IDENTIFICATION OF POLYMERS

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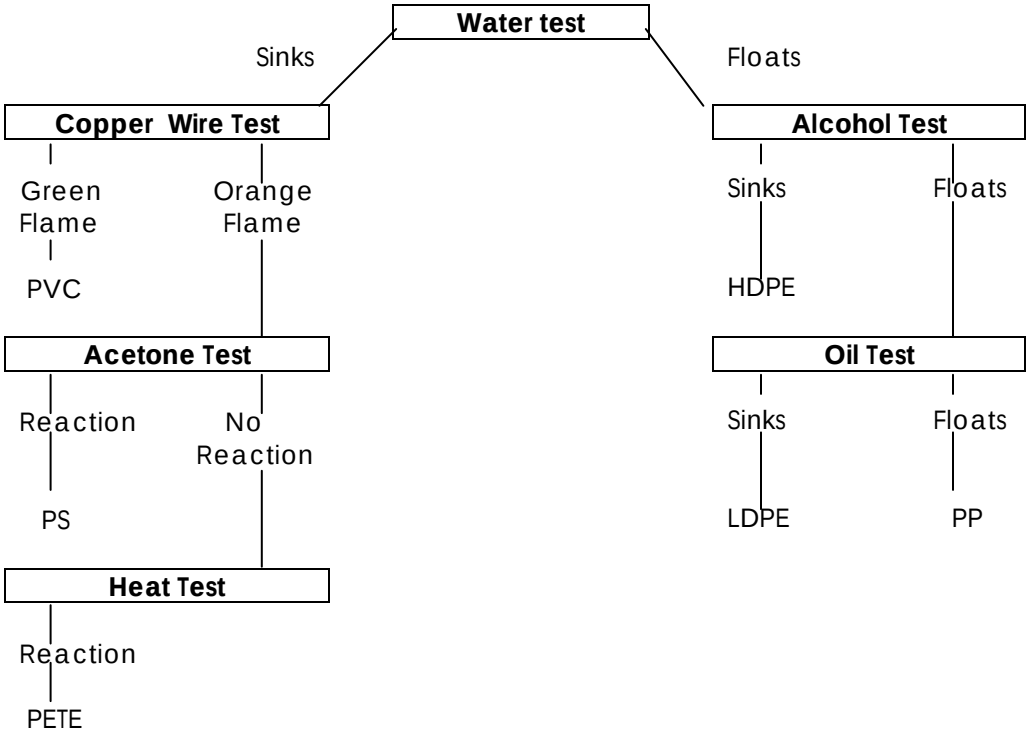
David A. Katz
Chemist, Educator, Science Communicator, and Consultant
133 N. Desert Stream Dr., Tucson, AZ 85745-2277 US

Introduction

In our everyday life, we encounter many polymeric materials, many of which are in the form of disposable containers used for many household products. As our natural resources are diminished and our landfills become filled[1], we are finding that it is better to recycle much of our waste materials than to dispose of them or burn them.

Most of the polymers we encounter in our daily lives are the six polymers listed in Table 1. To make recycling of these polymers easier, the plastics industry has adopted the codes shown. Since compliance in labeling is voluntary, not all plastics are labeled for identification. Identification, simply by appearance, is difficult, however, there are a few types that are readily identifiable. Clear, colorless containers that are used for soft drinks are most often polyethylene terephthlate (PETE). Opaque, translucent (and often white in color) plastics used for containers such as milk cartons are usually high-density polyethylene (HDPE). Bottles used for shampoos or cleaning materials are usually made from polyvinyl chloride (V or PVC). Plastic bags and some plastic wrap is often made from low-density polyethylene (LPDE).

In this experiment, we will examine some common plastics and perform several tests to identify them. A flow chart for the tests is given below:



[1] The major material filling landfills is paper, not polymers.

