Polymers, Solubility, and Recycling

When styrofoam is added to acetone (a common organic solvent) it very rapidly dissolves, making it look like it is disappearing. Starch-based packing "peanuts", on the other hand, will not dissolve in acetone, but do readily dissolve in water. Environmental consequences of these two properties will be discussed with the class. The melted plastic can be recovered from the acetone to make hard solid styrofoam plastic (thus illustrating recycling).

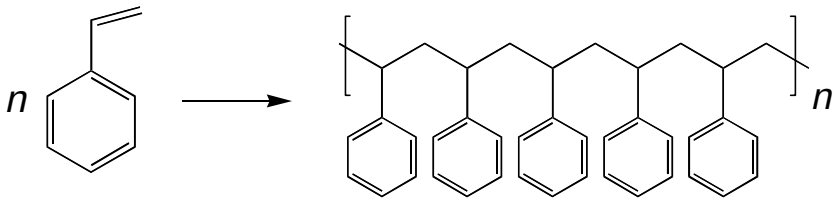
Materials:

- ***Styrofoam cups - at least one per student plus several extras (*you provide*)**
- ***Plastic straws to serve as stirrers (*you provide*)**
- ***Container of water (a clean one-gallon plastic milk carton should do nicely, *you provide*)**

Bottle of acetone (100 mL is plenty) (***we will provide – please return***)
3 or 4 small beakers, 150 mL or 250 mL (***we will provide – please return***)
Large beaker, 400 mL or larger (***we will provide – please return***)
Glass stirring rod (***we will provide – please return***)
Watch glass or big petri dish (***we will provide – please return***)
Styrofoam packing "peanuts" (***we will provide***)
Starch packing "peanuts" (***we will provide***)

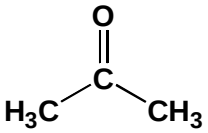
Background:

Polystyrene is a polymer ("*poly*" = many; "*mer*" = units) of thousands of styrene molecules linked together:



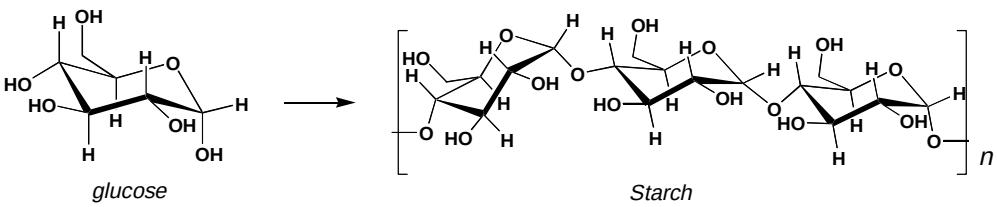
styrene *polystyrene*

Polystyrene is a clear, hard plastic. Air (or other "blowing agents") can be blown through molten polystyrene as it is extruded, producing the light foamy material that we all know as "Styrofoam™." Styrofoam™ is a very lightweight material because it is mostly air. In addition, the trapped air pockets make it a good heat insulator. Finally, the thin walls of the styrofoam bubbles make the material flexible enough that it is a good packing material. Styrofoam "packing peanuts" and cups are very common. However, they are ***not*** biodegradable. Styrofoam is readily soluble in acetone (see structure below), but is not soluble in water.



acetone

In recent years, concern for the environment has led to the development of biodegradable plastics, including biodegradable packing peanuts. These are made primarily of starch, which is a polymer of glucose. Starch packing peanuts are soluble in water (due to all the OH groups) but ***not*** soluble in acetone.



glucose *Starch*

Objectives:

At the end of this demonstration, the students should:

1) explain that styrofoam and starch do not disappear when they dissolve.
2) explain that not all liquids are water.
3) explain that different liquids have different properties and different solids have different properties.

Safety: Acetone is *flammable* and poisonous if drunk. Please be careful working with it. A few students may find the smell offensive – if so, keep them away from the acetone. It is not dangerous if it gets on the skin. It will sting quite a bit if it gets in the eyes. This is not normally dangerous, but it can cause problems for students wearing contacts. Students should, therefore, wear safety glasses when working near the acetone containers.

Procedure:

1) Pour 50 mL of acetone (volume is not too important) into a small beaker. Ask the students what it is. Don't let them smell it! Get as many responses as you can.
2) Ask the students what would happen if you poured the liquid into a styrofoam cup. Holding a styrofoam cup over a large beaker, pour the acetone into the cup. It should rapidly dissolve a large hole in the bottom.
3) Act surprised! Ask the students what happened! Where did the styrofoam go? You can recycle the same acetone, and try using 2 or 3 cups.
4) Do the same demonstration, substituting water for the acetone. Act like you think the styrofoam cups won't hold the water. Ask them why you sometimes got a hole in the bottom and sometimes didn't. Elicit as many responses as you can.
5) You can ask for a volunteer to smell the two liquids. But don't let your volunteer inhale too deeply! Use a small amount of acetone in a beaker and a small amount of water. This should confirm that the two liquids are quite different.
6) Show them that you can dissolve several styrofoam packing peanuts in a fresh 50 mL acetone sample. You can use a glass stirring rod to stir the mixture. Also show them that styrofoam peanuts do not dissolve in water.
7) Pour a small amount of the acetone-styrofoam mixture onto a watch glass and let it evaporate. Ask them what remains on the watch glass.
8) Pass out a styrofoam cup about 1/3 filled with water to each student. Ask them why the cup didn't dissolve.
9) Give each student two starch packing peanuts and a soda straw. Tell them that these packing peanuts are made of something different. Show them how to use the soda straw as a stirrer to dissolve the starch peanuts. Ask them how they would get the starch back.

You should discuss the concept of “like dissolves like” – acetone is more organic and is better at dissolving the more organic polystyrene molecules, while the starch molecules are covered in OH groups that are more like water molecules.