

# Lipid Coated Gold Nanoparticle Cores: Synthesis and Characterization



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## Introduction

Including environmental, industrial, and biomedical sciences, applications of gold nanoparticles are on the forefront of research in many areas. By altering the surface treatment of spherical gold nanoparticle cores, particularly those smaller than 100 nm (nanometers), one can influence their potential use in a number of ways. Lipid coated nanoparticles with specifically selected surface ligands can be used for multiple biomedical functions, including medical imaging, for use as colorimetric and plasmonic sensors within the body, and as cell or organelle specific targets for therapeutic drug delivery or cancer treatment.

Here, spherical gold nanoparticles ranging in size from 8-40 nm (avg. diameter 23-48 nm) have been synthesized and coated with poly(allylamine hydrochloride) (PAH) and a mixed lipid solution of 1:1 1-palmitoyl-2-oleoyl-*sn*-glycero-3-phospho-L-serine (POPS) and lysophosphatidylcholine (LPC), two of the four major types of lipids found in the human body. Characterization was performed using a NanoSight LM10HS particle sizer, and shows a gradual increase in size after each step in the coating process for nanoparticle cores ranging in size from 16-27 nm. The thickness of these purified and lipid coated nanoparticles was consistently 2-3 times that of the PAH coated sample it was layered onto, suggesting a successful, multi-layered coat that ranges in size based on the PAH coated core size. UV-Vis spectroscopy shows a slight red shift, indicating an increase in size and change in refractive index, which supports the presence of lipid coating on the PAH coated gold nanoparticle cores.

## Literature Cited

- (1) Yang, Jie An; Murphy, Catherine J. Evidence for patchy lipid layers on gold nanoparticle surfaces. *American Chemical Society Publications. Langmuir*. 2012. 28, 5404-5416.
- (2) Zhang, Liuyang ; Becton, Matthew; and Wang Xianqiao. Designing Nanoparticle Translocation through Cell Membranes by Varying Amphiphilic Polymer Coatings. *Journal of Physical Chemistry. B*, 2015, 119 (9), 3786-3794
- (3) Moffitt, Matthew G. Self-Assembly of Polymer Brush-Functionalized Inorganic Nanoparticles: From Hairy Balls to Smart Molecular Mimics. *Journal of Physical Chemistry Letters*. 2013, 4, 3654-3666

## Acknowledgments

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## Results

Figure 1 shows the comparison of visible extinction spectra peaks for one sample synthesized using 1.50 mL sodium citrate. Larger gold nanoparticles exhibit a higher peak in the extinction spectrum, shifting the peak toward more red wavelengths. (2) This phenomenon allows us to determine an increase in size of nanoparticles throughout each step of the coating process, as the stock solution had a measured  $\lambda_{\max}$  of 515 nm, then gradually increased to 532 nm for the final, lipid coated product.

