[Traditional Version of the Lab]

Experiment: Intermolecular Forces

Learning Objectives

In this experiment, you will:

- compare the solubilities of several compounds in different solvents.
- use your observations to determine the influence of intermolecular forces on solubility.
- consider how intermolecular forces influence surface tension.

Preliminary Exercises

On a separate sheet of paper complete the following exercises.

1. Look up and draw the Lewis structures for dichloromethane (CH_2Cl_2), cyclohexane (C_6H_{12}), sucrose ($C_{12}H_{22}O_{11}$), stearic acid ($C_{18}H_{36}O_2$), and iodine. [You may need to look some of these up in a reference book such as the Merck Index or your chemistry textbook.]

2. Paper is obtained from wood and primarily contains a polysaccharide known as cellulose which is made up of several hundred glucose molecules linked together. Draw the structure of glucose and decide if cellulose (paper) is polar or nonpolar and whether it can form hydrogen bonds with water.

3. (a) What is pencil lead? (b) Would you expect it to be polar or nonpolar? Explain.

Experimental Procedure

Obtain 16 disks (~0.5 cm in diameter) that have been blackened on one side with the lead of a pencil and a 100-mL bottle with a stopper. Place about 35 mL of dichloromethane and an equal a volume of water in the bottle. Record your observations.

Place 8 of the blackened disks in the bottle, stopper, and shake. How many disks are turned black side up and how many disks are turned black side down? Shake the bottle again and record your observation. Repeat a third time. When you have completed the three trials, place
the entire contents of the bottle in the appropriate waste container in the hood. (The dichloromethane can be recovered and reused.)

Rinse the bottle out and then pour in ~35 mL of cyclohexane and an equal volume of water. Record your observations.

Place the remaining 8 disks in the bottle, stopper, and shake. Again note how many disks are turned "up" and how many are "down." Repeat two more times and record your observations each time. Place the entire contents of the bottle in the appropriate waste container in the hood. **(Do not mix with the discarded dichloromethane/water mixture! !**)

Name ______________________

Partner ______________________

Intermolecular Forces

Observations of the contents inside the bottle containing dichloromethane and water:

Observations of the contents inside bottle containing cyclohexane and water:

Look up the densities of the solvents used and record this information below; include the reference for the data.

water: ________________ cyclohexane: ________________

dichloromethane: ________________

Reference:

Classify each of the solvents as polar or nonpolar. Additionally, determine whether the solvent can form hydrogen bonds.

Solvent	Polar or Nonpolar	Form Hydrogen Bonds?
Water		
Dichloromethane		
Cyclohexane		

Consider the densities and the types of intermolecular forces that are important for each type of solvent and explain why the disks were oriented in the direction you observed for:

dichloromethane/water

cyclohexane/water

[Modeling Version]

Experiment: Intermolecular Forces

Purpose: We will investigate the characteristics of liquids that do not mix.

Experimental Procedure

Part 1
At your station, you will find two 100 mL bottles. Each bottle contains two colorless liquids. One of the bottles contains equal volumes of cyclohexane and water. The other bottle contains dichloromethane and water. Your goal is to correctly predict which liquid is on top in each bottle.

In your lab book, sketch the bottles showing a clear interface between the liquids using a pencil. Then identify which liquid is on top and which is on the bottom. Give a reason for your ideas.

After completing your sketches, have a discussion with your group members about their predictions. When your group has reached a consensus, put your ideas on a whiteboard. The board should include a sketch of the bottles, and the reason for why one liquid would be on the top and the other is on the bottom.

(Instructional Note: Do not make any corrections on the initial white boards. Allow each group to present ideas.)

Notes to Instructor:

After listening to each group's explanation ask the following questions:

(1) Why do the two liquids stay separate in the bottles?
(2) If none of the groups mentions density, ask them to define the term.

Part 2
Each station has a ziploc bag with 16 paper disks that have been blackened on one side with pencil lead. Predict what you think will happen when half of these disks are added to the bottle with dichloromethane and water, the bottle is shaken, and then the contents allowed to settle. Sketch a new diagram in your lab notebook showing the bottle, each liquid, and the paper disks. Give a reason for putting the disks at the location you put them.

After completing your sketches and reasons, discuss your ideas with your group members. When your group had reached a consensus, put your ideas on a white board.

Note to Instructor:

Allow each group to describe their predictions and why they think the disks are located and orientated the way they are.

Add eight of the paper disks to the bottle containing dichloromethane & water to test your prediction. If your results are different than what you predicted, note these differences in your notebook and on the whiteboard.

Notes to Instructor:

Have another presentation of group ideas and whiteboards now showing the correct location and orientation of the paper disks.

Predict what you think will happen when the remaining paper disks are added to the bottle with cyclohexane and water, the bottle is shaken, and the contents allowed to settle. Sketch a new diagram in your lab notebook showing the bottle, each liquid, and the paper disks. Give a reason for putting the disks at the location you put them.

After completing your sketches and reasons, discuss your ideas with your group members. When your group had reached a consensus, put your ideas on a white board.

Note to Instructor:

Allow each group to describe their predictions and why they think the disks are located and orientated the way they are.

Add the remaining paper disks to the bottle containing cyclohexane & water to test your prediction. If your results are different than what you predicted, note these differences in your notebook and on the whiteboard.

Notes to Instructor:

Have another presentation of group ideas and whiteboards now showing the correct location and orientation of the paper disks.

In your notebook, summarize the results for the first bottle, and then the second bottle.

Part 3

To explain these results we need to learn more about the properties of the liquids we are working with.

[Assumption here is made that students have already been exposed to types of compounds such as ionic and covalent compounds, as well as an introduction to Lewis structures.]

To provide more information I will add a few crystals of iodine to bottles containing the same liquids that you have been working with. Before I do this, what type of compound is iodine? Draw the Lewis structure of iodine (I_2) in your notebook.

[*Can solicit feedback on expected results. Perform the demonstration and link the orientation of the paper disks to the layer in which iodine does <u>not</u> appear.*]
Begin discussion of intermolecular forces (PowerPoint).

Intermolecular Forces – Follow up Activity

Look up the densities of the solvents used and record this information below; include the reference for the data.

water: ____________________ cyclohexane: ____________________

dichloromethane: ____________________

Reference:

Classify each of the solvents as polar or nonpolar. Additionally, determine whether the solvent can form hydrogen bonds.

Solvent	Polar or Nonpolar	Form Hydrogen Bonds?
Water		
Dichloromethane		
Cyclohexane		

Consider the densities and the types of intermolecular forces that are important for each type of solvent and explain why the disks were oriented in the direction you observed for:

dichloromethane/water

cyclohexane/water

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Reference

University of Wisconsin–River Falls Chemistry 116 Lab Manual; K. Craighead, B. Nielsen, and R. J. Scott; 1996; pp 85 - 88. “Intermolecular Forces.”

The chemicals needed for this lab can be obtained from Flinn Scientific. We have been able to separate the liquids and recycle them for use in subsequent labs.