

PLASTICS ANALYSIS

I. Purpose

To identify the six kinds of recycled plastic polymers by measuring their physical and chemical properties.

II. Background Information

Every polymer has very distinct characteristics, but most polymers have the following general attributes:

1. Polymers can be resistant to chemicals. Consider all of the cleaning products that are packaged in plastic containers.
2. Polymers can be both thermal and electrical insulators. Thermal resistance is evident in the kitchen with pot and pan handles. Electrical resistance is evident in appliances, cords, wiring, and electrical outlets.
3. Polymers are light in mass with varying degrees of strength. Consider the range of applications where plastics are used. Inexpensive toys to the frame construction of the space station.
4. Polymers can be processed many different ways to form intricate parts. Plastics can be molded in to bottles and automotive body components. Some can be foamed like polystyrene (STYROFOAM™). Elastomers and some plastics stretch and are very flexible.

With all the superior attributes of polymers, there are some difficulties with the material. Most plastics deteriorate but do not decompose completely. However, applications for recycled plastics are growing every day. Plastics can be blended with virgin plastic (plastic that has never been processed) to reduce cost without sacrificing properties. Recycled plastics are used to make polymeric timbers for use in picnic tables, decks, fences, and outdoor toys, saving natural lumber. Plastic from 2-liter bottles is spun into fiber for carpet production.

The plastics industry uses polymer pellets to make plastic containers. Contained in the Hands On Plastics - Investigation Kit are recycled polymer pellets, color-coded to help you keep them separate, but each may be made in any color. These polymer samples have come from recycled products. [If possible, obtain virgin material of any/all of the six plastics]. In 1988, the Society of the Plastics Industry, Inc. (SPI) introduced the polymer identification coding system. The codes are molded or imprinted on the bottom of most plastic containers.

For plastics to be recycled, they must be separated by type. The polymer recycling codes enable us to distinguish between the common types of polymers. However, visual sorting is not efficient enough to be practical on a large scale. One physical method of separating polymers is by density differences. The plastics to be recycled are shredded and placed into a liquid such as

water. The plastics that are more dense than water will sink, while those less dense than water will float. The floaters and sinkers are recovered separately, and the process is repeated with other liquids having different densities. This can be done on a small scale with readily available liquids.

III. Materials

- 6 samples of resin pellets
- 250 mL beakers
- 100 mL beaker
- Bunsen burners or alcohol burners
- Forceps, tongs, and plastic spoons
- 1 hot plate
- Stirring rods or Popsicle sticks
- Copper wires (5 cm, 20 gauge)
- 50 mL acetone
- 60 g isopropyl alcohol (70%)
- Goggles
- Glass petri dish
- 100 mL corn oil
- Small cups to hold resin samples

Plastics Analysis Lab


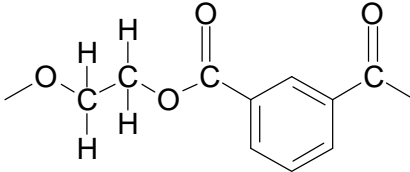

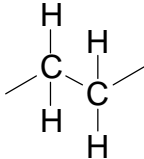

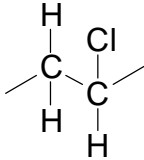

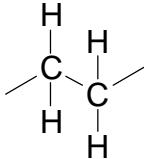

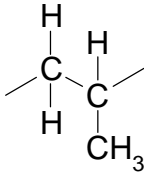

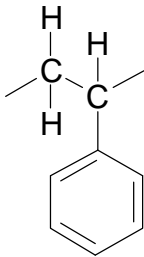

(modified from Christopher S. Kollman, Chem 13 News, January 1994)