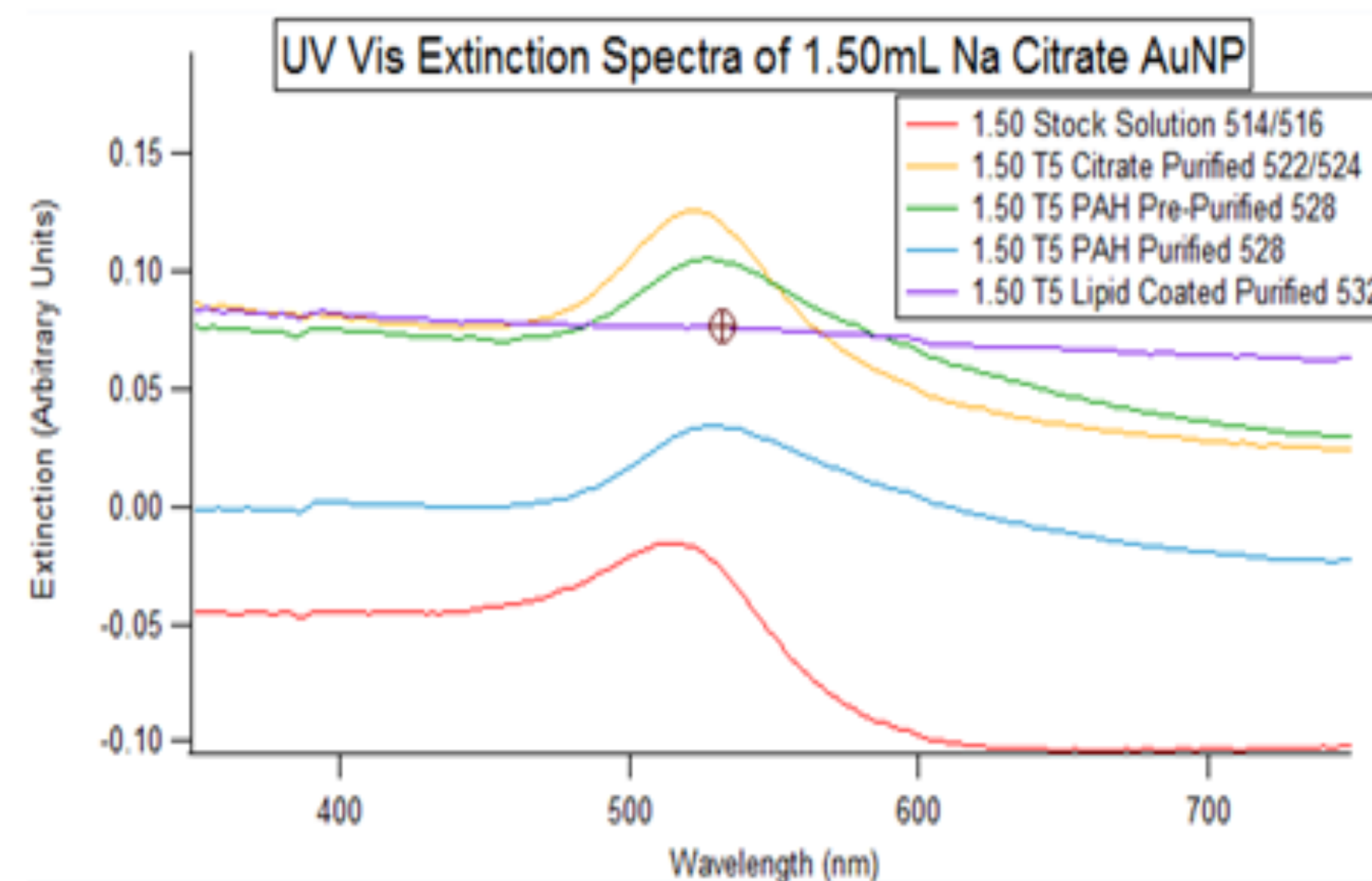


Figure 1: UV-Vis characterization of gold nanoparticle solution synthesized using 1.50 mL sodium citrate; a comparison from synthesis to lipid coating.

Figure 2 shows the original stock solution had the greatest concentration of nanoparticles with diameter 11 nm and particle sizes slowly increased throughout each step in the coating process. The PAH coated and purified samples had the greatest concentration of particles with diameter 31 nm and the lipid coated product had the greatest concentration of nanoparticles with diameter 137 nm.

