

Mix It Up, Sort It Out



Crash! Smash! The recycling truck is seldom quiet. What happens to all of your plastic and glass when it gets mixed in those bins? The answer: science!



GRADES
5-8



PREPARE:

Time Required: 2 class periods (90 minutes) without extensions

- Gather materials (see activity pages).
- Collect plastic products for the motivate section.
- Collect samples of plastic. Refer to the Plastic Classification Chart for examples if each category. Some suggestions are:
 - PETE from a beverage bottle
 - HDPE from a shampoo container
 - LDPE from a soft, squeezable bottle
 - Polypropylene from a medicine bottle or heat-resistant food container
 - Polystyrene (Styrofoam) from a coffee cup
 - Polycarbonate from a CD
 - Can also use PVC if you have the right tools for cutting.
- Cut samples into similar-sized bits. For some categories, you may be able to use a manual hole punch to create “punches.” For other categories, like polycarbonate from a CD, you may need to prepare bits by crushing, using eye protection, or PVC cutters for PVC. Each team will need at least 5 bits of each kind of plastic they are testing (1 bit to place in each of the 5 solutions).
- Make copies of Activity Pages and Student Data Sheets.
- Load images (if desired) onto a computer to project for students.
- Set-up projector/screen.



MOTIVATE:

The day before the lab activity, show students plastics you’ve collected and then challenge them to add to your collection (assign for homework and have students bring in items the following day). The following day, ask students if the collection has any value. There are at least three kinds of answers that might be discussed: economic value, saving energy and saving the planet.

Ask students to describe what they know about recycling, and if they can identify products which are made from recycled plastics in the school. The easiest examples might be fencing or landscape materials.



TEACH:

- Follow lab instructions provided (see activity pages), and have students discuss 5-7 different properties that might be used to identify the different types of plastics (examples students may give might include: color, shape, texture, transparency, size, smell, melting point, boiling point, density). Challenge students to consider why some characteristics cannot be used to identify materials – like size, weight, color, volume (may not be representative of that kind of plastic, and may only represent that particular sample).
- Review with class that there are 7 different types of plastics. They are often recycled together and mixed with other materials like glass, aluminum, and paper. Have students identify the properties of plastic that might be used to help sorting process.
- Discuss density and review. Students should have some previous experience with density. This should not be the first time students calculate the density of an object. If it is, consider frontloading this activity with an introduction to density and having students do some basic calculations. Review the concept of “floating” and “sinking” as this relates to density. Objects that are more dense than the solution in which they are placed will sink; objects that are less dense will float. You may need to do a demonstration (oil and water is a good example where oil is less dense than water and thus floats when placed in water). The formula for density is mass/volume ($d=m/v$).
- Have students work in teams of 3-4. Review safety procedures. Rotate around the room as students prepare solutions. Students should be wearing goggles and wearing gloves (vinyl preferred in case of latex allergies).
- Distribute samples of plastic to the students. Students should submerge the samples initially or stir them into the solution so they do not float from surface tension. Have students record whether they float or sink in the solutions.
- Challenge students to identify the Resin ID Code for a few samples different plastic based on the method of floating or sinking in solution. Optional: Hand out Resin ID code/chart.

