Polymers, Solubility, and Recycling

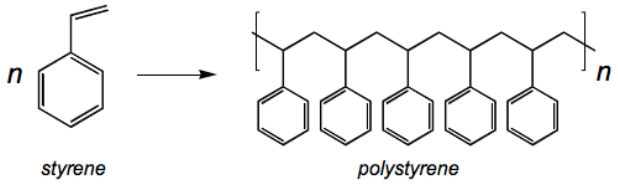
When Styrofoam is added to acetone (a common organic solvent) it very rapidly dissolves, making it look like it is disappearing. Starch-based packing “peanuts”, on the other hand, will not dissolve in acetone, but do readily dissolve in water. Environmental consequences of these two properties will be discussed with the class. The melted/dissolved 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)
- Large aluminum “turkey” basting pan (you provide)
- Bottle of acetone (200 mL is plenty) (we will provide – *please return*)
- Two 250 mL beakers (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 – *return extras*)
- Starch packing "peanuts" (we will provide – *return extras*)

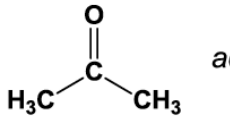
Background:

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



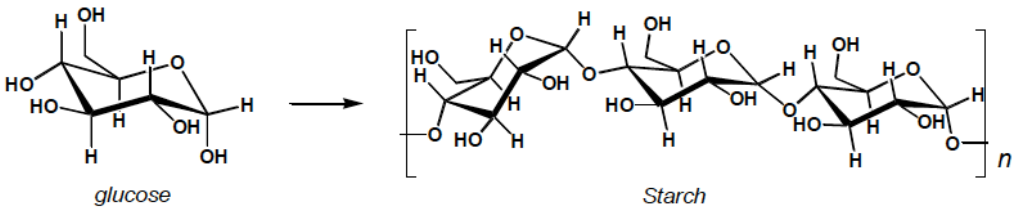
styrene *polystyrene*

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 "StyrofoamTM." 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, 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 (polar and non-polar) and different solids have different properties (polar and non-polar).

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) Pass out a starch and Styrofoam "chip" to each student. Have them examine them to note similarities and differences.
2) Pour about 50 mL of acetone (exact volume is not important) and 50 mL of water into two separate beakers. Ask the students what they are. Don't let them smell it! Get as many responses as you can. Most will say water.
3) Ask the students what would happen if you poured the first liquid (acetone) into a Styrofoam cup. Holding a Styrofoam cup over the large aluminum pan, pour the acetone into the cup. It should rapidly dissolve a large hole in the bottom. Make sure the acetone and dissolved Styrofoam go into the pan. Act surprised! Ask the students what happened! Where did the Styrofoam go? You can recycle the same acetone by transferring it into another beaker and try melting 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 volunteers 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 and a straw to each student. Ask them why the cup didn't dissolve.
9) Have the students put their starch packing chip into the water and stir with the straw to dissolve. Ask them how they would get the starch back (you'd have to evaporate all the water, which would take a while).
10) You can eat one of the starch chips!! They are initially tasteless, but as your saliva enzymes start breaking up the starch chains you will begin to sense a bit of sweetness from the sugar molecules that are split off.

You should discuss the concept of "like dissolves like" – acetone is more organic (non-polar) and is better at dissolving the more organic, non-polar polystyrene molecules, while the starch molecules are covered in polar OH groups that are more like very polar water molecules.

Discuss how movies often use Styrofoam sheets and acetone to simulate the action of a strong acid eating quickly through a thick piece of steel. Demonstrate if you have some bigger pieces of Styrofoam.

All the melted Styrofoam should be in the aluminum pan. Carefully drain off the acetone from the pan into a beaker and dispose of in a toilet (it is biodegradable). Leave the pan with the teacher to evaporate off the remaining acetone from the liquid Styrofoam. It will from a hard, solid piece of plastic after a week or so.