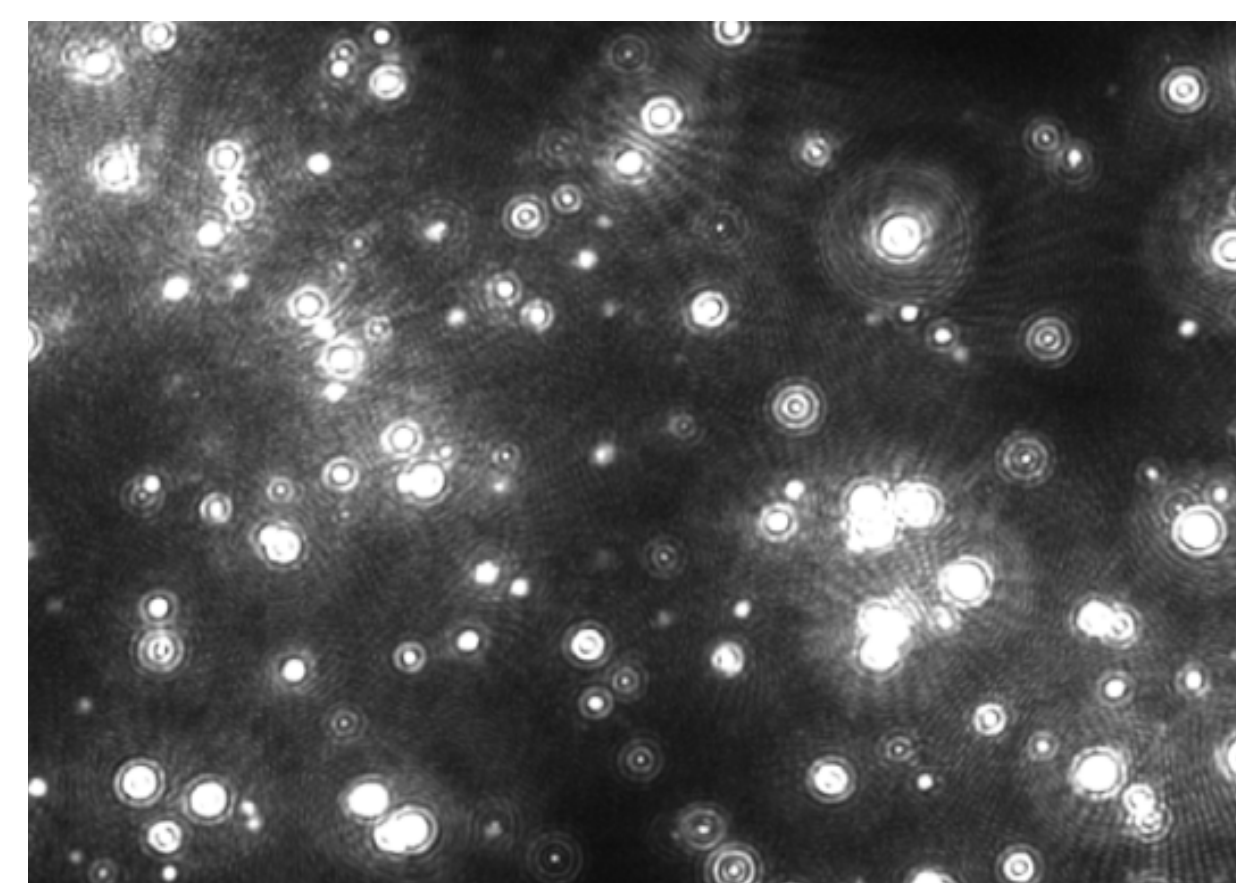


Figure 3: Gold nanoparticles in solution. Image captured using NanoSight LM10HS.