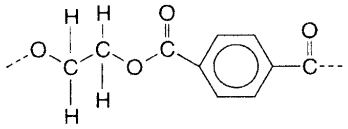
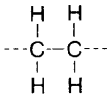
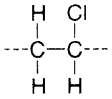
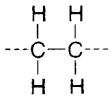
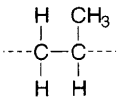
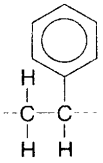
Symbol	Chemical Structure	Applications
1 PETE	 Polyethylene Terephthalate	Soft drink bottles, mouthwash bottles, peanut butter and salad dressing containers
2 HDPE	 High Density Polyethylene	Milk, water and juice containers, grocery bags, toys, liquid detergent bottles
3 V	 Polyvinyl Chloride	Clear food packaging, shampoo bottles
4 LDPE	 Low Density Polyethylene	Bread bags, frozen food bags, grocery bags
5 PP	 Polypropylene	Ketchup bottles, yogurt containers, margarine tubs, and medicine bottles
6 PS	 Polystyrene	Videocassette cases, compact disc jackets, coffee cups, tableware (knives, spoons and forks), cafeteria trays, grocery store meat trays, and fast-food sandwich containers.

Figure 1. Common polymers, their structures and packaging applications. (Source: **Hands On Plastics: A Scientific Investigation Kit**, American Plastics Council and National Middle Level Science Teachers Association.

Materials Needed

Samples of resin pellets in vials labeled 1 through 6
2 Unknown samples of plastics (These are in vials labeled 7 through 12)
Isopropyl alcohol solution, $CH_3CHOHCH_3$, 45.5% by volume. This solution is made by diluting 45.5 mL isopropyl alcohol to 100 mL with water. (Also, by diluting 65 mL 70% isopropyl rubbing alcohol to 100 mL with water.)
Mazola corn oil
Copper wire
Corks to fit 18 mm test tubes
Acetone
Test tubes, 18 x 150 mm
Stirring rod, glass
Bunsen burner
Beaker, 50 mL
Beaker , 250 mL
Tongs or forceps
Ring stand and ring with wire gauze

Safety Precautions

Isopropyl alcohol is flammable and the vapors are considered to be toxic. Keep containers closed and cover any open containers, such as a beaker, with a watch glass. Avoid flames.

Acetone is flammable and the vapors are considered toxic. Keep containers closed and cover any beakers of acetone with a watch glass. Work in a well ventilated area. Avoid flames.

The copper wire will get hot when heated in a flame. Hold the wire with tongs or forceps to avoid burns.

Disposal

Dispose of alcohol waste and acetone waste according to local regulations.

Mazola corn oil can be reused if it is not dirty or contaminated. Dispose of any waste oil according to local regulations.

Waste pieces of plastic can be disposed in the trash.

Copper wire can be reused.

Experimental Procedure

Obtain a set of vials containing the six kinds of recycled plastic resin pellets. Note that each type of resin is a different color. This allows for visual identification in this experiment. Actual resins may be almost any color depending on colorants added during its initial formulation.

Obtain samples of two different "unknown" polymers. These will be small pieces of polymer, not pellets.

The Water Test

Place approximately 5 mL of water in a test tube.

Start with one of the six plastic resin pellets. Place two of the pellets of the resin in the test tube containing water. Poke the each of the pellets with a stirring rod to remove any air bubbles adhering to the surface of the resin pellet and try to make it sink. Note whether the pellets sink or float. If both pellets do not behave in the same manner, test a third pellet of the same type and use the results of two that behaved the same way. Remove the pellets, dry them and save them for later use.

Repeat the water test with each of the remaining resin samples and with small pieces of the two unknown samples.

Save the samples that sank in the water for the copper wire test. Use the samples that floated for the isopropyl alcohol test.

The Isopropyl Alcohol Test

Place 5 mL of isopropyl alcohol solution in a test tube

Using one of the resins that floated in the water, add two pellets to the test tube containing the alcohol solution. Poke each pellet with a stirring rod to remove any air bubbles adhering to the surface of the resin pellet and try to make it sink. Note whether the pellets sink or float. If both pellets do not behave in the same manner, test a third pellet of the same type and use the results of two that behaved the same way. Remove the pellets, dry them and save them for later use.

