Classifying Emulsions

Here we are focusing on classifying different types of emulsions and exploring each one's physical characteristics. Through this activity we will learn how the ratio of each component of the emulsion—water, oil, and surfactant, which in this case is soy lecithin—affects the stability of the emulsion, as well as its appearance and texture.

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There are a few notes to consider before getting started:

1. Make sure your work surface, equipment, and containers are clean.
2. Organize your materials -- it is best to have everything ready.
3. Read through the protocol before starting so you know what to expect.

Materials and Equipment

Ingredients
Oil
Water
Soy Lecithin (or any surfactant of your choice)
Food coloring

Equipment
Sample tubes with caps
Scale
Weighboat
Stir stick or spatula
Mortar and pestle
Vortex & rubber bands
Rubber band
Notebook & Pen

Plan your Samples

Prepare a set of samples based on your own exploration or using the set of samples below. Use the Classifying Emulsions Workbook to organize your own emulsion concentrations.

	Emulsion A		**Emulsion B**		**Emulsion C**		**Emulsion D**	
Ingredient	*%*	*Mass*	*%*	*Mass*	*%*	*Mass*	*%*	*Mass*
Oil	70%	7g	20%	2g	45%	4.5g	20%	2g
Water	20%	2g	70%	7g	45%	4.5g	60%	6g
Soy Lecithin	10%	1g	10%	1g	10%	1g	20%	2g
Total	***100%***	***10g***	***100%***	***10g***	***100%***	***10g***	***100%***	***10g***

Prepare a Sample

1. Label a sample tube: e.g. **Emulsion A**.
2. Weigh out water for Emulsion A into the tube.
3. Weigh out soy lecithin* for Emulsion A in a weigh boat and pour into the tube.

   Note: if soy lecithin is chunky, use mortar and pestle to grind it thoroughly, but not smudging it onto the mortar, before putting it in.

4. Cap the tube and invert 2-3 times. Then vortex the tube for three minutes at level 8.

   Note: If there are still undissolved soy lecithin particles, vortex a bit more, and use a stir stick or spatula to manually break particles.

5. Weigh out oil for Emulsion A and pour into the tube. (Volume can also be used, but weight may be more accurate for viscous solutions like oil.)

6. Vortex again for 5 minutes until uniformly distributed.

Classify Your Emulsion

Record emulsion stability and change over time

1. Record the following characteristics immediately after vortex, 30 minutes after the vortex, and two hours after the vortex:
   - ☐ Emulsion state (can you see chunks of undissolved soy lecithin, or is the liquid uniformly emulsified?)
   - ☐ Volume (read off of the tube)
   - ☐ Color
   - ☐ Texture, by eye or by feel
   - ☐ Continuous and dispersed phases, using the **Emulsion Dye Protocol** (p.3-4)
   - ☐ Viscosity, using the **Viscosity Protocol** (p.5-6)
   - ☐ Conductivity, using the **Conductivity Protocol** (p.7)
   - ☐ Record other observations or add your own metrics for characterizing your emulsions

How stable is your emulsion over time? Which factors are most noticeable for analyzing emulsion stability?

Emulsion Dye Protocol

Ever tried to add food coloring to buttercream frosting, only to watch it stay in clumps beaded on the surface until you mix it in? This is just what you'll do in this protocol, as a more systematic tool for analyzing the continuous and dispersed phases of an emulsion.

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Overview

Emulsions can be referred to as oil-in-water (O/W) or water-in-oil (W/O) emulsion. In this nomenclature, the first part refers to the dispersed phase which is surrounded by the latter, the continuous phase. Thus you can refer to an emulsion using the nomenclature as dispersed-in-continuous.

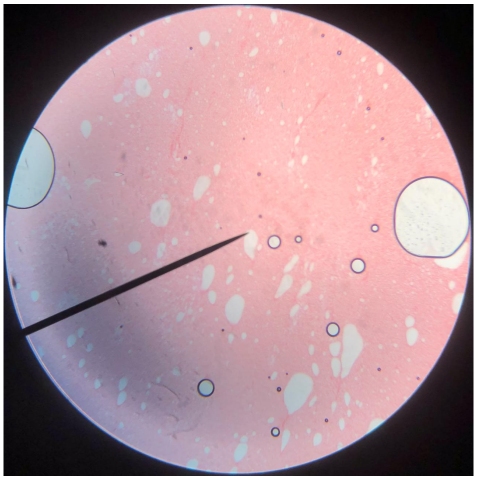
Materials and Equipment

Ingredients
Various emulsions (ideally a range of W/O and O/W emulsions)
Food coloring
Oil Red O ($25 for 25g)

Equipment
Glass slide (2 per emulsion)
Toothpick (2 per emulsion)
Plastic pipette (1 per emulsion)
Microscope and cover slips (optional)
Sharpie/lab marker

Prepare a Sample

1. Label two slides for each emulsion, and mark one W for the water-dyed sample and one for O for the oil-dyed sample e.g. Emulsion A would get two slides A-W and A-O
2. Transfer 2-3 drops of emulsion onto each of that emulsion's labeled slides.
3. On the "O" slide, dispense one drop of Oil Red O and on the "W" slide dispense one drop of food coloring.
4. Mix the sample and coloring well on each plate, using a separate toothpick for each slide.
5. Record the color dispersion within the sample.
6. (Optional) Cover the sample with a cover slip. Put the slide under the microscope and observe the dispersion of the sample. Which part of the sample is dyed and which part isn't? --- can you tell the dispersed phase and continuous phase?



