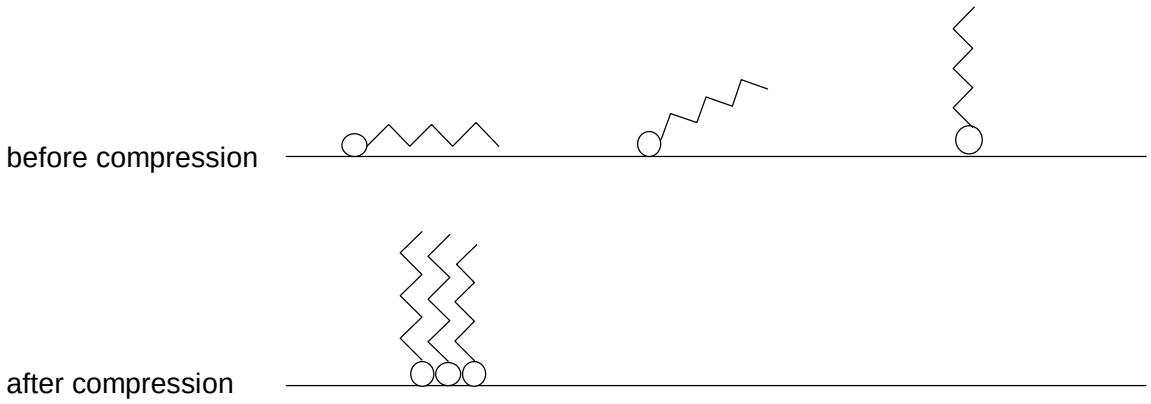
Determination of the Cross Sectional Area of Stearic Acid

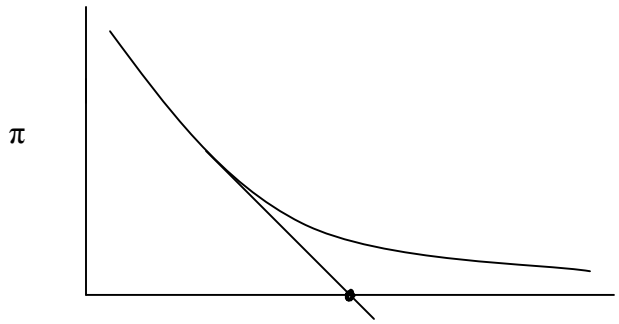
Introduction

Molecules with a long hydrocarbon tail and a polar head such as stearic acid, $CH_3(CH_2)_{16}COOH$, will spread over a water surface as a monomolecular layer (monolayer). This means that the thickness of the layer is one molecule. The polar heads are in the water while the hydrocarbon tails are in the air. If the surface concentration is sufficiently low, each molecule can move about with relative ease in its two dimensional space, the air-water interface (i.e., a two dimensional gas). If the concentration is increased the molecules have less room in which to move and eventually the tails become vertically oriented with respect to the air-water interface. If the number of molecules per unit area could be determined when this orientation is present, then the reciprocal is the area per molecule or more specifically the cross sectional area of the polar head.



Method

A known amount of stearic acid dissolved in diethyl ether is placed on a tray of water. The ether solution spreads over the surface. The diethyl ether evaporates leaving the stearic acid on the water surface. The monolayer is compressed to a smaller area with a bar across the tray. The result is a decrease in the surface tension. This change γ_0-γ (where γ_0 is the surface tension of the pure water and γ is the surface tension with the monolayer) is called the surface pressure (π) of the monolayer. The Wilhelmy plate method is convenient to measure the change in surface tension. A plot of the surface pressure vs the bar position will result in a curve of the following type. (on the following page)



The inflection point of the curve corresponds to the state in which the molecules start to "flip" and are now vertically oriented and in another type of surface film. We will extend the initial slope past the inflection point to zero surface pressure to find the cross sectional area of the polar head.

