At-Home Chemistry Experiment

Organic Chemistry: Introduction to Solubility

Objectives

Determination of conditions and properties favoring solubility. Mixing of commercially available household items will be carried out in this at-home experiment to qualitatively evaluate and understand solubility behavior.

Introduction

Solubility behavior is essential for understanding many procedures and techniques in the organic chemistry laboratory. In these laboratories, reactions are often run in nonpolar or slightly polar solvents such as dichloromethane, diethyl ether, hexane, or toluene. In recent years, much effort has been made to adapt reaction conditions to allow for the use of 'greener' (more environmentally friendly) solvents such as water or ethanol, which are polar and capable of hydrogen bonding. It is critical for any organic chemist to understand the factors which are involved in the solubility of different molecules in different solvents.

The general rule regarding solubility, 'like dissolves like', still applies in organic chemistry when looking at the interactions between solutes and solvents. For example, charged species (i.e. ions) are polar and are highly attracted to water, which is also polar. They will dissolve readily in water through ion-dipole interactions and are considered **hydrophilic** (water-loving). On the other hand, hydrocarbon molecules are nonpolar. Although there is attraction between neighboring hydrocarbon molecules through nonpolar van der Waals interactions, they are not attracted to polar solvent molecules such as water. They are considered **hydrophobic** (water-hating).

Packing peanuts are commonly used as a loose-fill packaging and cushioning material to prevent damage to fragile objects during shipping. They are made from either recycled polystyrene or from corn starch. Based on solubility, you will determine which type of packing peanut you have.

Figure 1: *Packing peanuts*

In this experiment, you will use common household solvents to investigate the solubility of various liquid-liquid and liquid-solid mixtures. You will also investigate the effect of temperature on solubility. As you are performing these tests, it is helpful to pay attention to the polarities of the solutes and solvents.

Materials

- Spatula (or popsicle stick)
- Teaspoon
- Aluminum foil
- Transparent containers (such as test tubes, shot glass, narrow drinking glass, etc.)
- Water
- Rubbing alcohol
- Baby oil
- Nail polish remover (ultra-powerful),
- Table salt (NaCl)
- Table sugar (sucrose)
- Petroleum jelly (vaseline)
- Packing peanuts
- Styrofoam pieces (from cups, or packages, etc.)

Procedure

General Notes

- Consistent shaking, not just stirring, needs to be done for each solubility test. Shake thoroughly to make sure every drop of the first component has the opportunity to mix with every drop of the second component.

- The type of container is not important as long as it is transparent and narrow. Example of containers include test tubes, shot glass, drinking glass (use whatever you have). Make sure it is clean and dry before each test. The word ‘’tube’’ will be used in the rest of the document but refers to any container.

- When performing a solubility test, add a small piece of aluminum foil (or parchment) on top of the tube, and shake it vigorously. The aluminum foil is used to prevent spillage during shaking.

- When you look at the mixture, make sure to observe your result in a well lit environment to see through your tube. Do not hesitate to raise your tube over a light source.

- 1 tsp is equivalent to 5 mL.

Part A – Solubility of Liquid Pairs

1. Record the brand name and the ingredients of the rubbing alcohol and nail polish remover being used.
2. Choose a pair of compounds (water, rubbing alcohol, nail polish remover or baby oil) and add equal amounts of each liquid to the same tube. Make sure the tube is clean and dry before each use.
3. Rigorously shake the tube for 10–20 seconds.
4. Let it stand for 30 seconds.
5. Determine if the two liquids are miscible (forms one layer) or immiscible (forms two layers). Record your results (miscible or immiscible) on the Data sheet provided.
6. Repeat for each pair.

Part B - Solubility of Solid Compounds

1. Use a spatula (or popsicle stick, or coffee stick) to manipulate the powders.
2. With the tip of the spatula, place a small amount of table salt (sodium chloride, NaCl) into each of five tubes that are clean and dry. The amount of salt does not need to be exactly the same in each tube, it only needs to be approximately the same.
3. Identify the tubes and then add about 2 mL of water to the first tube, 2 mL of baby oil to the second tube, 2 mL of rubbing alcohol to the third tube, and 2 mL of nail polish remover to the fourth tube. The fifth tube will be used as a control to visualize the starting quantity of the solid.
4. Cover the top of the tube with aluminum foil. Shake vigorously for 30 seconds. Let it stand for 30 seconds.
5. On the data sheet, record whether the compound is soluble (dissolves completely), insoluble (none of it dissolves), or partially soluble. You should compare each tube with the control in making these determinations. You should state that a sample is partially soluble only if a significant amount (at least 50%) of the solid has dissolved. For the purpose of this experiment, if it is not clear that a significant amount of solid has dissolved, then state that the sample is insoluble. If all but a couple of granules have dissolved, state that the sample is soluble.
6. Repeat steps 1-5 of Part B, substituting the table salt with table sugar (sucrose).
7. Repeat the experiment once more, substituting the table sugar with petroleum jelly (Vaseline). The petroleum jelly will have to be heated in a microwave for 20 to 30 seconds to get a liquid solute before mixing it with the liquid solvents.

