Introduction

The directed self-assembly of nanoparticles is increasingly relevant in the study of nanotechnology. The ability to control the size, shape, and arrangement of nanoparticles is expected to better control the properties of materials on the nanoscale. Gold nanoparticles have unique optical and electrical properties that give them potential biological applications such as sensors, diagnostics, labeling agents, and drug delivery [1].

Nanorods have different optical properties than their spherical counterparts, as well as unique electrical properties due to the localized surface plasmon resonance (LSPR). Nanorods are synthesized using a seeding process that begins with nanoparticles [2] [3]. Structural stability is essential to better control the self-assembly of nanorods. Because alcohols have been seen to stabilize the formation of the bilayer, experiments were performed to explore the use of alcohols as co-surfactants during the formation of the nanorods. Other surfactants were also tested. Ideal nanorod synthesis would produce two distinct peaks in UV-Visible Spectroscopy due to LSPR.

Experimental Methods

The method used to produce the nanorods mediated seeding. The seed solution was prepared in the manner of the El-Sayed group using 5mL of 0.00050M HAuCl₄ and 5mL of 0.2M cetyltrimethylammonium bromide (CTAB). Next, 0.6mL of ice-cold 0.010M NaBH₄ was added and vigorously stirred for 2 minutes then maintained at 25°C [2]. The growth solutions were prepared in the model of the Murphy group, consisting of 5mL of 0.00050M HAuCl₄ and 5mL of the surfactant or surfactant and co-surfactant mixture. The growth solutions were then mixed with 0.05mL of freshly prepared 0.1M ascorbic acid solution. The final addition was 0.025mL of the seed solution [3]. The reaction took approximately 15 minutes.

The different surfactants and co-surfactants added to create the growth solution was 5mL of 0.2M CTAB solution, 0.2M CTAB solution with 10% decanol, and 4mM cetyltrimethylammonium p-toluenesulfonate (CTAT). All glassware containing the gold salt was cleaned using an Aqua Regia solution, then rinsed with tap and Milli-Q water.

This test was repeated. All samples were characterized using UV-Visible Spectroscopy. Select samples were characterized using microscopy. The microscopy images were used to verify the results from the UV-Vis.

Results and Discussion

UV-visible spectroscopy, displayed in Figure 1, indicated that some of the samples may be nanorods. Nanorods are evident in the plots when there are two peaks for a sample. The two peaks indicate light absorption at two different wavelengths. These wavelengths correlate to a size, one peak predicted to be a diameter and the other length [1]. A sharper peak indicates a high concentration of a particular size and greater monodispersity.

Figure 1 indicates that not all of the samples have nanorods. The CTAB (1a) and CTAB with deanol (1b) sample have two peaks, although the second peak is very broad. This could indicate the synthesis polydisperse nanorods and nanoparticles. The CTAT sample appears to only have one size of nanoparticles.

The fact that there is little to no shift of the peak along the wavelength scale between samples in Figure 1a and 1b indicates that the diameter size is not changing greatly. The addition of decanol does not further elongate or the rod growth, or stabilize this growth since the peaks are both broad indicating a fairly broad range of particle sizes.

The presence of nanoparticles or nanorods was verified with microscopy. Figure 2a displays an unfortunately poor resolution image, but rod shapes can be distinguished compared to the evident spherical shapes of 2c. Figure 2b displayed aggregates and the shape of the components could not be distinguished to support the UV-visible plot.

These results show that, nanorods are not being consistently produced. The CTAT sample, which likely produced wormlike micelles, did not create stable nanorods, but instead created nanospheres. The CTAB sample successfully created nanorods and the CTAB with deanol likely produced nanospheres and possibly nanorods that aggregated and is therefore difficult to view with microscopy.

It is important to note that the sample containing CTAT began reducing before at the addition of the ascorbic acid and before the addition of the seed solution.

Conclusions

There is no co-surfactant that noticeably stabilizes nanorod synthesis. It is still difficult to control the synthesis of nanorods. Future work includes repeated experiments and analysis, new sample of the CTAB-decanol solution with a different percentage of alcohol and exploration of the kinetics of using CTAT since it appears to have began reducing prior to addition of seeding solution during the procedure.

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References