COLLEGE OF ENGINEERING

Chemical, Biological & Environmental Engineering

Synthesis of Nanoemulsions for Pesticide Application

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Project Opportunity

Nanoemulsion pesticides are thought to be a more sustainable alternative to traditional microemulsion pesticide formulations.

- Improved diffusion increases the bioefficacy
- A more effective pesticide application decreases environmental burden and cost to farmer

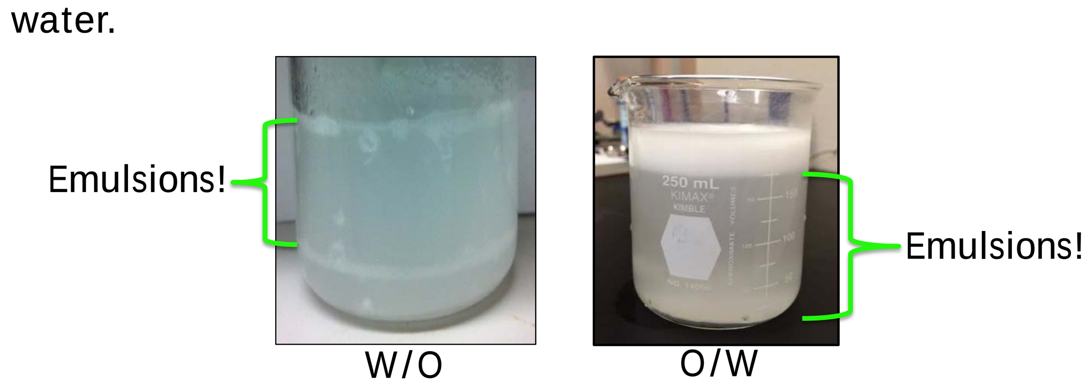
http://www.freedomsphoenix.com/Uploads/Graphics/102/04/102-0403094757-Plane-Spraying-Pesticide.jpg

Objective

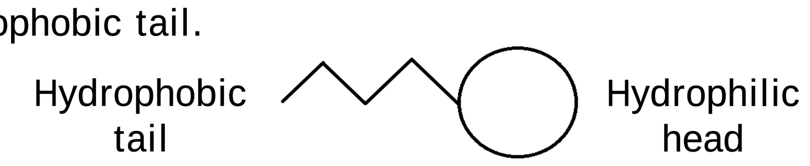
- Prepare water in oil (W/O) and oil in water (O/W) nanoemulsions with hydrodynamic diameters of 50, 500, and 1000 nanometers.
- Characterize the nanoemulsions for stability against various temperatures, light conditions, and centrifugal forces.

Background

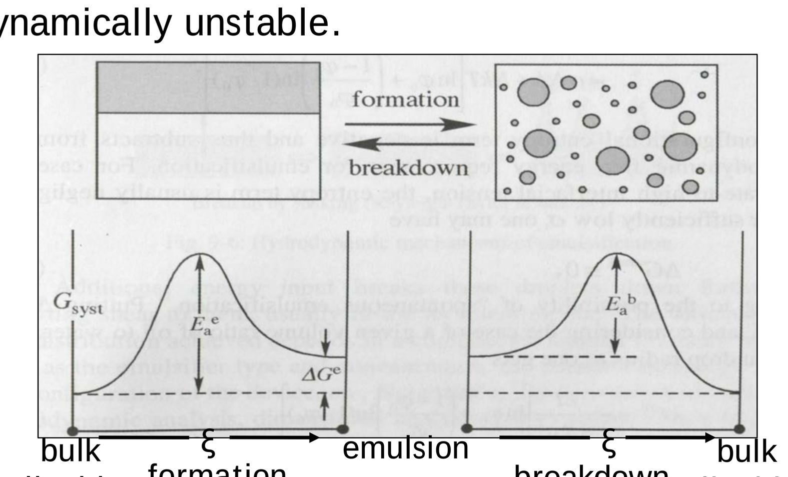
Emulsions
An emulsion is a liquid-liquid colloidal dispersion that is stabilized by the presence of a surfactant. A common emulsion is homogenized milk, an emulsion of fat globules suspended in water.



Surfactant
Surfactants are compounds used to reduce interfacial tension between two liquids. They contain a hydrophilic head and hydrophobic tail.



