Avogadro's Number

Experiment

3

Oleic acid is one of a number of liquids which have the property of spreading out in a mono molecular layer on a water surface. If you spread a known volume of oleic acid on water, the area of the layer can be measured.

$$area = length \times width$$

From the area, the thickness of the film can then be calculated.

$$volume = length \times width \times height$$

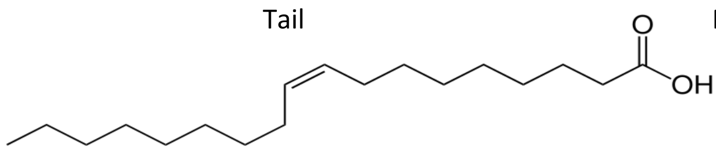
If you substitute thickness for height you get the following:

$$volume = area \times thickness$$

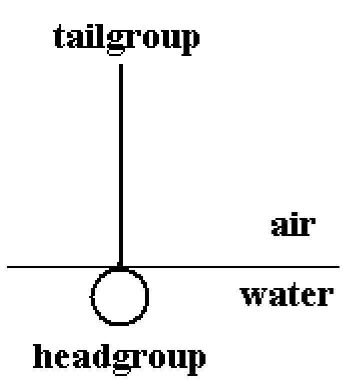
Oleic acid, $C_{18}H_{34}O_2$, contains a long non-polar hydrocarbon chain (tail) and a polar functional group at the other end of the chain (head). The non-polar chain is repelled by water (hydrophobic) and the polar end is attracted to water (hydrophilic).

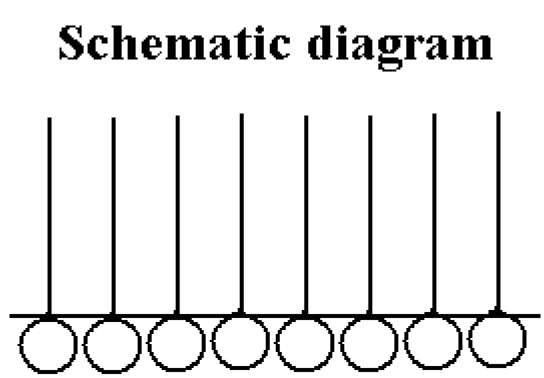
Hydrophobic Tail

Hydrophilic Polar head



When a molecule containing a polar and non-polar end is placed on the surface of water, the polar end will face down towards the water surface while the non-polar end points upward away from the water. If a small amount of the oleic acid is placed on the water surface, a monolayer will form.





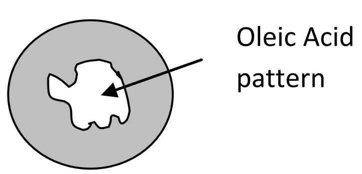
A very dilute solution of oleic acid in pentane will be used. The pentane will quickly evaporate to leave behind a monolayer of pure oleic acid. In this experiment you will count the number of moles in a sample and derive the number of molecules in the sample. From these results, you will be able to estimate Avogadro's number.

Equipment and Reagents

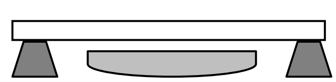
Grease (Vaseline)	wash bottle	pentane	graph paper
Large watch glass	cork dust	glass plate	scissors
Tap water	graduated pipet	4 stoppers	analytical balance
Dilute HCL	oleic acid solution	marking pencil	

Procedure

1. Rub a thin layer of grease around the rim of a large watch glass to make the rim water repellent.
2. Set the watch glass on the bench top and fill with tap water. Add a drop of dilute HCl. *The acid will neutralize anything in the tap water which might interact with the oleic acid*. Use a wash bottle to adjust the water level in the watch glass so that the water surface bulges up above the rim.
3. Dust the water surface with a very fine even layer of cork dust by gently tapping the side the sieve containing the cork dust while moving it above the water surface. *Warning: A layer that is too thick will give poor results.*
4. Use a graduated pipet to place exactly 0.10 mL of oleic acid solution on the liquid surface. Obtain the pipet and solution from your lab instructor. The solution contains oleic acid dissolved in pentane to give the following concentration:
$$\frac{6.8x10^{-5}\ mL\ pure\ oleic\ acid}{1.0\ mL\ solution}$$
5. Allow the pentane to evaporate from the water surface. Pentane is extremely volatile, so be sure to stopper the solutions tightly when not using them. The oleic acid will push the cork dust aside to form a pattern upon the surface.
6. Place a glass plate on supporting stoppers over the watch glass. Trace the outline of the film on the glass with a marking pencil then tract the film outline onto a piece of graph paper. Carefully cut out the film tracing and weigh the cutout on the analytical balance.



Top View



Side View w/ glass plate

7. On the same sheet of graph paper, measure a square or rectangle about 5 to 10 cm on each edge. Cut out the shape and weigh it on the analytical balance. Calculate the area of this shape in cm^2. This will be the comparison area used to determine the area of the oleic acid solution cutout above.

Calculations

1. Find the number of moles of oleic acid.
   First find the volume of pure oleic acid (assuming 0.10 mL of the solution was used).

$$vol.of\ acid = V_A = \frac{6.8x10^{-5}\ mL\ pure}{1.0\ mL\ soln.} \times\ 0.10\ mL\ soln. = 6.8x10^{-6}\ mL\ pure\ acid$$

   Then find the mass of oleic acid (density = 0.895 g/mL)

$$mass\ of\ acid = 6.8x10^{-6}mL\ \times\ \frac{0.895g}{mL} = 6.1x10^{-6}g\ pure\ acid$$

   From the molar mass (282 g/mol), calculate the moles of pure oleic acid.

$$moles\ of\ acid = mol_A = 6.1x10^{-6}g\ pure\ acid\ \times \frac{mol}{282g} = 2.2x10^{-8}mol$$

2. Find the number of molecules of oleic acid.
   Assuming the comparison area is a square, the area of the oleic acid film can be determined from the following equation:

$$Area_{film} = Area_{square} \times \frac{mass\ of\ film}{mass\ of\ comparison\ square}$$

   Solve for the thickness of the monolayer.

$$V_A = Area_{film} \times thickness$$

   Assuming a molecule of oleic acid is a cube, solve for the volume of the molecule.

$$V_{molecule} = (thickness)^3$$

   Thus, 1 molecule = $V_{molecule}$

$$number\ of\ molecules = V_A \times \frac{1\ molecule}{V_{molecule}}$$

3. Calculate Avogadro's number.

$$Avogadro's\ number = \frac{number\ of\ molecules}{mol_A}$$

4. Calculate the percent error between the accepted value of $6.02x10^{23}$ molecules/mol and the experimental value obtained. What are the possible sources of error?