1. Before conducting this lab, students should be familiar with the concept of density.
2. If students are not familiar with flow charts, we suggest that you try having them read the chart and discuss its meaning before the lab. Have students tell which plastic floats in alcohol and oil. Will this same plastic float in water? Which plastic has a green flame with the copper wire test? Will PS soften in acetone?
3. The four test areas must be set up before the class starts. Be sure to keep the flammable liquids and the hot plate in separate locations for safety reasons. Also, make sure students wear safety glasses and avoid breathing in fumes during the experiment.
4. If you do not want the students to have open flames in the room to do the copper wire test, have their students bring the resin to you to demonstrate this test for them. Using insulated copper wire by peeling off the end of the insulation also works well for this test.
5. Each group of students needs samples of the six recycled resins to identify. Each group should have about 10 pellets of each type.
6. Acetone is the active ingredient in some fingernail polish removers so the drugstore is a good source for this chemical. Please read the label of the fingernail polish remover to make sure

that the primary active ingredient is acetone. If you use fingernail polish remover instead of acetone, students must leave the plastic sample in the liquid for a longer period of time in order to detect any softening of the plastic. Please check the timing of this test before the students do the lab. A special container must be provided for the used resins since acetone on the pellet may be a fire hazard until the acetone evaporates.

7. Isopropyl rubbing alcohol is also available from the drugstore, but make sure it is 70 percent to 90 percent, since the density is not one gram/mL. When preparing the materials listed on page 27, 60 grams of isopropyl rubbing alcohol is equal to 65 mL for the alcohol solution.
8. Mazola® corn oil has the correct density to separate #4 and #5 resins so do not substitute another kind of oil.
9. Have the students place their used resins in appropriate containers at the end of the laboratory period so that you can recycle them for another class. Have labeled containers set up for the each resin.
10. The PET resin in this kit does not soften in boiling water for the heat test. Students will not have to use this test to distinguish between PS and PET because the acetone test will identify both. Most bottles made out of PET will soften in boiling water, so students can use this property when testing containers. To demonstrate this in class, simply use pre-cut strips of soda bottles.

IV. Recycling Codes and Chemistry

Recycling Code	Name of Polymer	Sample Uses	Structure
	polyethylene terephthalate (PET or PETE)	soft drink bottles• carpets• fiberfill• rope• scouring pads• fabrics• Mylar tape (cassette)	
	high density polyethylene (HDPE)	milk jug• detergent bottles• bags• plastic lumber• garden furniture• flower pots• signs• trash cans	
	Polyvinyl chloride or vinyl (PVC or V)	cooking oil bottles• drainage and sewer pipes• tile• bird feeders• credit cards• institutional furniture	
	low density polyethylene (LDPE)	bags• wrapping films• container lids• Elmer's® glue bottles	
	polypropylene (PP)	yogurt containers• automobile batteries• bottles• carpets• rope• wrapping films• lab equipment	
	polystyrene (PS)	disposable cups and utensils• toys• lighting and signs• foam containers and insulation	
	all other polymers	catsup, snack and other food containers• hand cream, toothpaste and cosmetic containers	

V. Procedure

1. Have students work in small groups of 4 or 5
2. Notice the test areas in the room. Some tests are to be done only at those locations, while others will be performed at the lab desk. There are four specific test areas in the room that have been set up:
 - a. Acetone Test—Have 50 mL of acetone in a 100 mL beaker covered with a glass petri dish. **KEEP THIS TEST AREA AWAY FROM FLAMES.** *Acetone is highly flammable and must be kept away from flames and covered when not in use.* Have tongs or forceps available.
 - b. Heat Test—Have 125 mL water in a 250 mL beaker on a hot plate. Keep this at a rolling boil. Have tongs available. Make sure this does not boil dry!
 - c. Isopropyl Alcohol Test—Put 60 g (or 65 mL) isopropyl rubbing alcohol (70%) in a 250 mL beaker and add enough water to make 100 g (or 100 mL) of solution. Mix. Have tongs or forceps available. Have plastic spoons available.
 - d. Oil Test—Put 100 mL of corn oil in a 250 mL beaker. Have tongs or forceps available. Have plastic spoons available.
3. The other two tests, water and copper wire, are to be done at the lab station.
4. You and your lab partner are given six different kinds of recycled resins. You should have about 10 pellets of each resin or color. Use the flow chart below and the descriptions of the tests to identify the resins. Keep notes of your observations on the sheet provided.

