Osmotic Pressure of Microgel Suspensions

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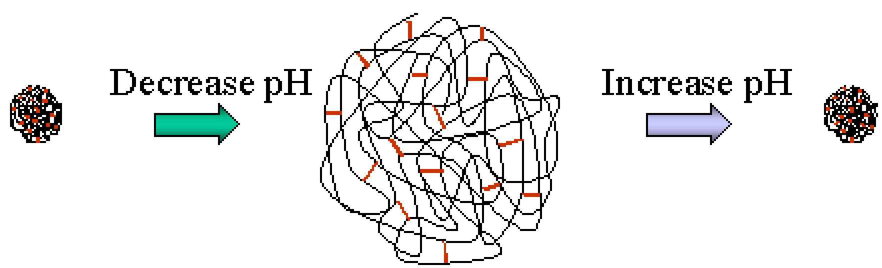
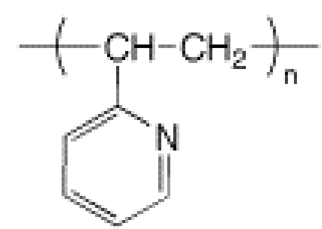
Microgels

- Microgels are a type of colloid consisting of cross-linked polymers immersed in solution.
- They display interesting properties, including the ability to change size in response to external stimuli.
- The particular microgel we will be focusing on is a pH-sensitive 2-vinylpyridine (VP) network with divinylbenzene (DVB) cross-linkers.





Motivation

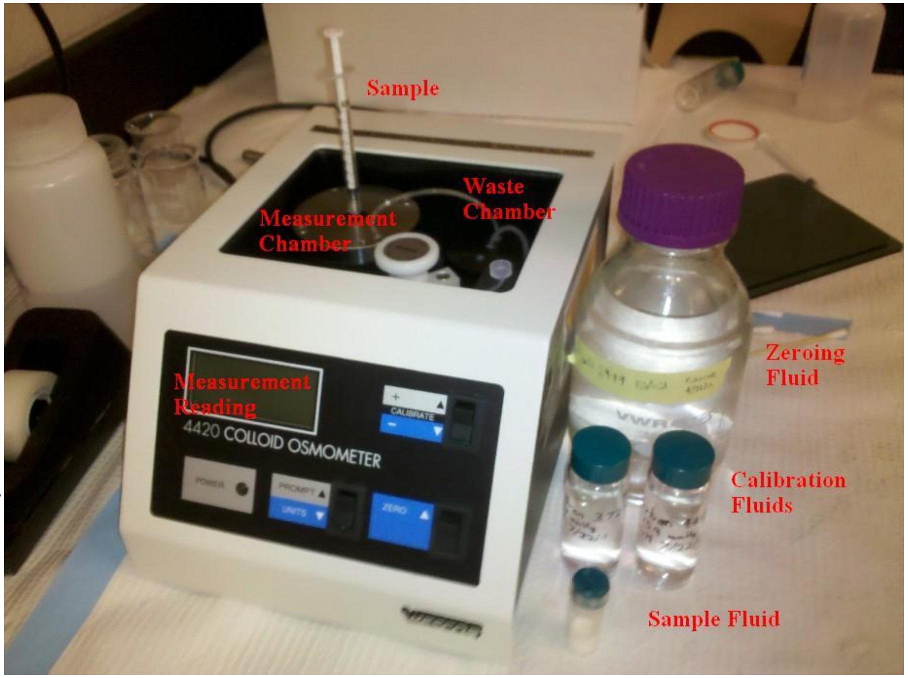
The microgel's intrinsic softness allows the particles to interpenetrate and deform, leading to rich, fascinating phase behaviors.

These phases will be investigated using osmometry, from which the osmotic pressure can be related to overall suspension stiffness.

This understanding will provide insight into similarities and differences between microgels and hard spheres, in addition to relating individual particle stiffness to suspension stiffness as a whole.

Setup

- The first step of experimentation involved developing a protocol for the colloid osmometer usage.
- After some development, a procedure and setup were perfected, as shown on the right.

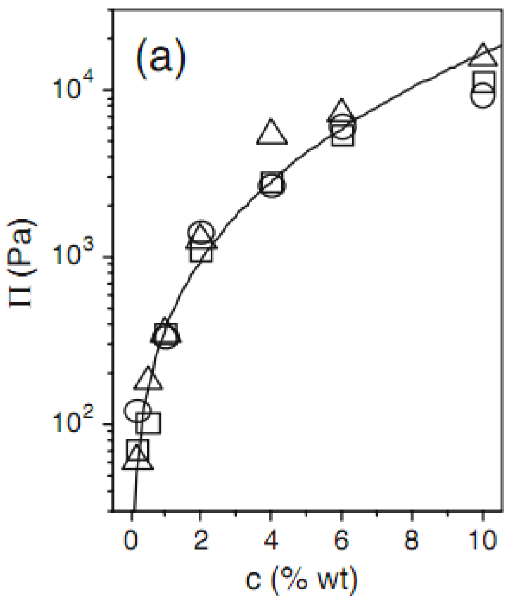


Reading Accuracy

The osmotic pressure of dextran at varying concentrations was found.