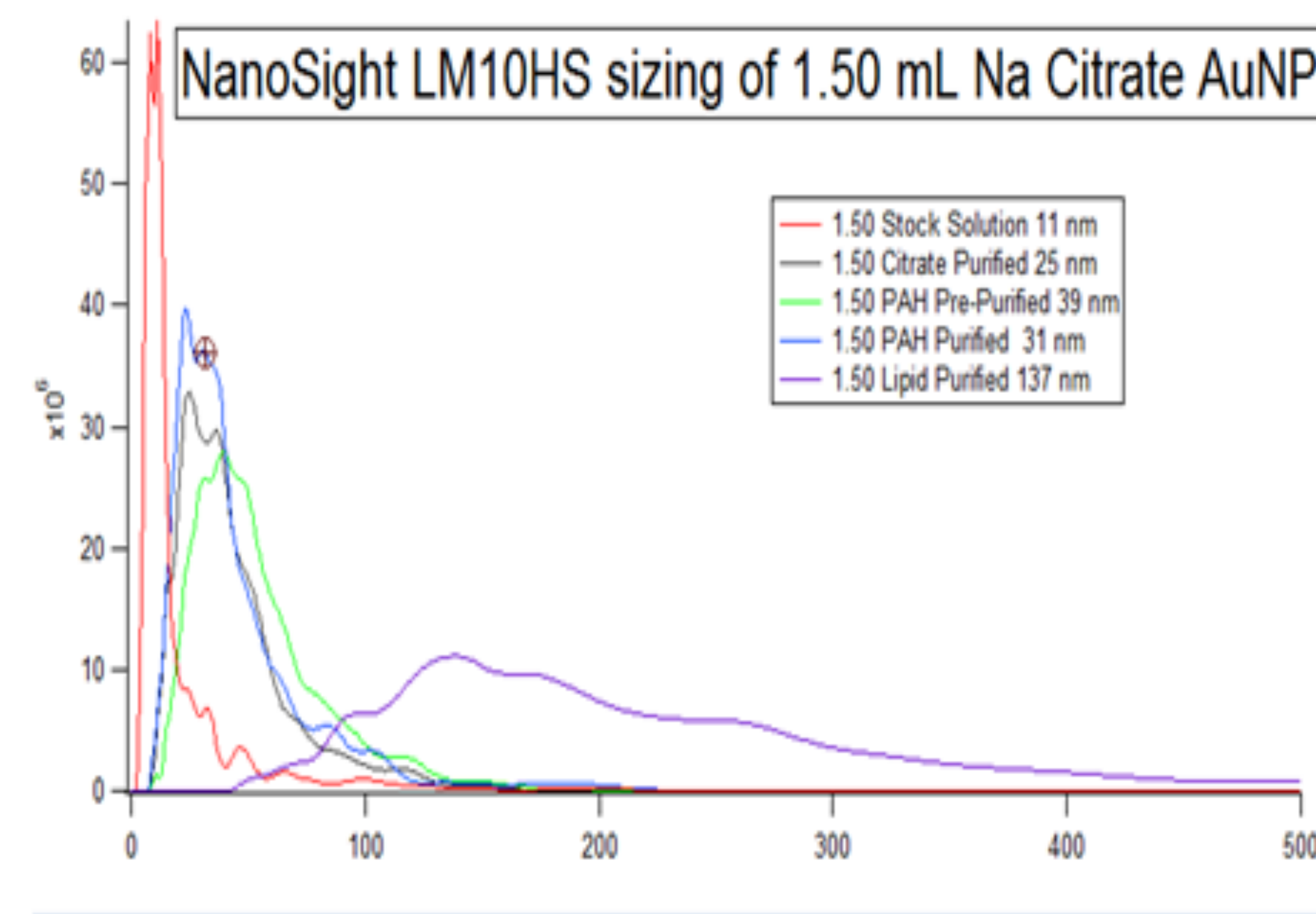


Figure 2: NanoSight LM10HS characterization of gold nanoparticles synthesized using 1.50 mL sodium Citrate; A comparison from synthesis to lipid coating.

## Conclusions

Characterization of nanoparticle cores after each step of the coating process revealed a slight increase in average diameter as well as a slight red shift in the extinction spectrum after each stage. This gradual and slight increase in the  $\lambda_{\max}$  is characteristic of an increase in particle size, which was confirmed by laser nanoparticle sizing. Extinction spectra gathered at each step in the coating process show the gradual and slight red shift, indicating a very small increase in size and change in refractive index, which support the presence of lipid coating on the PAH coated gold nanoparticle cores. The red line is the original citrate capped stock solution with extinction peak at 514-516 nm. Yellow shows an increase in extinction peak upon purification. Green and blue represent the PAH coated sample before and after purification, respectively, and purple shows a final lipid coated peak at 532 nm. Characterization using NanoSight LM10HS particle sizer shows a gradual increase in size after each step in the coating process for nanoparticle cores ranging in size from 16-27 nm. The purified lipid coating thicknesses of these nanoparticles was consistently 2-3 times that of the PAH coated sample it was layered on to, suggesting a successful, multi-layered coat that ranges in size based on the PAH coated core size.

## Materials and Methods

### Gold Nanoparticle Synthesis

Solutions of chloroauric acid (1.5 mL, 0.015 mM) and DI water (50 mL) were brought to a boil. Sodium citrate (1%, 0.45 mL, 0.75 mL, 0.85 mL, 0.90 mL, 1.00 mL, 1.50 mL) was added to each solution and allowed to boil until color change indicated production of colloidal nanoparticle solutions with a range of particle sizes.

Nanoparticle solutions were characterized using Hitachi UV-vis spectrophotometer and NanoSight LM10HS particle sizer, extinction spectra recorded, and particles determined to have average diameters of 48 nm, 42 nm, 35 nm, 35 nm, 46 nm, and 23 nm, respectively.

### Polymer coating of nanoparticles

A 1 mL aliquot of each nanoparticle solution was purified via centrifugation and resuspended in 1 mL DI water, then characterized again to ensure consistency of particle diameter sizes.

Poly(allylaminehydrochloride) (PAH) (200  $\mu$ L, 10 mg/mL) and sodium chloride (100  $\mu$ L, 0.1M) were added simultaneously to each sample and the samples vortexed and then allowed to incubate overnight before being purified via centrifugation and characterized again.

### Lipid preparation and coating

1-palmitoyl-2-oleoyl-*sn*-glycero-3-phospho-L-serine (POPS) (2 mg), lysophosphatidylcholine (LPC) (2mg), and HEPES buffer (2 mL, 20 mM, pH 7.19) were combined to form a 1:1 mixture of lipid solution (2mg/mL), and the mixture sonicated to fully suspend lipids. PAH coated nanoparticle samples were centrifuged to remove excess ligands and resuspended in HEPES (0.5 mL, 20 mM). The 1:1 POPS/LPC solution (0.5 mL) was added to each 0.5mL PAH coated sample and allowed to incubate overnight. Lipid-coated samples were then centrifuged to remove excess ligands, resuspended in HEPES buffer (1 mL, 20 mM) and analyzed again using Hitachi UV-vis spectrophotometer and NanoSight LM10HS particle sizer.

Chloroauric acid, sodium citrate, PAH, and HEPES were purchased from Sigma Aldrich and diluted with DI water to form desired concentrations. POPS and LPC were purchased from Avanti Polar Lipids. All glassware and storage containers were washed with aqua regia and deionized water before use.

## Further information

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