Attempt of Protein Coated Au Colloid Sol-Gel Sample Formation

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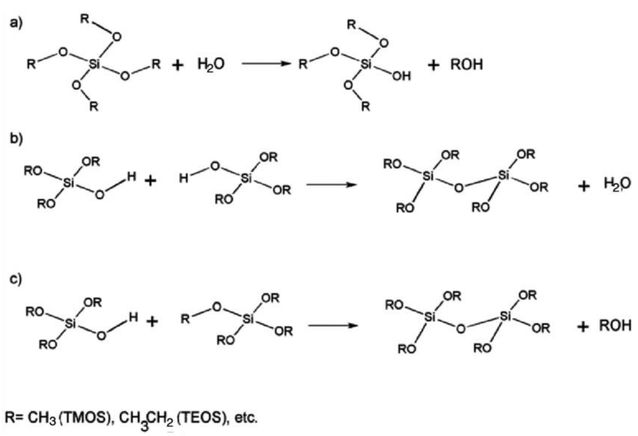
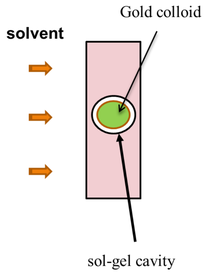
Abstract

Sol-gel is the preparation of polymers from a liquid to a network structure called “gel” through the use of liquid precursors. In this experiment, the use of silica containing sol-gel in order to trap gold nanoparticles with either Amyloid Beta peptide, which is related to Alzheimer's Disease, or SARS-CoV-2 spike protein is being tested. A liquid precursor for sol-gel which can then later be used to trap the gold colloid in the gel has been successfully made. Silica sol-gel is useful for these specific experiments because it can then be used with either the peptide or the spike protein and analyzed using the UV-VIS Spectrophotometer or Raman imaging microscope. The next step would be to find the best way to use the precursor and make the gel with the gold colloid to be analyzed using these methods.



Left: The reaction mechanism for the formation of sol-gel matrix.[1] Below: An illustration showing how sol-gel encapsulates gold colloid nanoparticles.



Background

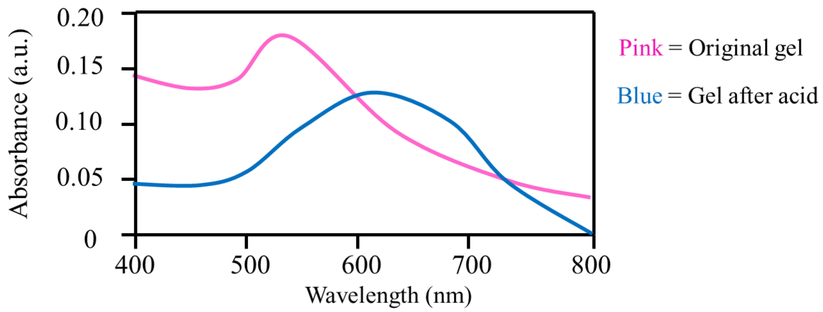
Sol-Gel is a TeOS solution mixed with colloidal particles that produces an integrated matrix of SO2. Specifically for our experiment, it can essentially trap the gold nanoparticles that are coated in either Amyloid Beta protein or SARS-CoV- 2 spike protein. The Amyloid Beta 1-40 protein is a protein that is found in patients with Alzheimer's disease. The SARS-CoV-2 spike protein attaches to the ACE2 receptor in our bodies triggering receptor mediated endocytosis. Sol-Gel is very useful because of its desirable properties including high thermal-resistance, transparency, and photo-stability. Some current examples of where Sol-Gel might be used are kidney dialysis, catalysis and diffusion across membranes. One important factor of our experiment is the impartation of a pink color to the gel after the addition of gold nanoparticles. The intensity of the pink color is directly related to the concentration of larger nanoparticles and pH.

Left: A series of samples of sol-gel showing the pH dependence of the color. The left-most sample is pH 2 and the right-most sample is pH 10.

Synthesis of Sol-Gel

The precursor for sol-gel was synthesized first using deionized water, 1 M hydrochloric acid, and tetraethylorthosilicate. This precursor was then sonicated for about 2 hours with best results at low temperatures. This species is what gives sol-gel its gel consistency.

From there, the precursor is mixed with deionized water, a pH 9.18 buffer, gold colloid nanoparticles, and the protein being studied. This mixture is then pipetted onto a microscope slide and allowed to sit for 20 minutes to fully gellize.