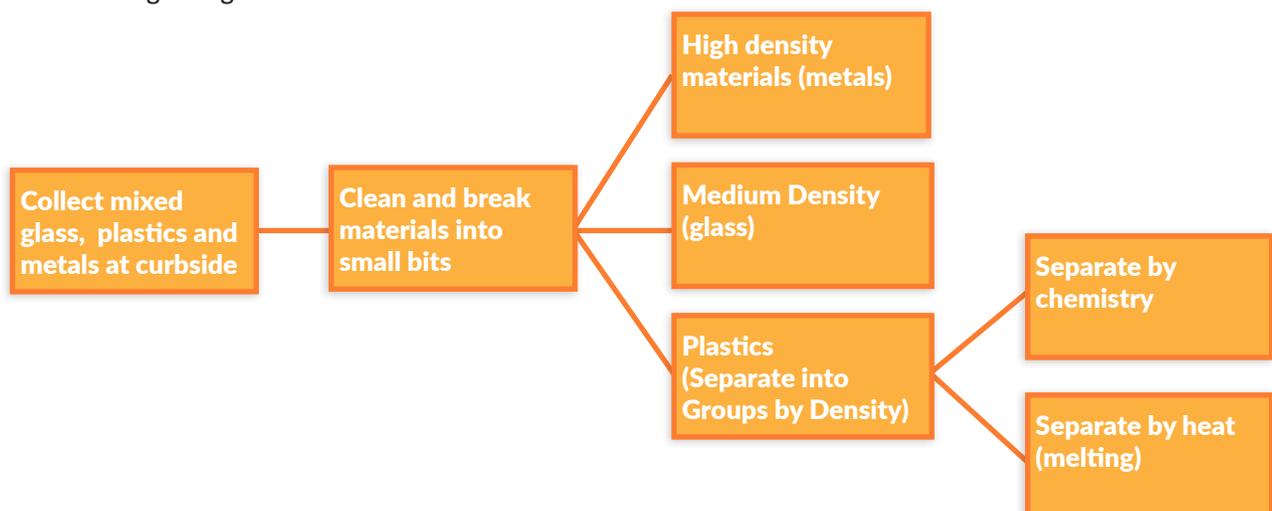


REFLECT/ASSESS

Facilitate a class discussion to allow teams to share their findings and come to a consensus on the items. Consider projecting Table III on a screen, and adding results based on class consensus as discussed.

Students should be able to:

- Compare class results and discuss why some of their results might differ from each other. Have them consider sources of error.
- Discuss how they would go about testing the items that sunk in all solutions further (one idea may be to make new, more dense solutions. This could be done by mixing in different amounts of karo syrup – dark karo syrup has a density of about 1.37g/mL).
- Construct an explanation that describes how density might be used in the process of recycling plastics. Optional: one way to have students describe this is by using a concept flow chart (see sample below). Students may require further instruction regarding this.





EXTEND

Have students construct an explanation of how a plastic bottle might become a shoe starting from curbside pick-up. Have students write a narrative from the perspective of a plastic bottle depicting its journey from new to used, to recycled, to new again!

Have students make a list of other products made from recycled plastics by conducting research. Have them find some of these products in their homes, or at local businesses like a building supply store, and take some pictures. Students can then prepare a communication for their community that shows the advantage of re-using plastics, using their photos as illustrations.



JOURNAL QUESTION

Have students read the article about Mike Biddle, a plastics engineer. Why is the work that Mike Biddle and Dr. Vilas Pol do important? Could they see themselves in this field someday?



WEBLINKS

Article: Mike Biddle, a profile of a Plastics Engineer

<http://www.jason.org/node/2163>

Mix It Up, Sort It Out

Background

The first manufactured plastics were created in the 1860's. "Parkesine" was an organic material derived from cellulose. Shortly afterward John Wesley Hyatt invented celluloid (the highly flammable material often used for old movie reels). Students may enjoy researching not only early forms of plastic but the new polymers that are being made from plant materials today. By 1907, one of the earliest forms of plastic used for utensils and toys, Bakelite, was on its way to becoming commercially successful.

Between 1950 and the present, the global production of plastic has grown approximately nine percent each year. Most are made from oil, but #2 and #4 can be made from natural gas and increasingly new forms are made from biological materials like corn. All indications are that the production and use of plastics will continue to grow, even as we move from fossil fuel (oil) to other sources of organic carbon. That means that the need to ensure these materials are recycled--for their value and for the environment--is increasingly important.

While this activity asks students to imagine all the ways that recycling plastic is valuable, there's really no limit to the list. We not only save raw materials like oil, but save space in landfills and avoid accumulating plastic "trash" that nature cannot break down. Plastic "lumber" is quickly replacing chemically-treated wood for landscaping, eliminating the need to use hazardous chemicals for treatment. According to the EPA plastic recycling results in a big energy savings (an estimated 50 to 75 million BTUs of energy per ton of recycled material).

The industry is exploding. In 2009, 479 million pounds of non-bottle rigid plastics were recovered--an increase of 47 percent in two years. In 2010, 9.2 billion pounds of plastics were recycled! But there is still a long way to go. We can still find discarded plastics in the trash and along the road, and some forms of plastic can't be easily separated here or in other countries.

Plastic Sample	Floats or Sinks in Solution				
	A (.78g/mL)	B (.91g/mL)	C (.93 g/mL)	D (1.0 g/mL)	E (1.14 g/mL)
1	Sinks	Sinks	Sinks	Sinks	Sinks
2	Sinks	Sinks	Sinks	Floats	Floats
3	Sinks	Sinks	Sinks	Sinks	Sinks
4	Sinks	Sinks	*	Floats	Floats
5	Sinks	*	Floats	Floats	Floats
6	Sinks	Sinks	Sinks	*	Floats
7	Sinks	Sinks	Sinks	Sinks	Sinks

* Densities of plastic may be equal to the density of the solution, or may slightly vary due to sources of error when mixing solutions or depending on what kind of plastic is being used. If the densities of the plastic and solution are the same, the plastic will neither float nor sink, but remain suspended (neutrally buoyant).