Thermodynamics
Nanoemulsions are metastable; kinetically stable and thermodynamically unstable.



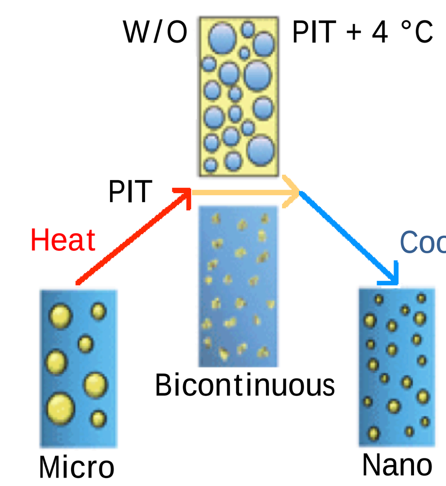
(Berg, An Introduction to Interfaces and Colloids)

Emulsification Methods

Phase Inversion Temperature (PIT)*

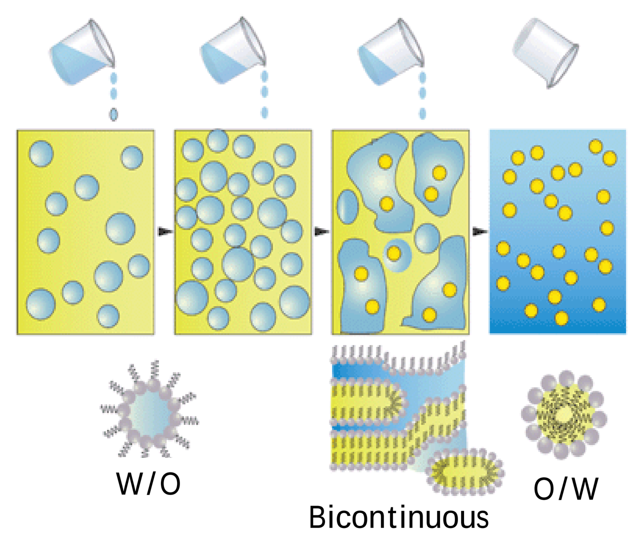
A mixture of water, oil, and surfactant is heated at a constant rate to the phase inversion temperature. At this point, water in oil (W/O) emulsions form and the solution is rapidly cooled to 5 °C. As cooling occurs, the W/O emulsions revert back to O/W emulsion. This process reduces hydrodynamic diameter from micron-sized to nano-sized.

Hydrodynamic diameter is sensitive to:
- Rate of quenching
- Oil to surfactant ratio



(McClements, Edible Nanoemulsions)

Phase Inversion Composition (PIC)*



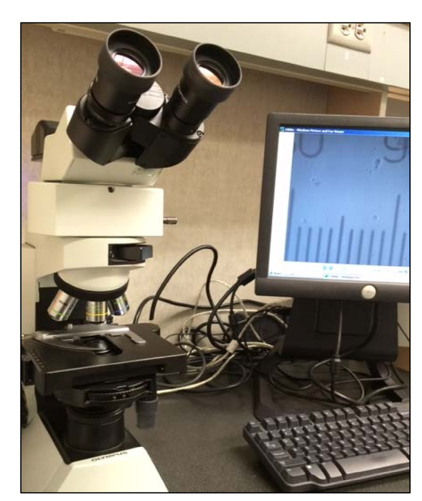
(McClements, Edible Nanoemulsions)

Water is added at a constant rate to oil and surfactant until the phase inversion point, at which a bicontinuous system exists. Additional water causes surfactant molecules to switch orientation, forming an oil in water nanoemulsion.
Hydrodynamic diameter is sensitive to experimental conditions:
- Temperature
- Stir rate
- Water addition rate

***Experiments performed without pesticide active ingredient**

Analysis

An Olympus CX41 microscope was used to analyze prepared nanoemulsions. A 10 μm stage micrometer slide provided a rough estimation of hydrodynamic diameter. Micrometrics SE Premium software was used to capture images of the emulsions. After imaging, samples were quantitatively analyzed with the Malvern Nano ZS Zetasizer and ImageJ software.

