IOWA STATE UNIVERSITY
Department of Chemical and Biological Engineering

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Synthesis of Complex Gold Nanostructures via Seeded Growth

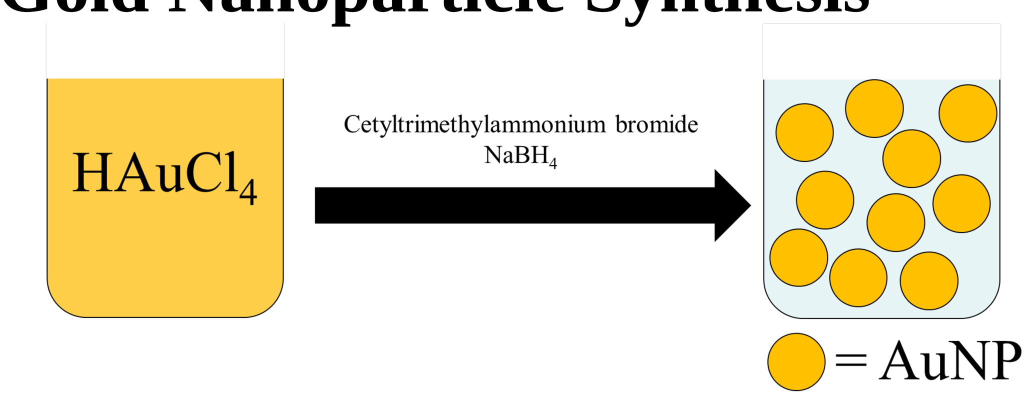
Introduction

- Gold nanostructures exhibit unique surface plasmon resonance (SPR) and other unique optical properties depending of size and shape
- Tailoring the size and specifically the shape may yield novel SPR and other optical properties

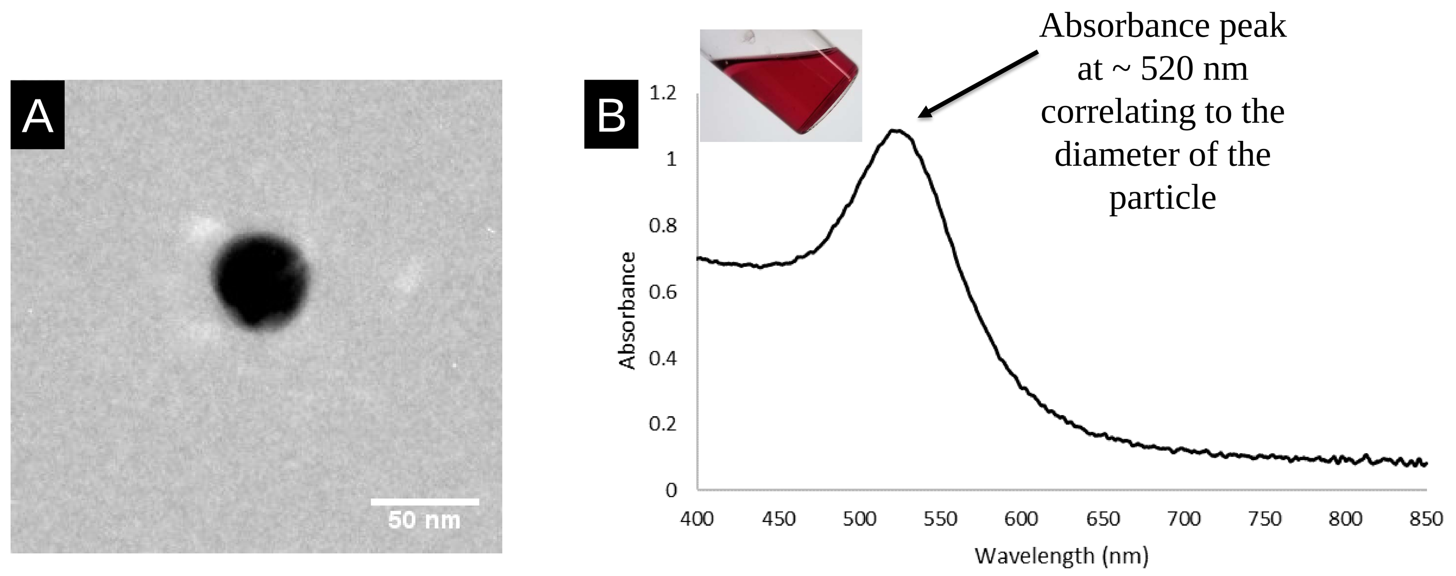
Motivation

- Several nanostructures are desired as a platform for more complex structures to be, providing a novel, unique optical signature

