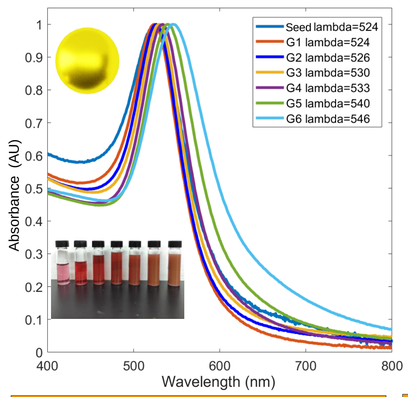


Synthesis Steps

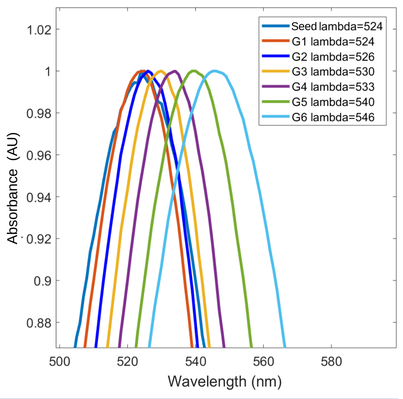


Results

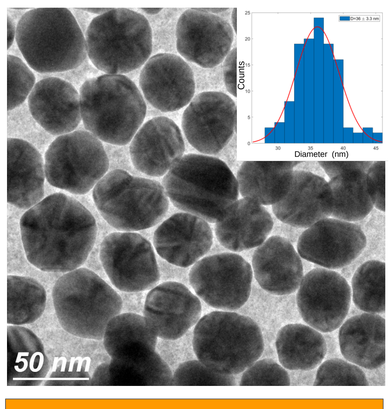
1.-Gold NPs with tunable size



Absorbance spectrum UV-Vis of AuNPs. inset: AuNPs solutions

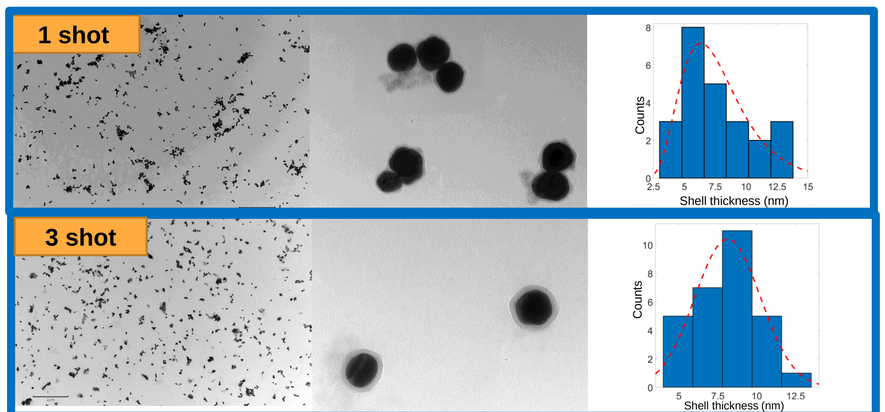


Absorbance spectrum UV-Vis of AuNPs (zoom)



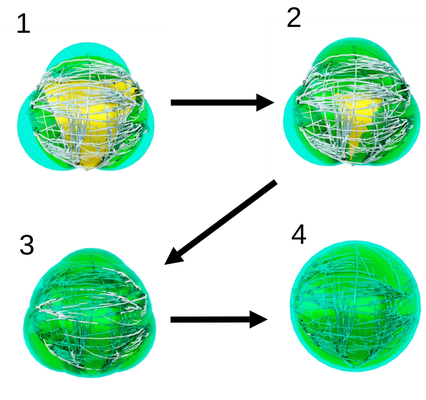
TEM micrograph of AuNPs. Inset: Size distribution of AuNPs

4.-Gold NPs with a different shell size of TiO_2



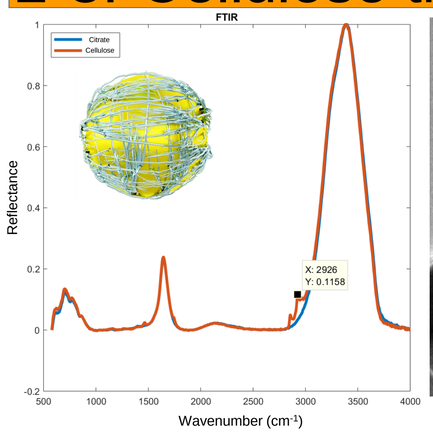
TEM micrographs of gold and titanium dioxide core-shell nanoparticles with a shell of different thickness

distribution of titanium dioxide shell thickness at different shots.

