Alloyed Nanoparticles with Lipid Coatings

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Introduction

Monodisperse silver and gold alloy nanoparticles of controlled composition and size were synthesized for the development of a potential drug delivery system. The seeded growth of the alloy nanoparticles through a co-reduction of gold and silver salts, using the Turkevich approach, was used for synthesizing the nanoparticles. The size of the nanoparticles was characterized using a NanoSight LM10 HS and their composition with a UV-Vis spectrophotometer. These alloys and earlier gold nanoparticles of varying sizes were introduced to live wild-type *S. cerevisiae* cells in their exponential growth phase, and the absorbance of the cells after incubation with nanoparticles was measured with a UV-Vis spectrophotometer.

Further information

Please contact Dr. Brian Gilbert, Linfield College, at **bgilber@linfield.edu** for more information.

Materials and Methods

Gold Seed Synthesis

Following the Rioux et al. protocol, chloroauric acid (30 mM, 300 µL) and DI water (25 mL) were brought to ebullition through reflux. As the boiling started, sodium citrate (170 mM, 200 µL) was added to cap and stabilize the reduction of the gold ions. The solution turned very dark purple then ruby red indicating nucleation was taking place. The final volume of the solution (300 µM) was achieved by adding DI water (4.5 mL). Using a NanoSight particle sizer the mean diameter of the produced nanoparticles in the colloidal solution was determined to be 20 nm.

Au/Ag Alloy Nanoparticle Synthesis

For the composition-controlled seeded growth synthesis of the alloy nanoparticles, the seed suspension produced (30 µM, 5 mL) was refluxed until ebullition with DI water (90 mL). The composition of the outer shell depends on the amount of $HAuCl_4$ (30 mM) and $AgNO_3$ (30 mM) is added when the solution starts to boil. The amounts used were based on the literature mentioned before[1]. Both are added at the same time and sodium citrate (170 mM, 900 µL) is added quickly after. The final solution is left to reflux for 30 more minutes for a complete reaction, and the final volume is adjusted with DI water (3. 65 mL). The composition was characterized using a UV-vis spectrophotometer.

Gold Seeds Addition to Yeast Cells

The yeast strain used, BY4741, cultivated overnight in a continuous shaker and grown in YPD. The cell culture per trial used was a 1:20 dilution from the original culture and the optical density was measured using a UV-vis spectrophotometer. According to the literature cited[2], 200,000 particles per cell were to be used so for each trial the concentration of the cell cultures was measured to determine the amount of nanoparticles (30 nm, 60 nm, and 100 nm) to be used. The absorbance of the solid was measured after each tube was centrifuged and washed with PBS three times. Chloroauric acid, silver nitrate, and sodium citrate were purchased from Sigma Aldrich and diluted to desired concentrations with DI water. All glassware and storage containers were washed with aqua regia and DI water before use.

Results

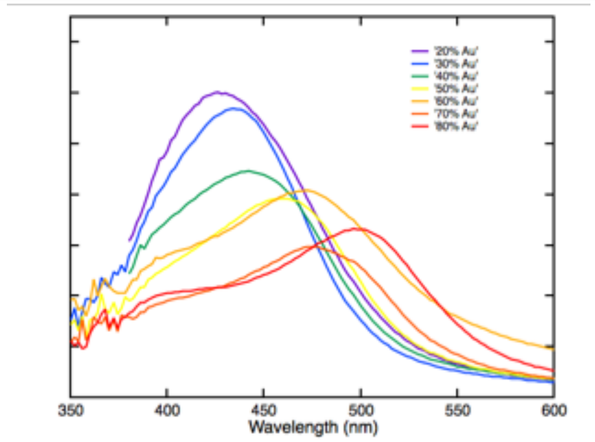

Figure 1: Au/Ag alloys of different composition characterized using their absorbance and maximum wavelength peak (λ_{max}).

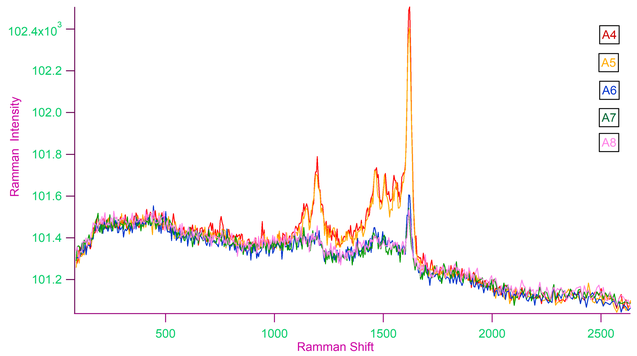

Figure 2: Raman spectra of DAPI using Au/Ag alloys of different compositions. A4 (20% Au), A5 (30% Au), A6 (40% Au), A7 (50% Au), A8 (60% Au).

Acknowledgments

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Conclusions

The absorption peaks of the nanoparticles changed depending on their composition. The alloys produced through the synthesis protocol by Rioux et al. showed this change in the absorption peaks in Figure 1. The λ_{max} ranged from 426 nm from the samples with 20% gold composition to 502 nm from the 80% gold composition sample. The reproduction of this protocol also allowed us to see the efficacy of alloys of different compositions as SERS probes. The alloys of a high composition of silver gave the best SERS image than the other alloys but were just as easy to make and did not show signs of aggregation after weeks of storage. In future research, this data will help select the best nanoparticles to introduce to yeast cells to make them easier to be located through SERES imaging. Even though the introduction of gold seeds to yeast cells did not yield the best results, future steps include adding antibodies to the nanoparticles that would attach to the surface of yeast cells or the breaking of the yeast cell wall using Lyticase.

Literature Cited

(1) Rioux, D.; Meunier, M. Seeded Growth Synthesis of Composition and Size-Controlled Gold–Silver Alloy Nanoparticles.

(2) (1) Sathuluri, R.; Yoshikawa, H.; Shimizu, E.; Saito, M.; Tamiya, E. Gold Nanoparticle-Based Surface-Enhanced Raman Scattering for Noninvasive Molecular Probing of Embryonic Stem Cell Differentiation http://journals.plos.org/plosone/article (accessed Jul 16, 2017).