Simple Gold Nanoparticle Synthesis



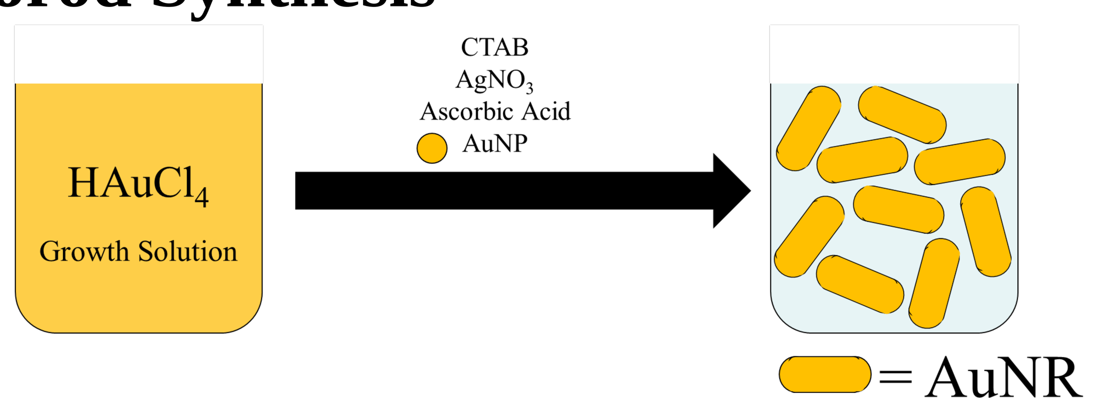
Nanoparicle Growth: HAuCl$_4$ is reduced by sodium borohydride in the presence of cetyltrimethylammonium bromide (CTAB). CTAB acts as a stabilizing agent by forming a micelle around the particle, stopping further growth



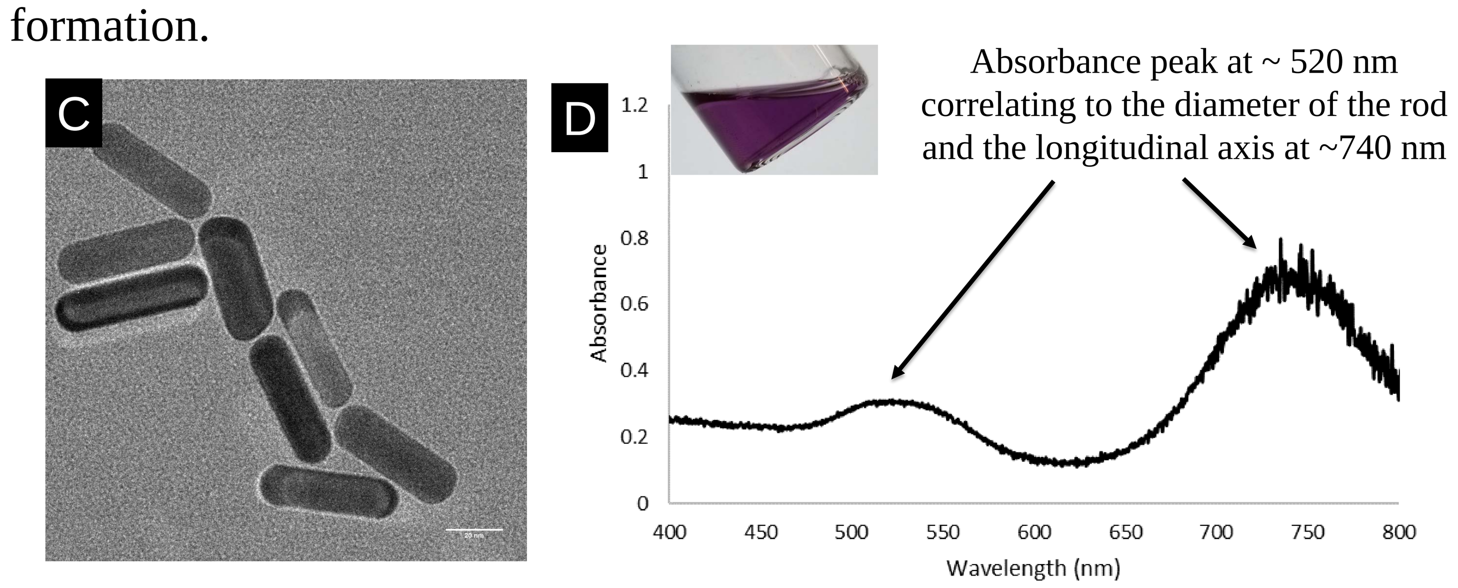
A transmission electron microscopy (TEM) image of a AuNP (A) and the correlated absorbance spectrum of the AuNP as a function of the wavelength (B).