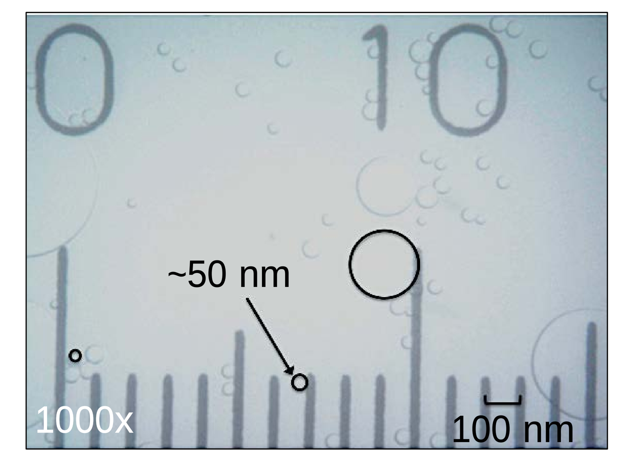


The Zetasizer measures the hydrodynamic diameter of the emulsion droplets by dynamic light scattering. The frequency of size measurements is displayed as a function of intensity. To reduce the polydispersity index (PDI), larger emulsion droplets are removed by a 0.2 μm syringe filter and measured again.

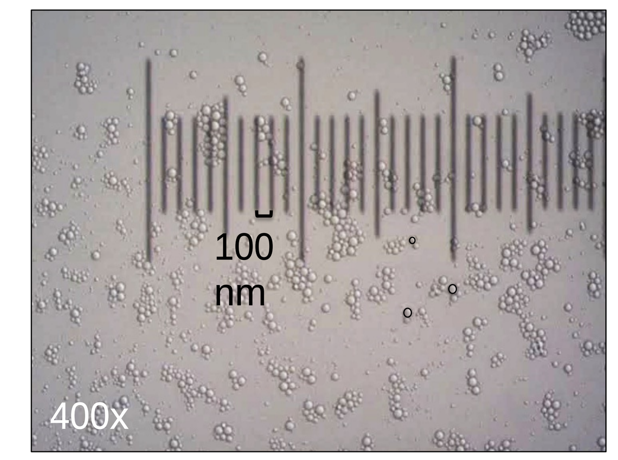
Results & Conclusions

PIT

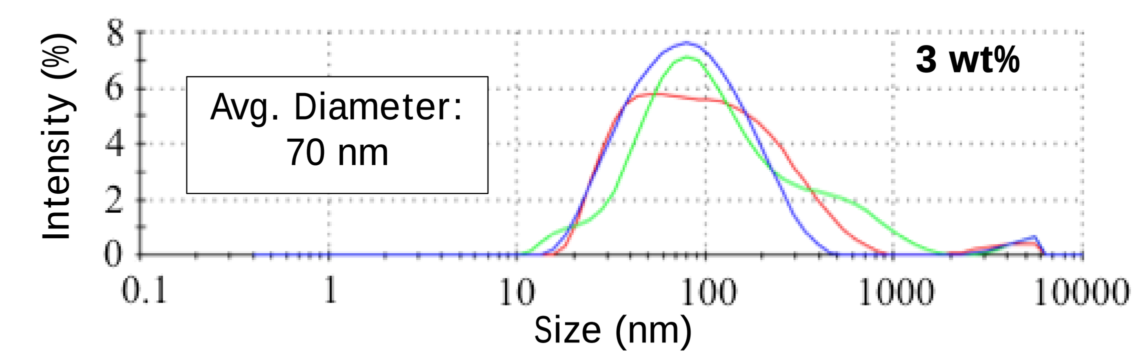
Decrease in surfactant concentration from 5 to 3 wt% reduced the average hydrodynamic diameter from 150 to 70 nm. Oil held at 20 wt%.