Repeat the isopropyl alcohol test with each of the remaining resin samples and unknowns that floated in the water.

The Oil Test

Place 5 mL of Mazola corn oil in a test tube

Using one of the resins that floated in the isoproply alcohol solution, add two pellets to the test tube containing the alcohol solution. Poke the pellets with a stirring rod to remove any air bubbles adhering to the surface of the resin pellets and try to make them sink. Note whether the pellets sink or float. If both pellets do not behave in the same manner, test a third pellet of the same type and use the results of two that behaved the same way. Remove the pellets, dry them and save them for later use.

Repeat the oil test with each of the remaining resin samples and unknowns that floated in the isopropyl alcohol.

Substance	Density g/mL
Water	1.0
PETE	1.38-1.39
HDPE	0.95-0.97
PVC	1.16-1.35
LDPE	0.92-0.94
PP	0.90-0.91
PS	1.05-1.07

Table 2. Densities of water and polymers

Copper Wire Test

This test uses the plastic samples that sank in the water. (They were more dense than water.)

Obtain a piece of copper wire about 5 cm long. Push one end of the wire into a small cork. (The cork is used as a handle so you are not touching a hot wire.)

Place one pellet or plastic sample near your Bunsen burner. This is the sample you will be testing.

Hold the free end of the copper wire in the burner flame until it is red hot and the flame no longer has a green color.

Remove the wire from the flame and touch the hot wire to the plastic pellet or sample you will be testing. A small amount of the plastic should melt onto the wire. If the wire sticks to the plastic sample, use a pair of tongs to remove it. (You do not want to burn a large piece of plastic.)

Place the end of the wire, with the small amount of plastic on it, into the flame. You should see a slight flash of a luminous flame (a yellow-orange color). If the flame turns green in color, then the sample contains chlorine.

Repeat this test for each of the remaining plastic samples that sank in the water.

The Acetone Test

There should be a beaker of acetone located under the hood. If not, place about 10 mL of acetone in a 50 mL beaker. Work under a fume hood to minimize vapors in the room.

For this test, use samples of plastics that did not give a green colored flame.

Using tongs, place a pellet of the plastic in the acetone for 20 seconds. Remove the pellet and press firmly between your fingers. A positive reaction has occurred if the polymer sample is soft and sticky. Scrape the sample with your fingernail to see if the outer layer has softened.

If the sample has a positive reaction, discard it in the trash as the conclusion of this test.

Repeat this test for each of the remaining plastic samples that did not give a green colored flame.

The Heat Test

Place approximately 100 mL of water in a 250-mL beaker and heat to boiling.

For this test, use the samples of plastics that did not have a positive acetone test.

Using tongs, place a pellet of the plastic in the boiling water for 30 seconds. Remove the pellet and press it between your fingers to see if it has softened. A positive reaction has occurred if the polymer sample is softened.

If the sample has a positive reaction, discard it in the trash as the conclusion of this test.

Repeat this test for each of the remaining plastic samples that did not have a positive acetone test.

Clean Up

Recycle all plastic resins in their appropriate containers.

Return all liquid solvents for reuse of dispose them according to local regulations. (Your instructor will advise you on this.)

REFERENCE

This experiment is a modification of *Plastics Analysis Lab*, **Hands On Plastics: A Scientific Investigation Kit**, American Plastics Council and National Middle Level Science Teachers Association.

Name _____ Date _____

IDENTIFICATION OF POLYMERS

Report Sheet

1. Results of Water Test

Known resin pellets	Unknown plastic

2. Results of Alcohol Test

Known resin pellets	Unknown plastic

3. Results of Oil Test

Known resin pellets	Unknown plastic

4. Results of Copper Wire Test

Known resin pellets	Unknown plastic

5. Results of Acetone Test

Known resin pellets	Unknown plastic

6. Results of Heat Test

Known resin pellets	Unknown plastic

7. Identification of Unknown Plastics

The unknown plastics are _____