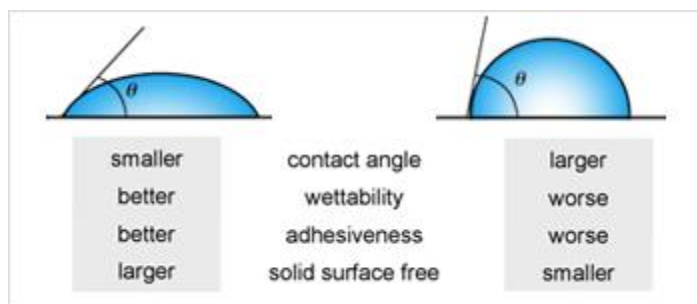


CHEM 355 EXPERIMENT 10

Contact Angle

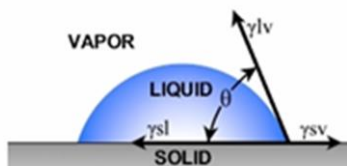
When a drop is deposited on a planar solid surface, the angle between the outline tangent of the drop at the contact location and the solid surface is called contact angle (θ). The contact angle is a measure of the ability of a liquid to spread on a surface. It is linked to the surface energy so one can calculate the surface energy and discriminate between polar and apolar interactions.

From the contact angle, physical properties of interaction between solid and liquid like wettability, affinity, adhesiveness and repellency can be studied. Typical evaluations are as shown below:



The shape of the drop at solid surface is affected by 3 parameters:

- Solid-Liquid interfacial free energy γ_{sl}
- Solid-Vapor interfacial free energy γ_{sv}
- Liquid-Vapor interfacial free energy γ_{lv}



The angle between a liquid drop and a solid surface, **Young's contact angle**, is related to the surface tensions of the three interfaces according to the relationship:

$$\cos \theta_Y = (\gamma_{sv} - \gamma_{sl}) / \gamma_{lv} \quad (1)$$

The **critical surface tension** of a material, γ_c , is a measure of the surface's wettability and it is proportional to the surface free energy of the material. A liquid with a surface tension less than or equal to the critical surface tension of a particular material will "wet" that surface. A material's critical surface tension can be determined from a **Zisman Plot**, which measures variation in Young's contact angle as a

function of the surface tension of a series of liquids. Zisman noticed empirically that a plot of $\cos(\theta)$ versus γ_{lv} is often linear. The value for which $\cos(\theta)$ extrapolates to 1 is termed the critical surface tension. A typical Zisman Plot is shown in Figure 1.

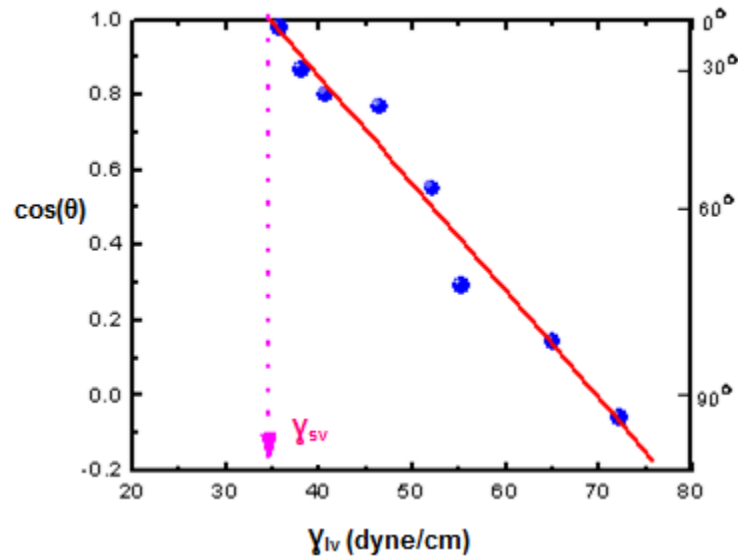


Figure 1. Zisman Plot for a polyethylene surface with a series of liquid.