Part C - Solubility of Packing Peanuts

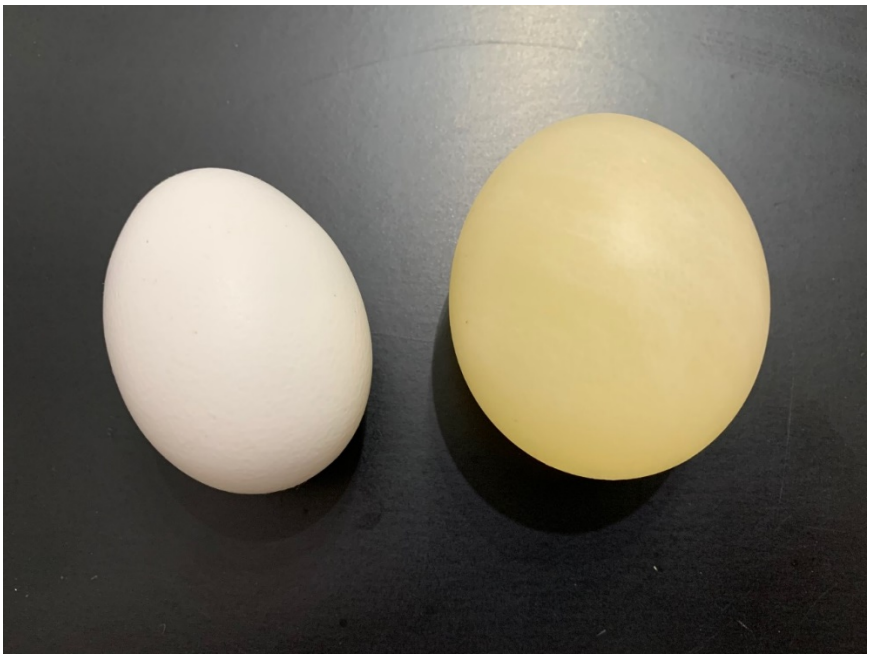
1. Place a piece of Styrofoam into each of three tubes that are clean and dry.
2. Identify the tubes and then add about 5 mL of water to the first tube, 5 mL of baby oil to the second tube, and 5 mL of nail polish remover to the third tube.
3. Cover the top of the tube with aluminum foil. Shake vigorously for 30 seconds. Let it stand for 30 seconds.
4. On the data sheet, record whether the compound is soluble (dissolves completely), insoluble (none of it dissolves), or partially soluble.
5. Repeat the instructions, substituting the Styrofoam pieces with a packing peanut.

Part D - Solubility and Temperature

1. Add a 1/2 cup of tap water to a transparent cup.
2. Gradually add table salt one teaspoon at a time to the tap water, stirring the solution between each addition. Stop adding salt when it no longer dissolves.
3. Record the number of teaspoons of salt added on the Data sheet.
4. Repeat the procedure with a 1/2 cup of ice water. Record your results.
5. Repeat the procedure with a 1/2 cup of boiling water. Record your results.

Solubility of an Egg Shell in Vinegar (optional)

1. Delicately place an egg into a transparent glass.
2. Add a large amount of vinegar (CH_3CO_2H) to cover the egg.
3. Observe the egg after 24, 48 and 72 hours to see if the vinegar has dissolved the eggshell, which is made up of calcium carbonate ($CaCO_3$).
4. Be careful, the egg will break very easily once the shell has dissolved.



Name _____ Section _____

Date _____

Organic Chemistry: Introduction to Solubility

Data

Part A – Solubility of Liquid Pairs

Brand of rubbing alcohol: _____

Ingredients: _____

Brand of Nail polish remover: _____

Ingredients (first 3 listed): _____

Mixed with	**Rubbing alcohol**	**Baby oil**	**Nail polish remover**
Water			
Rubbing alcohol	—		
Baby oil		—	

Table A: *Solubility of liquid pairs*

State the general trend observed:

Part B – Solubility of Solid Compounds

Mixed with	**Salt**	**Sugar**	**Vaseline**
Water			
Rubbing alcohol			
Baby oil			
Nail polish remover			

Table B: *Solubility of solid compounds*

State the general trend observed:

Part C – Solubility of Packing Peanuts

Mixed with	**Styrofoam pieces**	**Packing peanut**
Water		
Baby oil		
Nail polish remover		

Table C: *Solubility of packing peanuts*

Which type of packing peanut (polystyrene or cornstarch based) did you have? Briefly explain your reasoning.

Which packing peanut is more eco-friendly (polystyrene or corn starch based)? Briefly explain your reasoning.

Part D – Solubility and Temperature

Temperature of water (°C)	**Quantity of salt (# teaspoons)**
0	
Room temperature	
100	

Table D: *Solubility and temperature*

At which temperature is salt more soluble in water? _____

Is a saturated salt solution at 30°C still saturated at 70°C? Briefly explain your reasoning.

Troubleshooting suggestions:

- Use a chop stick (popsicle stick or spoon) to press the Styrofoam or packing peanut onto itself to help the solubility.

References

- Experiment 1 Solubility in *Introduction to Basic Laboratory Techniques - small scale approach*, 2nd ed., by D.L.Pavia, G.M. Lampman, G.S. Kriz and R.G. Engel, Thomson Brooks/Cole, **2005**, page 6-15.

- Topic 4.4 Solubility. (2019, June 5). Retrieved March 9, 2021, from https://chem.libretexts.org/@go/page/17044

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