The Effect of pH on Methanobactin and Gold Nanoparticle Formation

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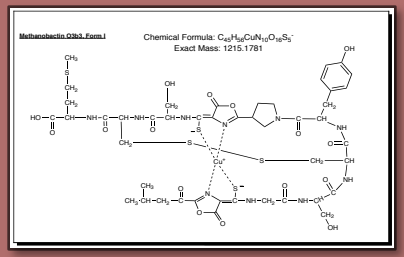
Purpose

- To control the formation of gold nanoparticles by methanobactin using adjustments in pH

Introduction

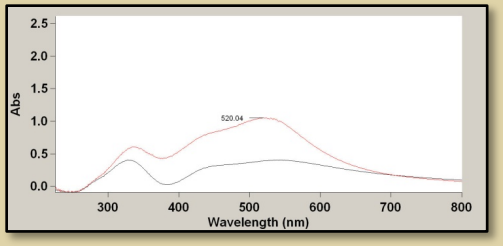
- Methanobactin (mb) is a small peptide secreted by methanotrophic bacteria that binds copper outside of the bacterial cell



- Methanobactin can also bind to several other metals including gold, nickle, iron, zinc, cobalt, cadmium, mercury and uranium
- Methanobactin's two oxazalone (5-membered) rings open up at acidic pH. Our model is that once the ring opens, mb can no longer bind Au
- Au (III), or gold in the 3+ oxidation state, is catalytically reduced to gold zero in solution. These molecules then go on to form gold nanoparticles
- Gold nanoparticles can be seen with the naked eye, as they turn a gold solution from yellow/gold to a deep cranberry/red
- The nanoparticles also display a characteristic absorbance of 520 nm on UV-Vis

Materials & Methods

- 1 mM solution of mb was added in stoichiometric ratios to an approximately 1 mM solution of chloroauric acid (HAuCl4) which served as the source of gold (III). The ratios used were 9, 7, 5, and 3 gold (III) per one methanobactin
- The solutions were adjusted to a basic pH using a dilute solution of sodium hydroxide (NaOH)
- After a period of time, the solutions were again adjusted, but this time to an acidic pH, using dilute hydrochloric acid (HCl)
- UV-Vis kinetic scanning programs monitored nanoparticle formation for 24 hours after acidic adjustment
- Once solution reached a cranberry color, the pH was again adjusted to pH 10



Results

pH	Ratio of Au to Methano -bactin	Solution Color	Time Between pH Adjustment & Initial Solution Color Change
10	9:1, 7:1, 5:1, 3:1	Yellow-No Change	No color change
2	9:1	Yellow → Pink	~10 minutes
2	7:1	Yellow → Pink	~30 minutes
2	5:1	Yellow → Pink	~3 hours
2	3:1	Yellow → Pink	~1 day

Conclusions

- Gold nanoparticles form at acidic pH but not at basic pH
- The ratio of gold to mb correlates to the rate of gold nanoparticle formation
- Gold nanoparticle formation can seemingly be stopped at a nanoparticle size by adjusting the acidic solution to a pH of approximately 10

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