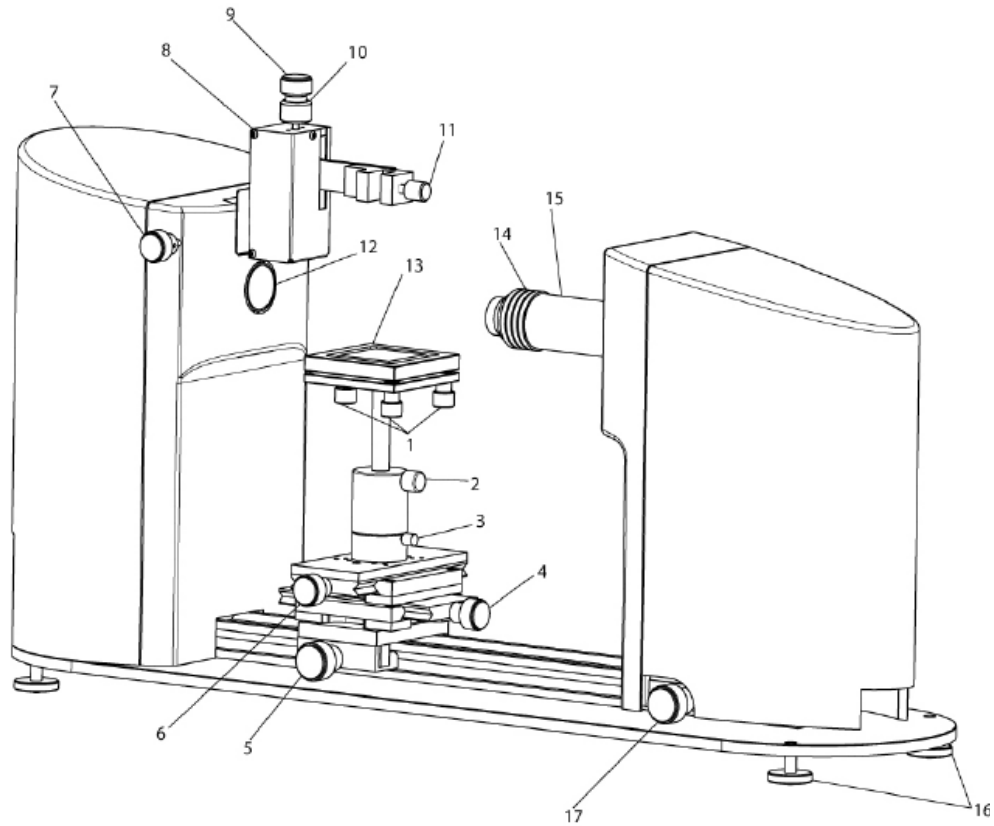


Figure 1. Theta Optical Tensiometer

- | | |
|--------------------------------------|---|
| 1) Stage level adjustment | 10) One-touch dispenser adjustment |
| 2) Stage height adjustment | 11) Syringe Clamp |
| 3) Stage height lock | 12) LED light source |
| 4) Stage linear adjustment | 13) Sample stage |
| 5) Stage rail lock | 14) Camera lens zoom adjustment |
| 6) Stage lateral adjustment | 15) Camera lens focus adjustment |
| 7) Syringe lateral adjustment | 16) Level adjustment legs |
| 8) One touch dispenser | 17) Camera rail lock |
| 9) Syringe height adjustment | |

Purpose: To explore the concepts of surface free energy, adhesion and wetting by measuring the contact angle of a series of liquids on a polytetrafluoroethylene (teflon) substrate.

To create a Zisman Plot from a series of contact angle measurements to determine the surface tension of polytetrafluoroethylene (teflon).

