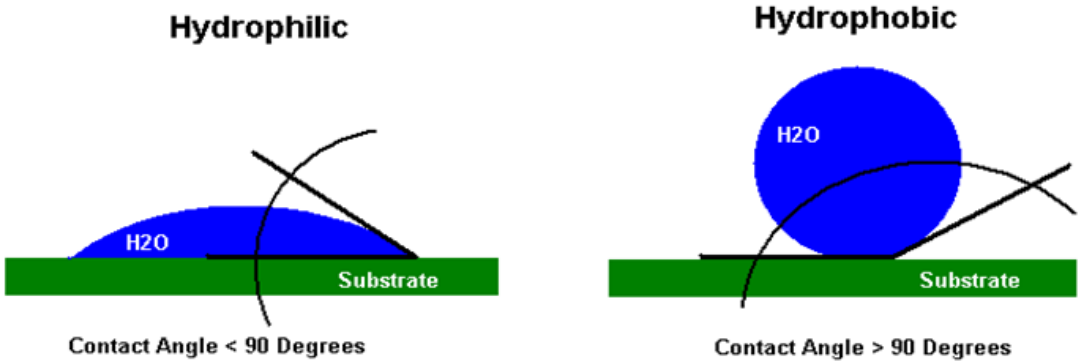
Student Guide

Exploring Surface Energy of Polymers by Contact Angle Estimation

Introduction: A liquid has a tendency to form a bead or a sheet on solid surfaces depending on the properties of the surface and the liquid. Properties of surfaces and interfaces are due to opposing intermolecular interaction forces across the surface or interface. The interaction between the surface and liquid can be described as either hydrophilic ("water loving") or hydrophobic ("water hating"). These characteristics can be attributed to the surface energy between the solid substrate and the liquid.

Both hydrophilic and hydrophobic surfaces have important applications in all types of engineering: chemical, automotive, nautical, industrial and civil. For example, applying a hydrophilic anti-fog coating to glass causes any condensation to form into a thin, even layer of water instead of droplets, so the glass remains transparent while adding hydrophobic rain-repellent glass treatments to windshields causes water to bead and roll off the windshield surface to improve visibility and enhance safety. Hydrophobic surfaces are also important in protecting surfaces from water damage and stains.

In this activity, you will explore the concepts of wetting and contact angle. You will distinguish between hydrophobic and hydrophilic surfaces. You will examine the contact angle of water on different polymer films or sheets and relate your measured contact angles to the surface energy of water and the polymer substrate. Finally, you will predict whether the water substrate interaction can be described as hydrophilic or hydrophobic. In addition, the class will discuss the intermolecular forces that may be prevalent at the nano-level, the wettability and possible engineering and technological applications of your polymer samples based on your observations and measurements. Below is a schematic of contact angles for hydrophilic and hydrophobic surfaces.



Safety: Safety gloves and goggles should be worn when working with laboratory chemicals and polymer sheets

Materials:

- Sheets of films of cut into 5cm x 5cm squares:
  - Polystyrene
  - Polymethyl methacrylate (PMMA)
  - Polyethylene
  - Polyvinyl chloride (PVC)
  - aluminum (these maybe in the form of sheets or films)
- protractors
- droppers/pipets
- water
- USB or cellphone camera
  - Images need to be able to be printed in class
- Printer

Activity:

1. Cut polymer films and aluminum into 5 cm x 5 cm squares.
2. Place the 5 cm x 5 cm piece of polymer on a flat surface.
3. Use a pipet to place 3 drops of water on the center of the surface of the 5 cm x 5 cm pieces.
4. After about 30 seconds, observe and describe the shape of the drop.
5. Take a digital photograph of the drop. Make sure that the camera is level with the surface of the sheet. (see Appendix for examples of images)
6. Repeat steps 2- 5 for all of the samples.
7. Print a copy of the images and measure the contact angle with a protractor.
8. Record the results.
9. Repeat steps 2-7 to confirm your results.

Record your observations:

Polymer	Test 1	Test 2	Average Contact Angle
	Measured Contact Angle	Measured Contact Angle	
PMMA			
PS			
PS			
PVA			
Aluminum (non polymer)			

Analyze your results:

1. Describe the shape and estimate the size of the drops.

2. Did you have a control group?

3. Do your observations leave you with any more questions? Do they enable you to make more predictions? If so, what are they?

4. Classify the polymer samples you used as hydrophobic or hydrophilic

Hydrophobic	Hydrophilic

Draw Conclusions:

1. Based on your results, do you feel that you can predict the type of forces and interaction in a polymer sample at the nanoparticle level? Explain your answer.

2. How could the size of the contact angle be used to predict if two polymers in a block copolymer can undergo phase separation?