Density = mass/volume

Students should remember to subtract out the mass of the cup or beaker when finding the mass of the solution. The actual densities may vary slightly from the table provided here as a guide.

Quick Reference to Densities of Different Plastics and Examples

Density of Plastics	Examples
PETE (1) (Polyethylene terephthalate) 1.38-1.39 g/mL	Water bottles, soda bottles, peanut butter jars
LDPE (4) (Low-density polyethylene) 0.92-0.94 g/mL	Plastic bags
HDPE (2) (High-density polyethylene) 0.95-0.97 g/mL	shampoo containers
PP (5) (Polypropylene) 0.90-0.91 g/mL	Prescription medicine bottles
PS (6) (Polystyrene) 1.05-1.07 g/mL	disposable coffee cups
Other (7) (Polycarbonate/Lexan) 1.2 g/mL	cd bits
V (3) (Polyvinyl chloride) 1.18-1.30 g/mL	PVC

In the recycling process, densities can be used as a first step to separate plastics. A simplified version of this process is demonstrated in the laboratory. In actual recycling other chemicals may be needed. The table above serves as a quick reference for the the densities of different plastics along with samples of each kind.

Plastic samples of PETE (1), V (3) , and Other (7) will sink in all solutions. Unless students know something more about the items, it is acceptable to list unknown samples that sink in all solutions as possibilities in all three of these categories. Some students may recognize polyvinyl chloride as PVC, in which case they can go ahead and classify it as such. The Resin Identification Code Classification Chart can be passed out afterwards to allow students to further classify the items into their correct categories. In the reflect/assess section, students are challenged to come up with a way to further distinguish these three groups and determine their actual densities. One way would be to create additional solutions using denser liquids, such as dark karo syrup which has a density of about 1.37g/mL and could be diluted to make a few solutions of different densities. Students could explore this in the extension.

For unknown samples, the category may not be obvious. A plastic bag, for example, might also be placed in HDPE if it sinks in solution 2. This could happen if the particular plastic bag being sampled has a density on the higher range – 0.94 g/mL, and if there were some sources of error when mixing the solutions. The important concept is that plastics have different densities and can be sorted in this manner. More fine-tuned methods to determine density might be necessary to get down to the exact category in some cases.

ASTM International Resin Identification Coding System (RIC)



PET

Polyethylene Terephthalate, or **PETE** is used to make many common household items like beverage bottles, medicine jars, peanut butter jars, combs, bean bags, and rope. Recycled PETE is used to make fabrics and carpets.



HDPE

High-Density Polyethylene, or **HDPE** is quite stable and suitable for foods and drinks. It can be used to contain milk, motor oil, shampoos and conditioners, soap bottles, detergents, and bleaches, and to make children's toys—especially those that might be chewed. It can be recycled make plastic crates, plastic lumber, fencing, and more.



V

Polyvinyl Chloride, or **PVC** is used for plumbing pipes and tiles. It is not commonly recycled, but when it is, it can be used to make flooring, mobile home skirting, and other valuable products.



LDPE

Low-Density Polyethylene, or **LDPE** is both durable and flexible and used to make plastic cling wrap, sandwich bags, squeezable bottles, and plastic grocery bags. It is not normally recycled in the standard municipal mix, but when placed in designated containers (often at the stores) it can be used to make garbage cans, lumber, furniture, and more.



PP

Polypropylene, or **PP** is strong and can withstand higher temperatures than most plastics. It's found in plastic diapers, food containers, prescription bottles, and plastic coffee cups. Only a few municipal systems currently recycle it, but when it is reclaimed it can be used to make tools.



PS

Polystyrene (Styrofoam), or **PS** can be recycled but often ends up in landfills because the recycling processes don't account for its low density. It's found in disposable coffee cups, plastic food boxes, plastic cutlery, packing foam, and packing peanuts are made from PS. It can be recycled to make license plates, rulers and other durable plastic objects.



OTHER

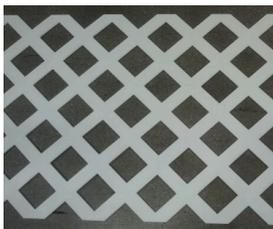
If a plastic is unique and doesn't fit into another category it is classified in this one. Examples include polycarbonate, used to make water bottles, compact disks and some medical products. It can be recycled to make plastic lumber.