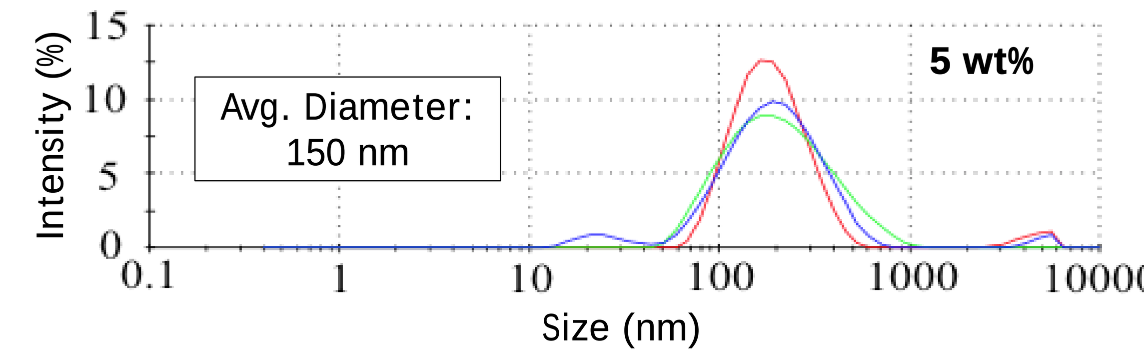


3 wt%



5 wt%

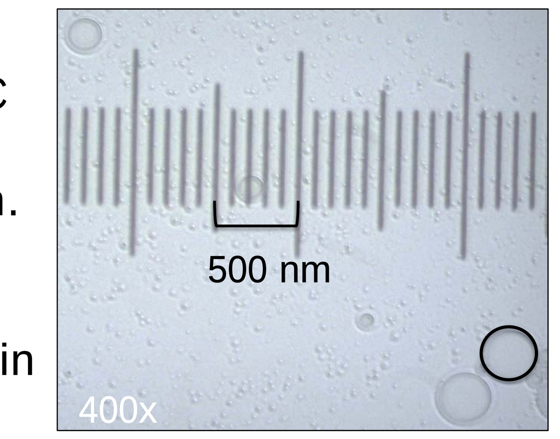


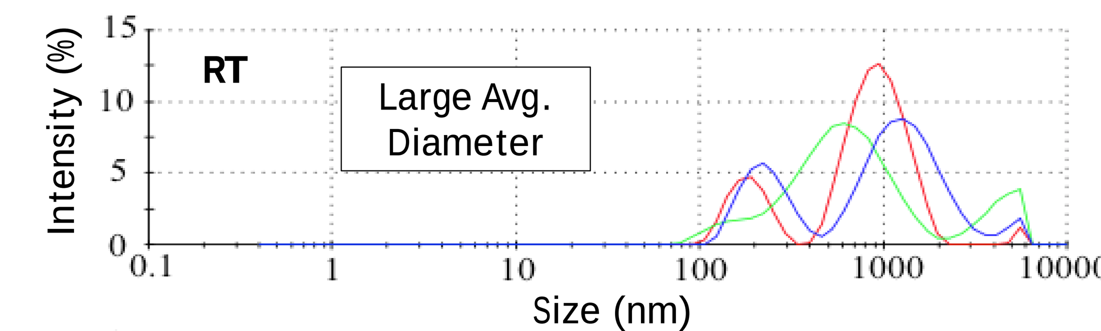


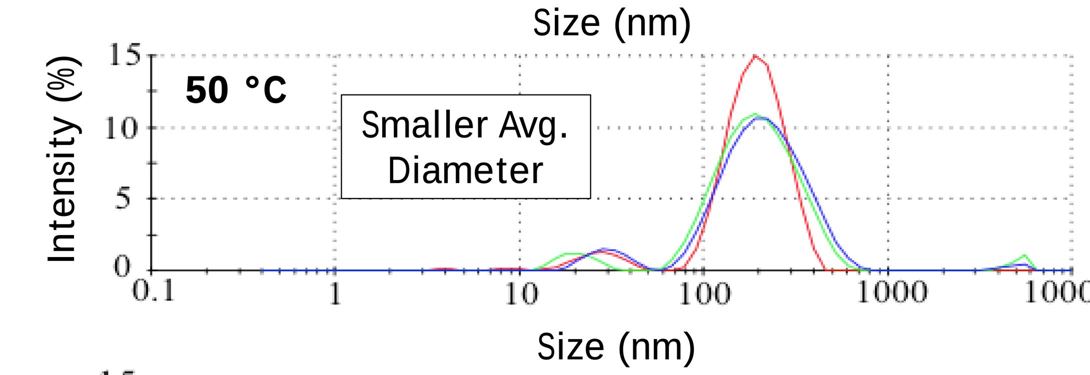
PIC

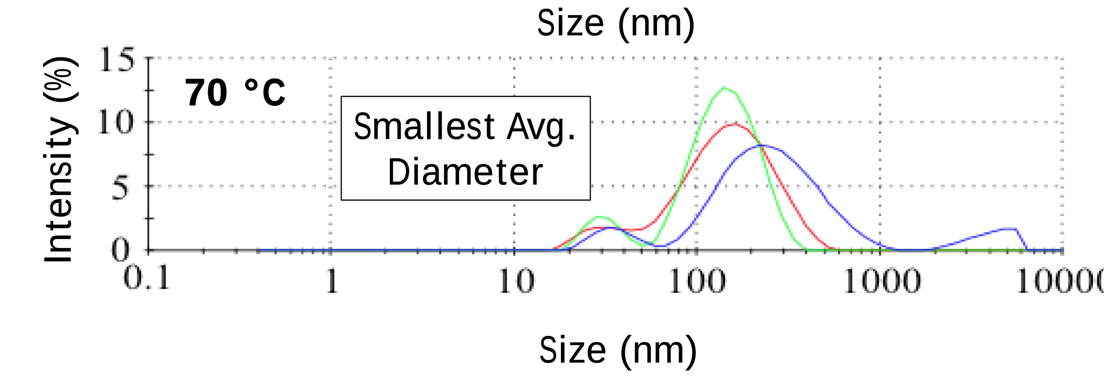
Increase in steady state temperature from RT to 70°C decreased hydrodynamic diameter from 580 to 140 nm.

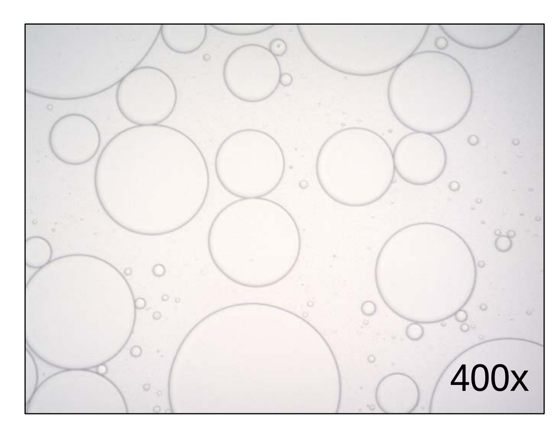
Oil:Surfactant of 1:1
Water addition rate: 5 mL/min
Stir rate: 500 RPM

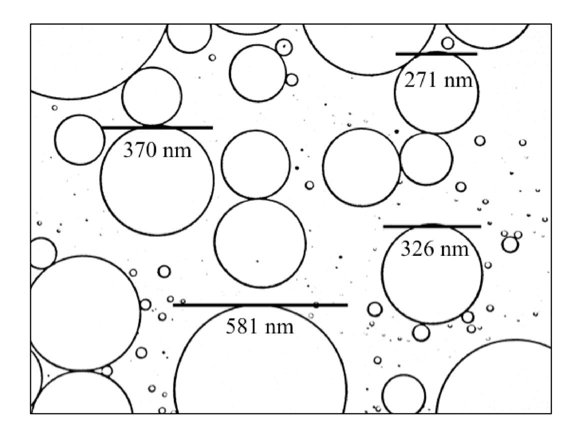












Microemulsions agitated at 500 RPM for 5 mins, allowed to settle for a day, then re-stirred at 500 RPM for 5 mins.

PIT has more industrial promise due to high repeatability, user friendliness, and viability of both O/W and W/O nanoemulsions. PIC is highly sensitive to experimental conditions and did not yield desired nanoemulsion hydrodynamic diameters below 100 nm.

Nanoemulsion stability and toxicity will be compared against current microemulsion pesticides to determine the most viable emulsions for pesticide applications.

Future Work

Future work for this two-year project will consist of replicating experiments and performing stability tests. Size and separation will be evaluated over time with varying light conditions, temperature, and gravitational forces. Nanoemulsion toxicity will be evaluated using *Danio rerio* (zebrafish) for blank nanoemulsions and nanoemulsions loaded with various pesticide active ingredients.

Acknowledgements

Dr. Stacey Harper (Project Sponsor), Bryan Harper (Research Coordinator), Alicea Clendaniel (Project Manager), Andy Brickman (Technical Expert), Dr. Philip Harding (Mentor)

References

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