The following resins are the six you need to identify:

1. PET—polyethylene terephthalate
2. HDPE—high density polyethylene
3. PVC—polyvinyl chloride
4. LDPE—low density polyethylene
5. PP—polypropylene
6. PS—polystyrene

Water Test

At your lab desk, place one pellet of each of the recycled resin samples in 100 mL of tap water at room temperature in a 250 mL beaker. Poke the pieces with a glass stirring rod to knock off any adhering bubbles and try to make them sink. Note whether the sample floats or sinks. Do not pour the resin samples down the sink — they are insoluble in water! Take the resin pellets out of the water with your fingers and save the pellets for later. Use the Density Table on the previous page to find the density ranges for each type of plastic. Proceed down the flow chart, do the tests indicated, and record all your observations on the sheet provided.

Copper Wire Test

At your lab desk, using forceps, hold the 5 cm length of copper wire in the hot part of the flame of a Bunsen burner or alcohol burner until it is red hot. Remove from the flame and carefully touch a resin pellet with the hot wire. It may stick to the wire at this point so you will need to take another pair of forceps to pull the pellet off the wire. Place the wire with some plastic glob on it (not the pellet) back in the flame, observing the color of the flame that comes from the glob. You will notice a green or orange flame color. Quench the sample in a beaker of water to stop the burning and cool the wire. Proceed down the flow chart.

Acetone Test

Take your sample resin to the acetone test area in the room. Using tongs, place a pellet in acetone for 20 seconds. Remove the pellet and press firmly between your fingers. The polymer chains may "loosen up" and feel soft and sticky. Try to scrape off some plastic with your fingernail. There may be no reaction to this scrape test. Discard the pellet in a container provided.

(Note: If you are using fingernail polish remover instead of acetone, leave the resin pellets in for at least one minute. Use your fingernail to try to scrape the pellet to see if the outer layer has softened.) Place the used resin pellet in the special container for waste. Proceed down the flow chart.

Heat Test

Take your sample resin to the heat test area. Using tongs, hold one pellet in boiling water for 30 seconds. PET (1) has a relatively low softening point and will show some reaction to the 100-degree Celsius water. Press the pellet between your fingers to see if it feels softened after you remove it from the water. Discard the pellet in the trashcan. Proceed down the flow chart.

Isopropyl Alcohol Test

Take five resin pellets to the isopropyl alcohol test area. Place the pellets in the solution and poke the pellets with a stirring rod to release any bubbles. Note whether the pellets float or sink. Scoop the pellets out with a plastic spoon and take the pellets back to your lab station. Proceed down the flow chart.