- AuNP size is directly related to the gold, stabilizing agent, and reducing agent concentrations, allowing tailorable sizes for seeds and altering the final nanostructure size
- Stabilizing agents range from trisodium citrate, CTAB, poly-vinylpyrrolidone, polyethyleneimine, dimethylaminopyridine, changing the stability and surface charge of the particles

Gold Nanorod Synthesis

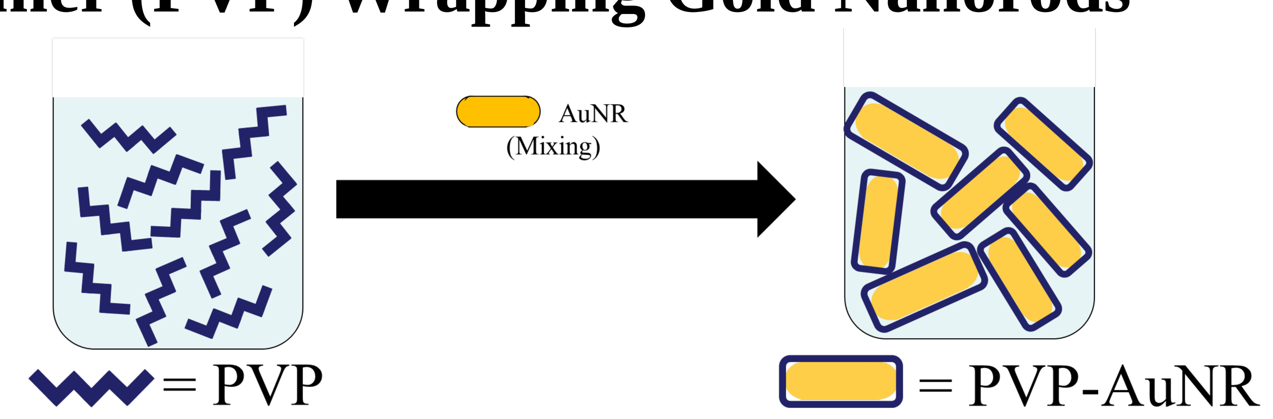


Nanorod Growth: HAuCl$_4$ is partially reduced by ascorbic acid in the presence of AgNO$_3$, AuNPs and CTAB. The CTAB and AgNO$_3$ adsorb to surfaces of the AuNP which limits growth in some direction, leading to rod formation.

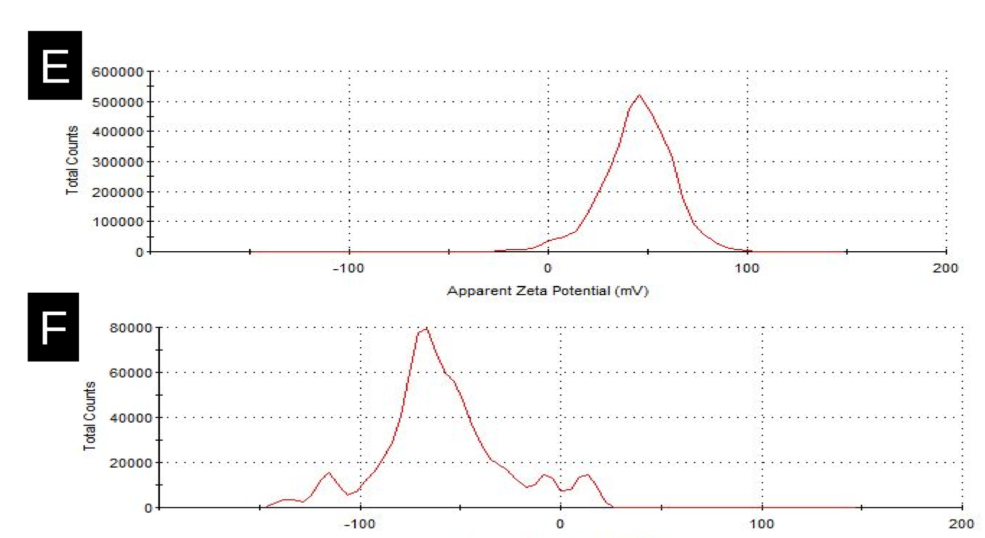


(C) A TEM image of AuNR and (D) the resulting absorbance spectrum from these AuNRs as a function of the wavelength.