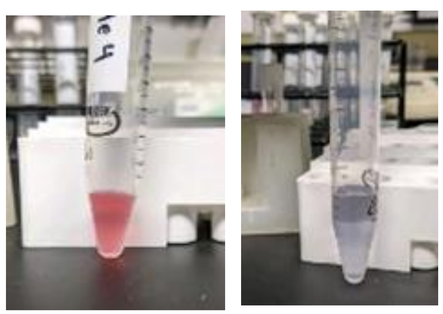


Above: A graph showing the shift in absorption signal after the addition of acid to a sample of sol-gel. We are hoping to recreate this such that we can observe this shift in real time using the Raman Spectrometer.

Color Dependence

We wish to examine the kinetic dispersion qualities of the sol-gel under the Raman Spectrometer. Ideally in an experiment we would be able to observe the sol-gel prior to any addition, and then add the desired species and observe how it disperses through the gel. This dispersion can be tested with acid because it induces a color change. We first tested these qualities by adding 1 mL of 1M hydrochloric acid to the top of the set gel. It was found that even after several days, the acid did not disperse through the gel. The gel made was too stable. Next steps will involve testing out different gel makeups such that anything added after gelification would be able to diffuse.

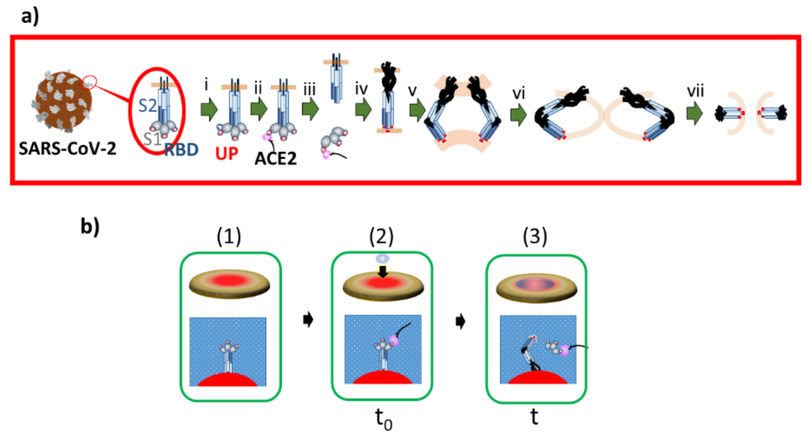
Left: A series of samples of sol-gel all with added HCl on top. No dispersion took place several hours of waiting.



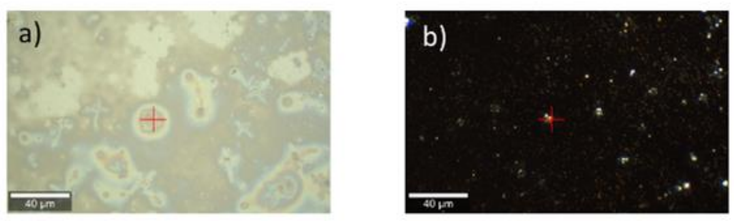
Right: Image of our sol-gel before and after the addition of HCl prior to the setting of the gel; can clearly see the color change.

Future Experiments

The SARS-CoV-2 spike protein undergoes significant conformational changes when it associates with the ACE2 protein. This reaction is incredibly quick, amd Sol-gel is hypothosised to limit diffusion sicj tjat the spike protein binding to ACE2 can be cobserved. The gel matrix additionally prevents gold nanoparticle aggregation which quenches raman signal. The use of Sol-Gel will improve resolution for protein interactions.



*Above: **a)** A sketch showing change in conformation caused by the binding of the SARS-CoV-2 spike protein to the ACE2 receptor. **b)** Some sketches SARS-CoV-2 spike protein bound to the surface of a gold nanoparticle and suspended in sol-gel. The progression shows the addition of the ACE2 receptor and binding to the SARS-CoV-2 spike protein (2), and the subsequent change in conformation and departure of the ACE2 receptor (3)*



*Above: **a)** A white light image showing the binding of the SARS-CoV-2 to 60 nm gold colloid nanoparticles. **b)** A dark field video image of the same sample.*

Acknowledgments

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References

[1] - Immobilization of Proteins in Silica Gel: Biochemical and Biophysical Properties - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Fig-2-Mechanism-of-silica-gel-formation-through-the-sol-gel-method-A_fig2_279232122 [accessed 1 Apr, 2022]