Oil Test

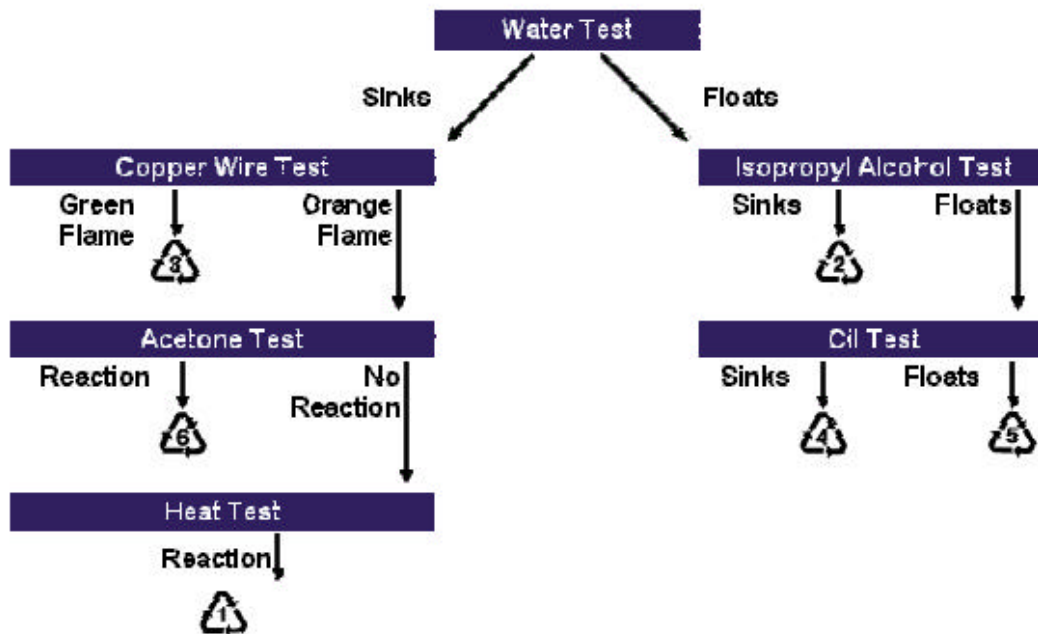
Take five resin pellets to the oil test area. Place them in the oil and poke the pellets with a stirring rod to release any bubbles. Note whether the pellets float or sink. Identify the resin from the flow chart. Scoop the pellets out with a plastic spoon and wipe them off with a paper towel. Take the pellets back to your lab station.

Clean Up

Please recycle your resins in the appropriate containers. Try not to mix the resins.

Flowchart

Activity Flow Chart



Density Table	
Substance	Density
Water	1.00
(1) PET	1.38-1.39
(2) HDPE	0.95-0.97
(3) PVC	1.16-1.35
(4) LDPE	0.92-0.94
(5) PP	0.90-0.91
(6) PS	1.05-1.07

Density Table

Floats On Type of Plastic	Alcohol/Water	Vegetable Oil	Water	Glycerin
PET				
HDPE				
PVC				
LDPE				
PP				
PS				

VI. Discussion and Evaluation

1. Identify the resins by color.
 1. PET — Polyethylene Terephthalate (white)
 2. HDPE — High density Polyethylene (off-white)
 3. PVC — Polyvinyl Chloride (gray)
 4. LDPE — Low density Polyethylene (brown)
 5. PP — Polypropylene (black)
 6. PS — Polystyrene (blue)
2. Your boat is sinking about a mile offshore and you are not a good swimmer. You notice six large solid plastic blocks labeled 1, 2, 3, 4, 5, and 6. Which three should you grab? Why? *HDPE, LDPE or PP because they float. Their densities are less than 1.00 g/mL.*
3. You wish to make a plastic handle for a cooking pan. Which plastic should you avoid? *Do not use PET because it softens at 100°C (212°F, boiling water).*
4. Why is it important to dislodge any adhering bubbles in the density tests? *Adhering air bubbles will add buoyancy to the samples resulting in a lower than expected density.*
5. Sometimes plastic containers are made from two or more polymers. What would happen to the water density test if LDPE and PP were mixed? If PET and HDPE were mixed? *The mixture of LDPE and PP will not show up in the water density test since their densities are so similar. A mixture of PET and HDPE will change the density depending on how much of each is present in the mixture.*
6. Observe the rate at which each type of plastic sinks into each of the density layers.

VII. Continuing the Concept

An alternative procedure is contained in the Hand On Plastics: Investigation Kit - Learning Cycle Activities 2.

VIII. References

Hands on Plastics (www.handsonplastics.com) (modified from Christopher S. Kollman, Chem 13 News, January 1994)

Polymers all around you. Terrific Science Press, Center for Chemical Education, Miami University Middleton.

Density Table (Answer Key)

Floats On Type of Plastic	Alcohol/Water	Vegetable Oil	Water	Glycerin
PET	No	No	No	No
HDPE	No	No	Yes	Yes
PVC	No	No	No	No
LDPE	Yes	No	Yes	Yes
PP	Yes	Yes	Yes	Yes
PS	No	No	No	Yes