Polymer (PVP) Wrapping Gold Nanorods



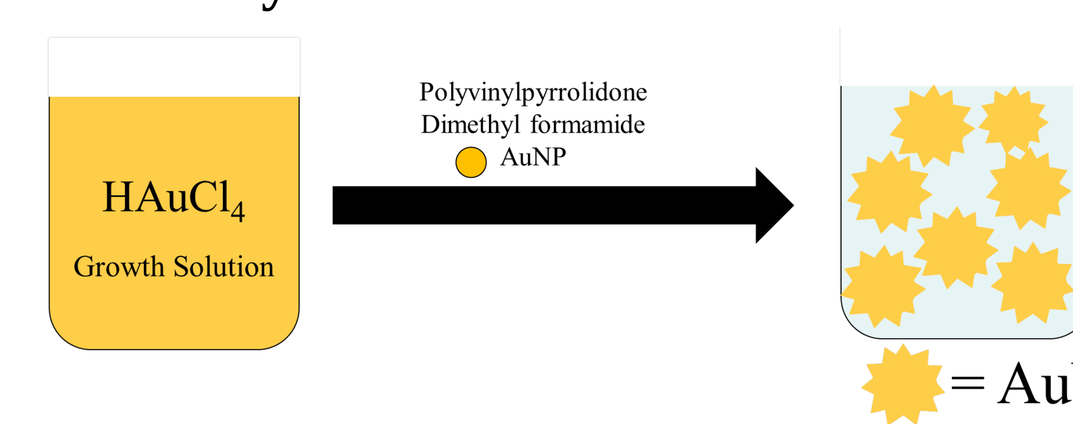
Polymer wrapping (PVP) of gold nanorods for use as seeds for more complex growth



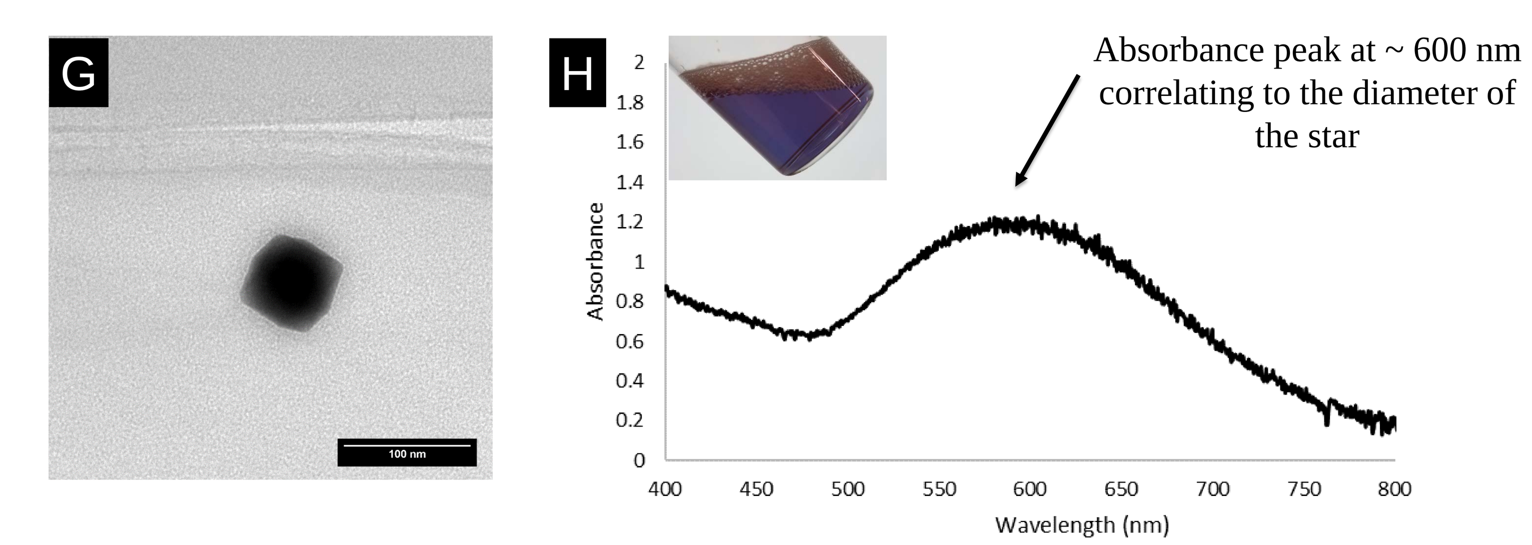
Polymer Wrapping: The zeta potential (electrostatic potential) of gold nanorods before (E) and after wrapping (F) PVP. The change from positive to negative correlates with the change from the positively charged CTAB to the negatively charged PVP