Ignore the shapes with bold outlines as those are air bubbles. Focus on the texture of the more uniform sample of water and ail.

How does changing the magnification allow you to see how uniform your emulsion sample is?

Viscosity Protocol

Viscosity is a measure of the thickness or “stickiness” of a liquid. While measuring viscosity directly can be technically involved, we propose here a method for measuring a proxy of viscosity.

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Overview

There are various ways to measure viscosity and you can always get creative as long as you can find a way to correlate your method with the stickiness of the emulsion. Here we use a slanted surface and the distance a liquid travels over a given time. Viscosity has units of *force x time / area* (Ns/m^2). In this experiment we directly measure the distance traveled per set time under the constant force of gravity, and the inverse of this measurement is a proxy for viscosity.

In addition to this slope method, viscosity can be measured by a falling ball viscometer, viscosity cup, capillary viscometer, and so forth.

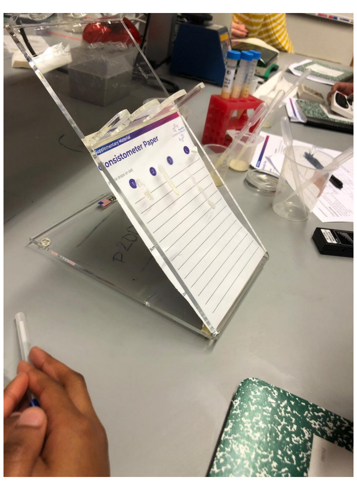
Materials and Equipment

Ingredients
Various emulsions (ideally a range of consistencies)

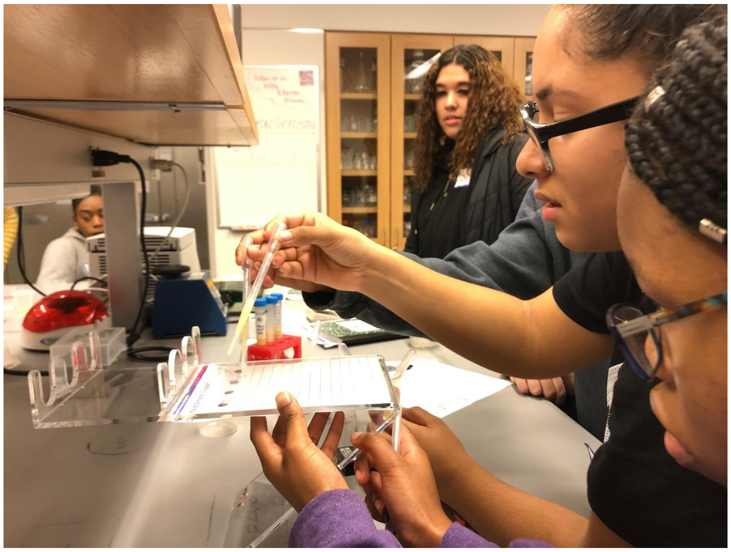
Equipment
Consistometer paper or other marked surface
Flat surface held at an angle
Plastic pipette (1 per emulsion)
Timer or video recording device

Analyze a Set of Samples

1. Set up your slanted surface. Some examples shown here:



2. Adjust your surface to be flat. Add a small, consistent amount of each emulsion sample, using a separate pipette for each sample. An example is shown at the right:



3. Prepare your timer or video recording, then tilt the surface to its set slanted position. Video recording allows for multiple timepoints of analysis so is preferred if possible. If not, record the distances traveled by each sample after the set amount of time (e.g. 30 seconds or 2 minutes, it will depend on your setup and samples).

4. Calculate the inverse (1/measurement) of each emulsion as a proxy of viscosity.

5. Record the viscosity category of each sample, such as using the standards below (in units of cm^{-1}), or another categorization that better exemplifies your data.
   <0.2 : Low Viscosity
   0.2-.0.5: Medium Viscosity
   >0.5: High Viscosity

6. Repeat samples to get a sense of the precision of your measurements

Conductivity Protocol

Conductivity is a measure of the free flow of electrons within a fluid. This metric of emulsions works best with some amount of salt present in the emulsion.

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Overview

Assuming sufficient mobile charges are present within your emulsion, emulsions with an oil-based continuous phase will exhibit low conductivity while a water-based continuous phase will allow for higher conductivity. This measurement can be hard to interpret between real-world emulsions, but can be an interesting comparison between emulsions of varying proportions of oil, water, and surfactant.

Materials and Equipment

Ingredients
Various emulsions (ideally a range of concentration ratios and with some salt present)

Equipment
Conductivity tester

Analyze a Sample

1. Prepare your emulsion sample in a tube wide enough to accommodate both probes of the conductivity tester, with sufficient depth to cover the ends of both probes.
2. Observe and record the conductivity level.
3. If low levels of conductivity are consistently recorded, you can try adding some salt consistently to each sample. Let the samples equilibrate for some time before retrying your recordings.

Note: If you are preparing fresh emulsions for these tests, consider the following:

1. To achieve a 1% final salt concentration (close to the concentration in a cell), dissolve salt into water to create a 10x (10%) concentrated solution. Thus, for 10ml of 10x salt solution, weigh 1g sodium chloride and add water up to 10 ml. Shake to ensure it's dissolved.
2. Add 1ml of this 10x salt solution to each emulsion sample (as one of the ml of water added in total). For example, Emulsion A would be 1 ml 10x salt + 1 ml water to achieve the 2 ml (2 g) of water as calculated. Emulsion B would be 1 ml 10x salt + 6 ml water to achieve the 7 ml (7 g) of water as calculated.

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