

PLASTICS IDENTIFICATION

I. Objective

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


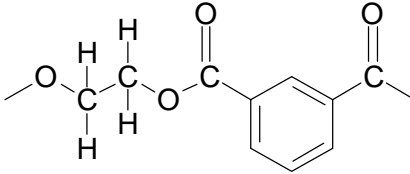

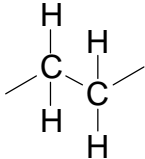

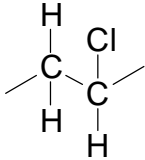

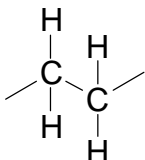

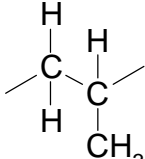

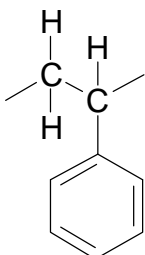

- Samples of each of the plastic types listed in the table on page 3, cut into equal size strips.
- Isopropanol (rubbing alcohol) (NOTE; make sure the isopropanol is 99%)
- Vegetable oil (Mazola corn oil is preferred)
- Glycerin
- Water
- Small cups or egg carton to hold plastic pellets/strips
- Craft sticks or tongue depressors

Optional:

Tongs or forceps

Boiling water

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.A. Procedure Have students work in small groups of 4 or 5

- 1) Collect samples of each of the first six plastic types listed in the above table.
- 2) Cut each plastic into equal sized strips or squares.
- 3) Make up a solution of 3 parts rubbing alcohol to 2 parts water and fill cup or egg holder half way and label each container accordingly.
- 4) Fill a cup or egg holder half way with the remaining solutions (vegetable oil, water and glycerin) and label each container.
- 5) Drop a plastic strip into each of the solutions. If it does not sink immediately, push it down gently with a craft stick and observe until it stops moving.
- 6) Record on the data sheet whether it sinks or floats in that particular liquid.
- 7) Repeat steps 5 & 6 with samples of the remaining other plastics.
- 8) Use the chart to determine the identity of the plastic samples.
- 9) Notice that the PET and PVC give the same results. You can tell them apart by bending a sample. PVC will whiten when bent, but the PET will not.
- 10) All plastic strips can be disposed of in a recycling container and all solutions can be disposed down the sink.

Optional Test for determining difference between PET and PVC

- 1) Boil some water, keeping at a rolling boil. Do not boil dry!
- 2) Using tongs or forceps, hold the strips of each plastic in the boiling water for 30 seconds.
- 3) The PET has a relatively low softening point and will show some reaction to the boiling water.
- 4) Carefully press bend or pull the strip between your fingers to see if it feels softened after it was removed from the water.

V.B. Alternative Procedure

A density tower can be used instead of the procedure above. Use a tall, narrow jar or bottle. Add liquids in the following order: glycerin, slightly colored water, slightly colored alcohol/water mix, Mazola® corn oil. Carefully drop sample into the tower. Check for any air bubbles that might effect the results. Note: PVC does not always sink immediately. It may require a few minutes for any air bubbles to escape the surface. The polystyrene samples will vary in their densities. This would be a good time to discuss how processing methods can effect the properties of a material.

Kids love a challenge! Once students have completed their density tables, give each group a mystery bag containing 3 to 5 unknowns for testing. (Use the pellets found in the “Hands On Plastic” kits to force the students to identify through density testing.) By going one step further with this activity, you are having them use the highest levels of thinking – application and analysis. If you do not have time within your lesson to do the challenge, ask the teacher to give students time to test their unknowns. You can either give the teacher the “mystery answer key or you can have students give you their results on your follow-up visit. Or, they can e-mail their

results along with support for their findings. You'll really get them excited about science if you take a few minutes to respond.

Note: Do not use PET and PVC in the same mystery bag, as they are not easily distinguishable.

Density Table

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

VI. Discussion and Evaluation

1. 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.*
2. 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).*
3. 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.*
4. 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.*
5. 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

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