Apparatus and Chemicals

Apparatus: Theta Optical Tensiometer 1-mL syringe, flat piece of teflon (~3cm x 3cm), clean cotton swabs

Chemicals: n-heptane, n-octane, octanol, dodecane, acetone, ethanol

Procedure

Prepare substrate

Clean the teflon surface with ethanol using a cotton swab. Dry with clean cotton swab. Place teflon on the sample stage.

Prepare liquid

1. Clean syringe by filling it with acetone past 0.1 mL mark and emptying three times. Depress plunger multiple times to get out any residual acetone. (Do not turn the top too far – it will make the glass crack!)
2. Pre-rinse syringe with the testing liquid by filling with ~0.05 mL, turning syringe upside down and depressing the plunger past 0.1 mL, then turning it upside down a few times to rinse the sides of the syringe. Empty pre-rinse liquid into waste.
3. Fill syringe with ~0.1mL of testing liquid and secure in the syringe holder above the sample stage.

Image Recording

1. From Theta main menu start a new Contact angle experiment. Fill in the relevant data on the “Experimental Setup” screen.
 - a) **Name:** Group No
 - b) **User:** Student (Write “student” only. Do not write your names)
 - c) **Solid:** Teflon/ Lamella
 - d) **Select the proper liquid**
 - e) **Liquid Light Phase:** Air
 - f) **Start**
2. Lift or lower the sample stage until the solid is visible on the bottom part of the screen.
3. Lower or raise the syringe until it is just visible at the top of the screen. (Upper green line)
4. Alter the depth of the one-touch dispenser so that when the dispenser is pushed down the syringe does not hit the sample (Do this as when the syringe hits the sample it might damage the surface and alter the contact angle data obtained).
5. Lower an appropriate drop from the syringe. (Size of the drop should be between two green lines)
6. Select the **Fast Tab** recording mode and set the parameters as below.
Flame Interval: 16 ms Number of Frames: 5

7. Press down and release on the dispenser and immediately click **Record**. Wait for the images to be recorded and then press **Done**.

Curve Fitting

1. Select **To End** from the Fitting Options box, make sure that **Use AutoBaseline** is selected and press **Execute**. The software will then process all of the images from the viewed one onwards, and the results along with the images are then stored on the computer.
2. The red line represents the baseline, and it should connect the widest points of the curve profile and its reflection to each other. Check this visually, and if unsatisfied unselect **Use AutoBaseline** and set it manually by clicking and dragging on the white circle and the toggles available.
3. Place the blue box (the execution area) around the entire drop profile similarly, return to the first acceptable image and press **Execute** again. Press **Close** to continue to data analysis.

Treatment of data

1. From the main menu select **Browse Experiments**.
2. Use the Find Experiment parameters to find the wanted experiment and select it. Right click on it and select **Calculate**.
3. If the contact angle is stable from the beginning of the graph onwards then simply press **Calculate** and from the "Calculated Values" window press Calculate again to view the relevant statistical information available.
4. To calculate the average contact angle from a certain point onwards, right click on the experiment and select Graph to calculate mean Contact Angle. Double click on the limits wanted and press Calc Mean to view the average contact angle.
5. To see the precise value press Calculate in the Calculated Values window.

QUESTIONS

1. What do you expect to see if the liquid surface tension is less than or equal to the critical surface tension of a surface?
2. What is hydrophobicity and hydrophilicity? Give an example for each of hydrophobic or hydrophilic surface encountered in day-to-day life.
3. Explain the reason for the differences you observed in the θ 's for the different liquids.
4. Compare your calculated value of the surface tension of teflon to a literature value. Explain any discrepancy between your value and the one you find.

DATA SHEET Experiment 10 Contact Angle

Group Number:

Student Name:

Date:

Assistant name and signature:

1. Fill the following table.

Liquid	mean θ for Teflon

2. Find the mean $\cos \theta_Y$ for each liquid.

3. Plot the mean cosine value for each liquid against its surface tension. Find the best linear fit and extrapolate this line to find the surface tension value that gives a cosine value of 1.

4. Calculate the percent error for the surface tension of the Teflon.