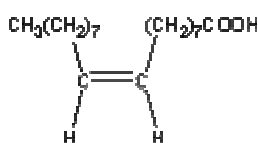




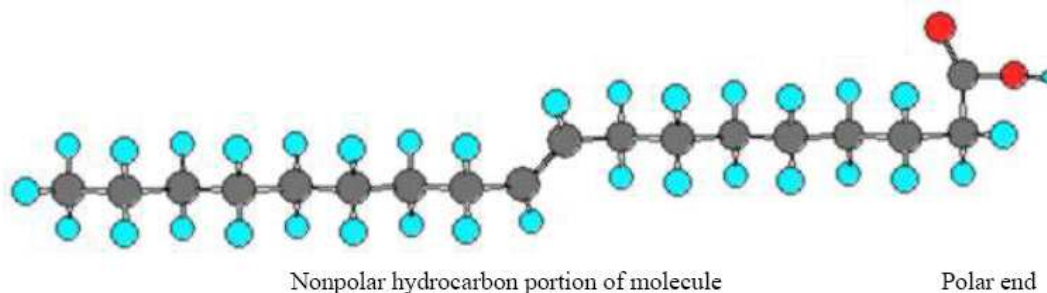
## STEM ED/CHM Nanotechnology at UMass Amherst

## Oleic acid thin films

Oleic acid is a component of most fats and oils, including cocoa butter. Oleic acid is used to flavor many food products. It is a mono-unsaturated fatty acid because of one double bond that exists between two carbons in a very long chain of carbon atoms. The structural formula and skeletal structures of oleic acid (shown below), provides a hint of one of its properties.



The illustration (shown below) provides an even stronger hint of a property of oleic acid that causes one end of the molecule to be attracted to water when a drop of an oleic acid solution is placed onto the surface of water.



Source: [www.chymist.com/size%20fatty%20acid.pdf](http://www.chymist.com/size%20fatty%20acid.pdf) -

The polar end of the oleic acid molecule includes a carboxylic acid group with two oxygen atoms. The polar end of the oleic acid molecule is attracted to polar water molecules. The nonpolar end of the oleic acid molecule is hydrophobic. As a result, when a drop of an oleic acid solution is placed on the surface of water, the oleic acid molecules form a thin layer as alcohol evaporates. Because the polar end of the oleic acid molecules are attracted to surface of the water, the oleic acid molecules are aligned vertically in a layer on the surface of water like blades of grass on a lawn and similar to the diagram shown below.



**Therefore**, if one can determine the thickness of an oleic acid monolayer, one is might also be able to calculate the length of an oleic acid molecule.

## The Procedure

Read the entire procedure before starting

### Get Started

- Create a work space large enough for a circular tray, graduated cylinders, paper towels, paper cups, a medicine dropper, a pipette, and a ruler.
- Place enough water in a circular tray to form a layer of water with a depth of approximately half a centimeter.
- Each group will be given a small amount of oleic acid.
- Bottles of isopropyl alcohol (rubbing alcohol) will be provided.

### Make two solutions of oleic acid

- Put  $1.0 \text{ cm}^3$  of pure oleic acid into a  $25 \text{ cm}^3$  graduated cylinder. One method is to use a pipette obtain the  $1.0 \text{ cm}^3$  sample of oleic acid. The other method is to use the  $10 \text{ cm}^3$  graduated cylinder to measure  $1.0 \text{ cm}^3$  of pure oleic acid.
- Add alcohol to the oleic acid in the  $25 \text{ cm}^3$  graduated cylinder until the total volume of the solution is  $25 \text{ cm}^3$ .
- Transfer the solution back and forth between a clean plastic cup and  $25 \text{ cm}^3$  graduated cylinder to thoroughly mix the solution. In the last step of the mixing process, the oleic acid solution should be in the plastic cup.
- Put  $1.0 \text{ cm}^3$  of the oleic acid solution into a  $25 \text{ cm}^3$  graduated cylinder.
- Once again, add alcohol to the oleic acid in the  $25 \text{ cm}^3$  graduated cylinder until the total volume of the second solution is  $25 \text{ cm}^3$ .
- Again, transfer the solution back and forth between a clean plastic cup and the  $25 \text{ cm}^3$  graduated cylinder to thoroughly mix the solution. In the last step of the mixing process, the oleic acid solution should be in the plastic cup.
- Now use a medicine dropper and a  $10 \text{ cm}^3$  graduated cylinder to determine how many drops (N) of the second solution of oleic acid is in  $1.0 \text{ cm}^3$  of the second solution.

### Make an oleic acid thin film

- Use baby powder (chalk dust, very finely ground pepper, etc.) to cover the surface of the water in the food tray.
- Use the dropper to drop one drop of the second oleic acid solution onto the surface of the water in the circular tray.
- Allow a short time for the alcohol solvent to evaporate into the air and dissolve in the water. The remaining oleic acid will spread across the surface of the water.
- Use the ruler to estimate the average diameter (**in centimeters**) of the circular layer of oleic acid. Record the average **radius** of the area.

### Calculate the Depth (thickness) of the Layer of Oleic Acid

Do your work for each of the following steps on a separate sheet of paper.  
Record the information for each step on the Oleic Acid Calculation Worksheet.

**Step 1:** You added enough alcohol to  $1\text{ cm}^3$  of pure oleic acid to make a solution with a total volume of  $25\text{ cm}^3$ . Write a fraction that indicates how much pure oleic acid is in  $1.0\text{ cm}^3$  of the first solution that you made.

**Step 2:** Change the fraction in Step 1 into decimal form.

- Now you know how many  $\text{cm}^3$  of pure oleic acid are in  $1.0\text{ cm}^3$  of the first solution that you made.

**Step 3:** Then you diluted  $1.0\text{ cm}^3$  of the first solution by adding enough alcohol to make a second solution with a total volume of  $25\text{ cm}^3$ . Determine how many cubic centimeters of oleic acid are in  $1.0\text{ cm}^3$  of the second solution that you made.

**Step 4:** Record the number of drops in  $1.0\text{ cm}^3$  of the second solution.

**Step 5:** Determine the volume of pure oleic acid that was in one drop of the second solution. Record that value with the proper unit for volume.

- Now you know the volume of oleic acid that formed the thin film.

**Step 6:** Record the average radius of the circular area of the film of oleic acid.

**Step 7:** Determine the area of the oleic acid thin film? Show your step by step calculation and then record the area. Include the proper unit for area.

- Now you know the volume **and** the area of the thin film of oleic acid.

**Step 8:** Determine the depth (thickness) of the thin film of oleic acid. Show your step by step calculation and then record the thickness of the oleic acid thin film.

**Step 9:** Change the depth of the thin film from centimeters to meters. Record the thickness using scientific notation.

#### A few questions:

**Question 1:** The length of an oleic acid molecule is approximately 2.0 nanometers. What are some sources of experimental error in the procedure you followed?

**Question 2:** How can experimental error for this activity be reduced?