Gold Nanoparticles and Shape Influence from Methanobactin

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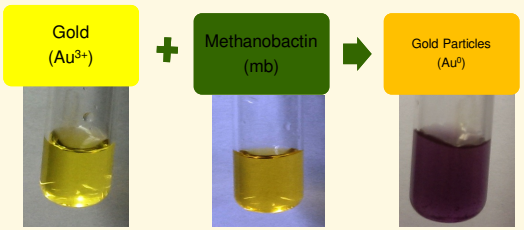
Abstract

Methanobactin is a biological molecule that is secreted by methanotrophic bacteria (that is, bacteria that live on methane gas). Methanobactin's role is to bind, reduce, and chaperone Cu^{2+} ions from the environment back inside the bacterium. In addition to copper, methanobactin has been shown to bind a wide variety of metals and in some cases to reduce them. Our research project involves the study of methanobactin's chemistry with gold, namely the reduction of Au^{3+} to Au^{0} (that is, reducing gold ions to gold atoms). The gold atoms then combine to form gold nanoparticles. With appropriate concentrations of the gold and methanobactin, nanoparticles of various sizes (and to some extent, shapes) are produced in water at room temperature. My presentation will provide evidence for the reduction of gold ions and the formation of gold nanoparticles.

Synthesis Method

- ❖$HAuCl_4$ (gold solution) to methanobactin was kept to a 5:1 ratio.
- ❖The appropriate concentrations used for methanobactin were 1mM, 500µM, 250µM, 100µM, and 75µM. The volume of the methanobactin solution was then adjusted for the desired ratio.
- ❖Gold solution concentration was kept the same at 10mM. We only adjusted the volume to arrive at the 5:1 ratio.
- ❖Gold solution was mixed with the methanobactin. After 5 minutes, the solution conditions were adjusted to suppress nanoparticle growth. Later we triggered nanoparticle growth.



*All images were taken originally by author

Concentration Effect on OB3b

mb Concentration (µM)	Gold to mb Ratio	Time for np to form
1000	5:1	1-3 minutes
500	5:1	5-48 minutes
250	5:1	15 minutes
100	5:1	80+ minutes
75	5:1	3+ hours

Ultraviolet-visible Spectroscopy (UV-Vis)

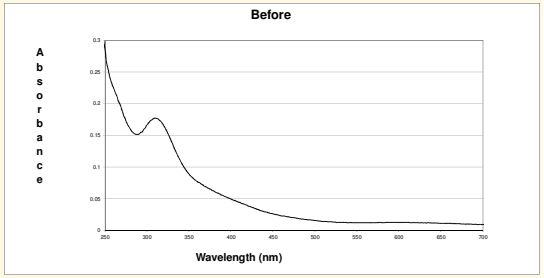


Fig 1.1 Shows a spectrum of the mixed solution (25µM OB3b) before particle production. The peak shown here at 320nm is the peak of the remaining methanobactin.

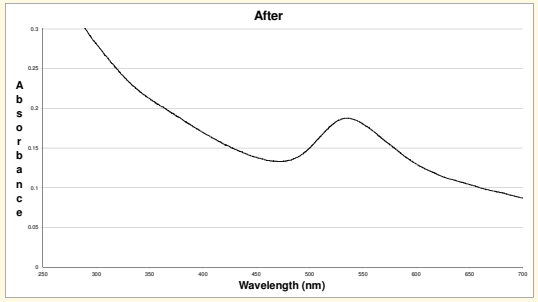


Fig 1.2 Shows a spectrum of the mixed solution (25µM OB3b) after particle production peaking at ~530nm. Methanobactin peaks are no longer present.

Scattering of light is picked up at 520nm. We can relate the scattering of light to the presence of gold nanoparticles. Using the Uv-Vis we can determine whether or not we have particles before using the Transmission Electron Microscope. Absorbance corresponds to the concentration of the particles in the solution.

Transmission Electron Microscopy (TEM)

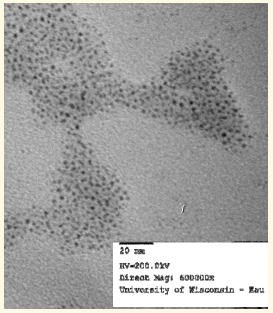


Fig 2.1 (100µM mb) The TEM sample was prepped .1 hours after nanoparticle production began.

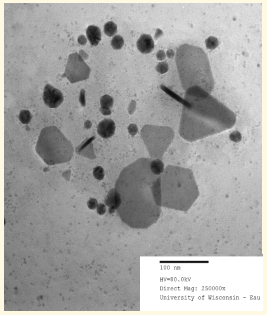


Fig 2.2 (100µM mb) The TEM sample was prepped 48 hours after nanoparticle production began.

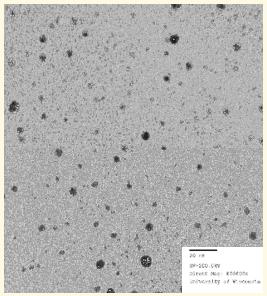


Fig 2.3 The concentration of methanobactin in this image was 25µM. Particles range in 3-10nm.

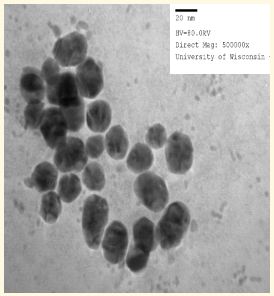


Fig 2.4 The concentration of methanobactin in this image was 50µM. Particles range in 15-30nm.

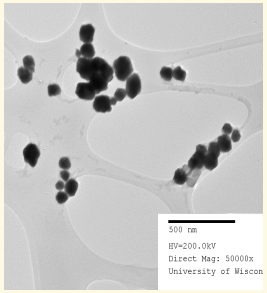


Fig 2.5 Another region from Fig 2.4 where the nanoparticles are even larger. Particles are on order of 30-100nm.

Fig 2.6 Another region, again from Fig 2.4, showing that there are still some smaller particles that can be found that range from 5nm and smaller.

*All images were taken with the Materials Science Center's TEM.

Results and Further Research

- ❖ Particles range from ~5nm (immediately after nanoparticle growth begins) up to the ~30nm range (in addition to the plates).
- ❖ Letting the solution continue producing particles does allow the particles to grow larger, and from there they aggregate to produce other shapes.
- ❖ It is not yet known if methanobactin is playing a role in this shape alteration – i.e., producing plates and rods – as all solutions are prepped right away and later timing preparation did include spheres as well.
- ❖ Generally, larger concentrations of methanobactin produces larger particles; however, this does not affect the formation of platelets. This research is ongoing to determine methanobactin's specific role in directing the shape of the nanoparticles as well as its effect on nanoparticle kinetics.

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