Mix It Up, Sort It Out



Do you ever wonder where all the plastics you put into the recycling bin go? Thanks to new technology, the plastic you recycle today might become the running shoes on your feet tomorrow! Recycling technology has come a long way. Plastics recycling innovator, Dr. Vilas Pol, is a materials scientist who works at Argonne National Laboratory in Illinois. He has invented a “green”, environmentally friendly way to convert used plastic bags, plates, and recycled bottles into new materials through a process called “upcycling.” During this process, plastic is heated to a temperature of 700°C and converted into a fine black powder that can be used in products like batteries, toners and printer inks, lubricants, and tires. In 2010, 9.2 billion pounds of plastics were recycled. Making new products from plastics require that they are properly sorted because mixing plastics can degrade the quality.

Plastics are generally classified into one of seven categories. When plastics are collected for recycling, they are generally mixed and may also be collected with denser glass and metals. In this activity, you will consider why recycling plastic is valuable. Next, you will investigate the properties of plastic and how one of those properties can be used to sort the different types as an important step in recycling.



Plastic bags, plates, and bottles can be made into items such as fencing, running shoes, wristbands, and even bridges!

Materials

- [Champions of Recycling, Mike Biddle Article](#)
- Goggles
- Graduated cylinders (2.50 ml) for each group
- Beakers (5), 200 ml or larger, for each group. Plastics cups can also be used as a substitute.
- Isopropyl alcohol (350 ml per group)
- Water (400 ml per group)
- Sugar (sucrose, 75 g per group)
- Stirring rod or plastic spoon (per group)
- Balance (accessible to each group)
- Samples of unidentified plastics: HDPE, LDPE, Styrofoam, PETE, PP and polycarbonate per group (“hole punch” size if possible or something comparable- each team will need at least 5 bits of each kind of plastic – 1bit/solution)
- Calculators

Optional: ice cube trays (one per group), can help keep plastic bits organized.

Part 1: Prepare the Solutions

1. Consider all the different kinds of plastics there are. Using the samples provided by your teacher, make observations and list at least 5-7 different properties that might be used to identify the different types of plastics. Can any of these properties be used to help sort them?
2. Put on your eye protection.
3. Find the mass of five empty beakers and record.
4. Create solutions of 70 percent isopropyl alcohol, water and sugar as directed in the table.
5. Find the mass of each solution (how will you do this?)
6. Write the formula for calculating density. Calculate the density of each solution, and show the math.

Part 2: Determine Density

1. Obtain samples of plastics from your instructor.
2. Wearing eye protection, carefully place a bit of the first plastic into each of the five solutions (choose the one you wish to start off with). Make sure they aren't placed flat, floating on the surface, by stirring them into the solution a bit. Make observations.
3. Repeat step # 2 for each of your samples.
4. Record whether the sample floats or sinks in the solutions.
5. Your teacher will provide you with a sample or samples of plastics with unknown Resin ID Codes (RICs). Try to determine the RIC for each of the plastics you tested. Describe how you determined this using evidence from your findings.

Reflect and Apply

1. Compare your findings with your classmates and come to a class consensus based on the evidence. Why might some of your findings differ? Discuss potential sources of error.
2. There may be samples that sink in all of the solutions. What further investigations could you conduct to determine which categories of plastic these represent?
3. With your group, construct an explanation that describes how the methods you've used in this lab might be used in the process of recycling plastics.

Extensions

How does a plastic bottle become a shoe starting from the curbside pick-up? Write a narrative from the perspective of a plastic bottle depicting its journey from new to used, to recycled, to renewed.

Make a list of other products made from recycled plastics by conducting research. Next, find some of these products in your home, or at local businesses like a building supply store, and take some pictures. Prepare a communication for your community that shows the advantage of re-using plastics, using your photos as illustrations.



JOURNAL QUESTION

Read about [Mike Biddle, Plastics Engineer](#) Why is the work that Mike Biddle and Dr. Vilas Pol do important? Could you see yourself in this field someday?

Student Name: _____

Period: _____

Table I. Densities of Solutions

Formula for Density: _____

Solution	Amount Alcohol	Amount Water	Amount Sugar	Mass of the Solution	Volume of the Solution	Density (show the math and proper units)
A	150 mL	0 mL	0 g			
B	100 mL	40 mL	0 g			
C	80 mL	40 mL	0 g			
D	0 mL	150 mL	0 g			
E	0 mL	150 mL	75 g			

Table II. Observations of Plastic Samples When Placed in Solution

Plastic Sample	Floats or Sinks in Solution				
	A	B	C	D	E
1					
2					
3					
4					
5					
6					
7					

Table III. Identification of Unknowns

Name / Description of Unknown	Classification/ Resin Identification Code & Evidence
Ex. piece of white yogurt container	6 - sample sank in solutions A-D, but floated in E