This data was compared to that found in literature to test method accuracy.

The points correspond to various pH solutions, and the line corresponds to literature values.



Particle Bulk Modulus

- The osmotic pressure exerted by dextran can be used to measure the bulk modulus of an individual microgel particle.
- The dextran exerts a pressure on the microgel particles, which can force them to deswell.
- The particle size is measured using dynamic light scattering.
- A relationship between particle size and external pressure yields to the particle bulk modulus, a measure of its stiffness.

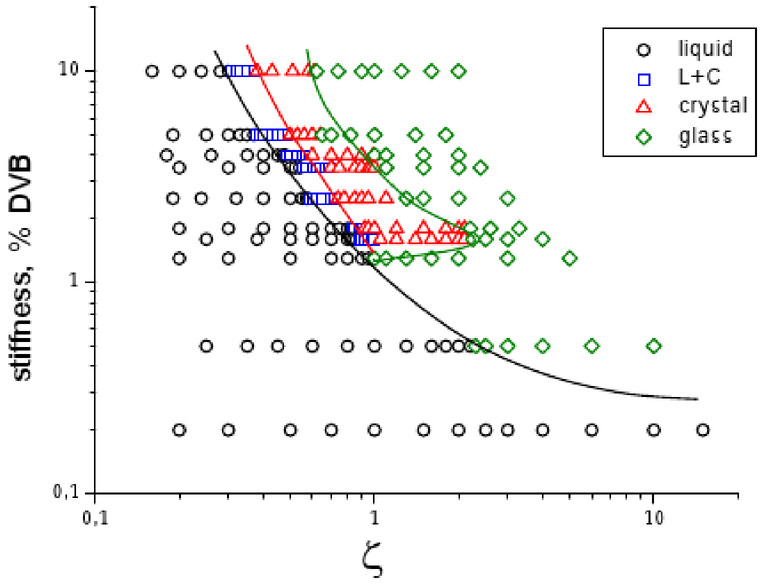
$$K_p = -V_p \left(\frac{\partial \Pi_{ext}}{\partial V_p} \right)$$

Phase Osmometry

Final experimentation involves the osmotic pressure of a microgel in different phases.

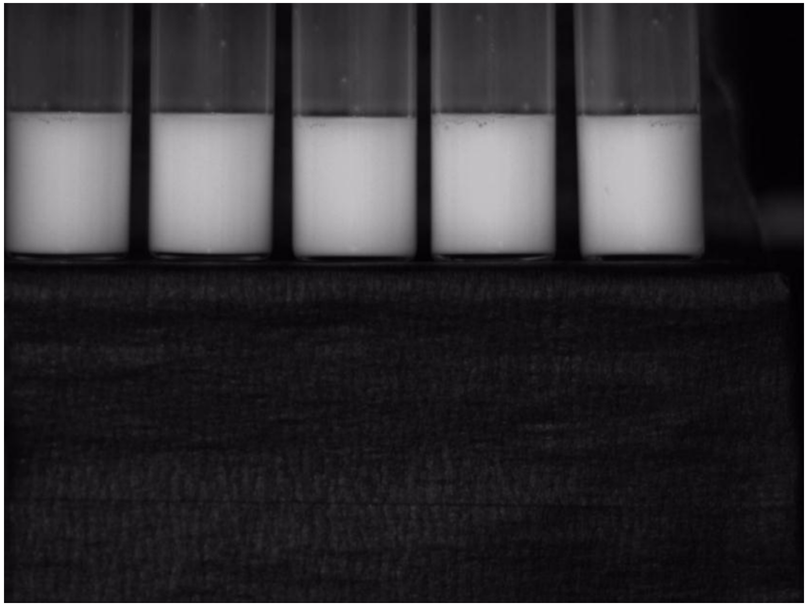
Phases are controlled by microgel volume fraction, so they are kept at the same temperature.

Initially, it is important to know the phase of the suspension being measured.



Crystal Phase

- For samples in a crystal or liquid and crystal phase, we need to know the crystallization timescale.
- Snapshots of these samples were taken over time to estimate crystal development inside the osmometer.
- Although difficult to see, this helps show when crystals will begin to form.



Osmometer Measurements

Once the phase behavior is known, the osmotic pressure at the composition will be measured.

The system will be allowed to fully develop, so only the osmotic pressure at equilibrium is found.

The suspension bulk modulus can then be found.

$$K_s = \zeta \left(\frac{\partial \Pi_s}{\partial \zeta} \right)$$

It is expected that these results will provide meaningful results for better understanding phase transitions and the link between particle and suspension properties.

Contact Information

Special thanks to Dr. Liétor-Santos (JJ) and Dr. Fernandez-Nieves for their help with this project. Thanks to Benjamin for his work on developing microgel phase diagrams.

For more information, feel free to contact me at gmarkou@gatech.edu