Procedure

Cleanliness is very important. Clean the trough with soap, rinse with tap water, and rinse with distilled water. Clean all glassware with cleaning solution and rinse thoroughly.

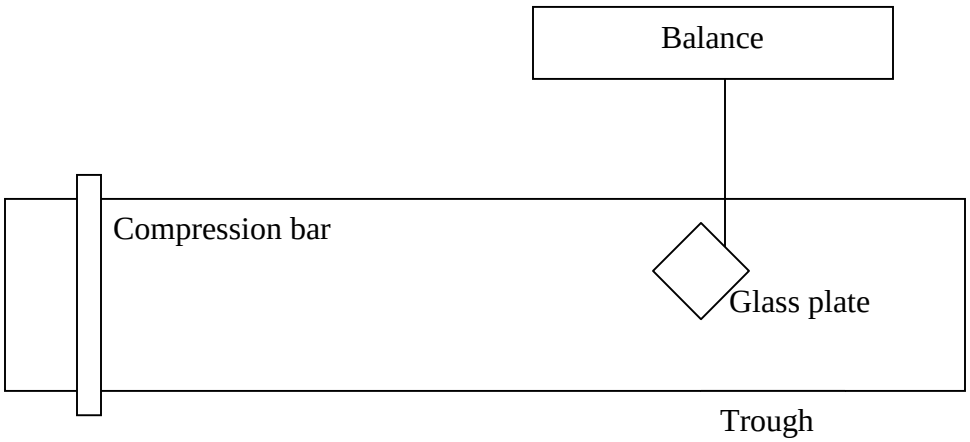
The trough and bar should be coated with paraffin. If it is not, then melt some paraffin in a clean beaker in hot water and coat the top edge of the trough and the whole bar.

Rinse the trough and bar with distilled water and place in position under the balance. Hang a clean microscope cover glass so that the bottom edge is about the same height as the top of the trough. Place some distilled water in the trough and level the trough. Fill the trough so that the water level is above the top edge of the trough. The water surface may be vacuum cleaned by drawing a glass tube into a tip, making a 90 degree bend above the tip, hooking it to the aspirator, and touching the tip to the water surface.

Refill the trough. Place the compression bar on the end of this trough opposite the Wilhelmy plate. Slide it slowly toward the Wilhelmy plate. Observe the balance reading. If the balance reading changes, an impurity is on the water surface and must be removed by continued vacuum cleaning.

When the surface is clean, position the bar at the end of the trough, record the balance reading, then add dropwise 0.25 mL of a solution of 8 mg stearic acid in 100 mL of diethyl ether. Allow each drop to evaporate before adding the next. (Caution: The diethyl ether is very flammable.) Move the bar slowly one centimeter at a time, making the balance readings at convenient positions. Better results will be obtained if you do not stop the bar. (In other words you need to take continuous readings to minimize the error from leakage of stearic acid molecules around the bar.)

Calculate the cross sectional area per molecule from the extrapolation to zero surface pressure (where the molecules are aligned vertically).



Calculations

The total weight as measured by the balance is

$$w_{tot} = w_{plate} + \gamma p$$

where p is the perimeter of the plate and γ is the surface tension.

As the surface tension changes the total weight changes. The surface pressure, π, (the difference in surface tensions) then equals

$$\pi = \Delta w/p$$

Since $\Delta w = \Delta mg$ (where g is the acceleration due to gravity)

then π is proportional to Δm. We will graph Δm versus the area per molecule and extrapolate the initial linear portion of the graph to zero surface pressure.

Raw Data

Concentration of stearic acid _____.

Volume of stearic acid _____.

Balance reading for pure water _____.

Width of surface (cm) _____.

Stearic Acid Data		
Length of surface (cm)		Balance reading (g)

Number of molecules of stearic acid _____.

Δm	Area ($Å^2$)	Area/molecule

Graph data in table above and determine the inflection point. Calculate the area per molecule. A good value is in the neighborhood of 20. $Å^2$. No error analysis is required for this lab.