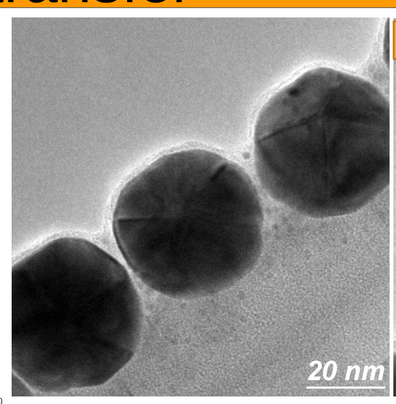


Proposed mechanism that occurs when the titanium dioxide precursor is used in the solution of the gold particles

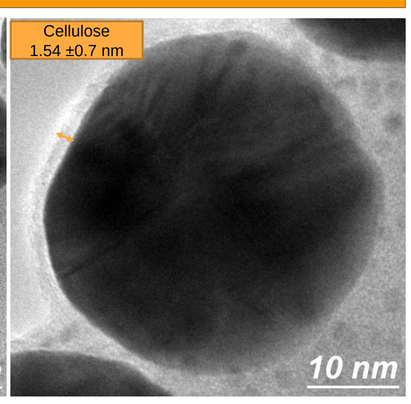
2-3.-Cellulose transfer



ATR-FTIR spectrum of AuNPs, with sodium citrate and cellulose as stabilizing medium

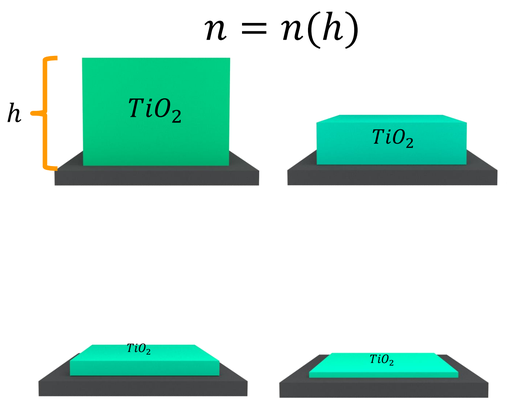


TEM micrograph of AuNPs-cellulose

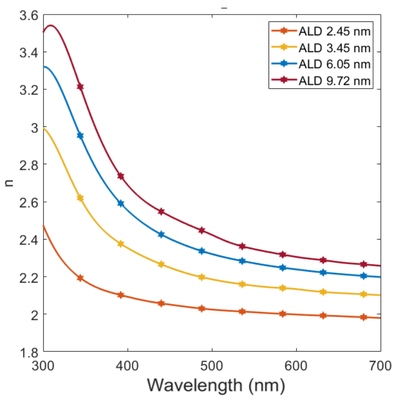


TEM micrograph of AuNPs-cellulose (Zoom)

Modeling the TiO_2 thickness by FEM (COMSOL)

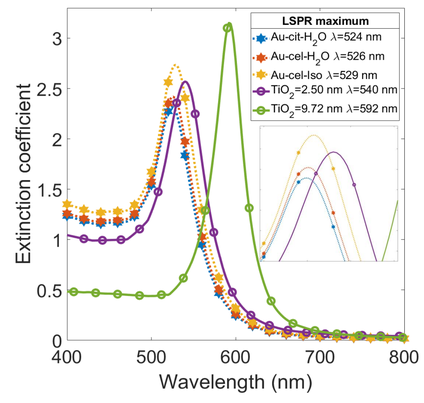


Graphical representation of a TiO2 thin film at different thicknesses



Refractive index of titanium dioxide reported by the ALD technique

[7] Liu, W. L., et al. 2013. Nanoscale, 5(17), 7953–7962



Extinction spectrum of 36 nm AuNPs in water with a 2.5 and 9.72 nm TiO_2 shell

Conclusions

This work presents the synthesis of core-shell nanoparticles (AuNPs@TiO2) through a seed-mediated growth approach to control the size and plasmonic properties of gold cores, followed by the deposition of TiO2 shells using the sol-gel method.

Throughout the process, shifts in the localized surface plasmon resonance (LSPR) peak were observed via UV-Visible spectroscopy, directly correlating with the material composition and shell thickness. These shifts serve as reliable indicators to monitor the synthesis stages of AuNPs@TiO2 nanoparticles using standard spectroscopic tools.

Acknowledgments:

We gratefully acknowledge the financial support provided by CONACyT under project A1-S-17539. G.M.-V. thanks CONACyT for his Ph.D. scholarship. The authors also extend their gratitude to Francisco Ruiz, Jaime Mendoza, David Dominguez, Jesus A. Diaz, Eloísa Aparicio, Israel Gradilla, Eduardo Murillo, and Hugo Borbón-Nuñez for their technical assistance.