- AuNR growth is controlled by stabilizing agent, AgNO$_3$, HAuCl$_4$ concentrations and proven able to be wrapped by polymers to change the surface chemistry

Gold Nanostar Synthesis



Nanostar Growth: HAuCl$_4$ is reduced by a solution of dimethyl formamide (DMF) and polyvinylpyrrolidone (PVP) in the presence of AuNPs. DMF/PVP complexes allow fast growth on some surfaces, leading to 'spike' formation

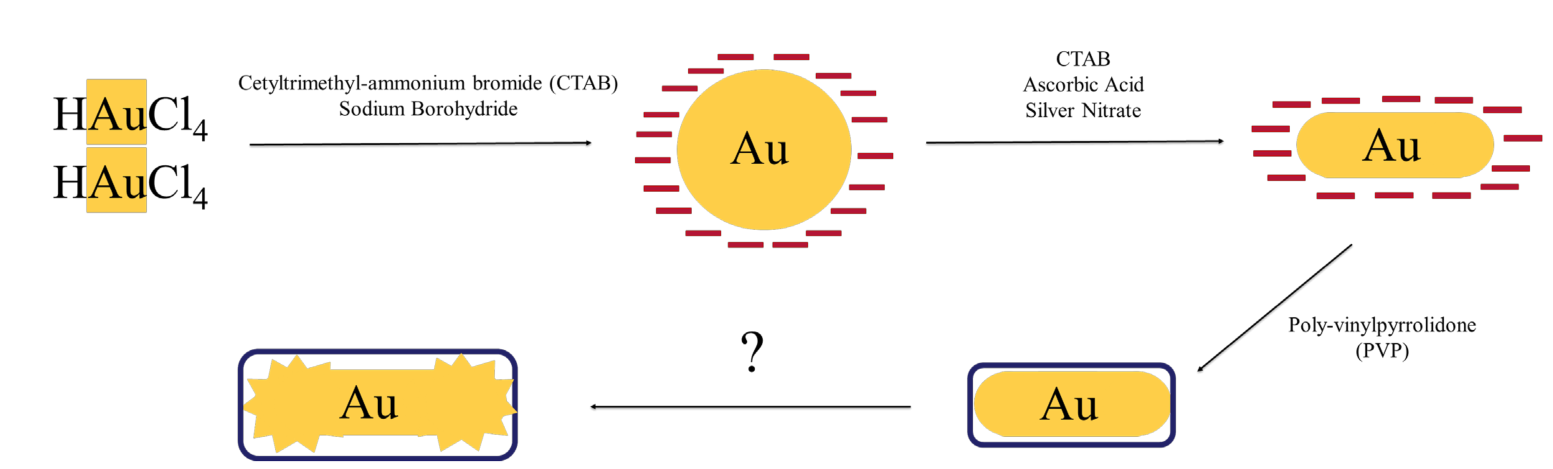


(G) A TEM image of a AuNS and (H) the resulting absorbance spectrum from these AuNSs as a function of the wavelength.

- Nanostars have been synthesized in a tailorable method allowing the diameter, spike length and spike density to be altered by changing PVP and gold concentrations

Next Steps

- It is theorized that utilizing the PVP wrapped AuNRs as seeds in a gold nanostar growth solution will yield a nanorod with complex star like growths on either end(See the schematic below)
- Further growth from these complex particles seek to produce ring or 'U' shaped nanostructures via a seeded growth



Complex Nanostructure Growth: Schematic illustration of the theoretical synthesis path for the production of a complex nanostructure

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