Sorting Recycled Trash: An Activity for Earth Day 2007

by Mary E. Harris and Harold H. Harris

The American Chemical Society will celebrate Earth Day on April 22, 2007 with the theme “Recycling—Chemistry Can!” In the activity described in this article, middle or high school students separate commingled recyclable trash to simulate sorting in a recycling center. Like many such real centers, the students’ imaginary “solid waste recycle and reuse center” accepts newspaper, steel cans, aluminum, glass, LDPE bags, PETE bottles, and HDPE containers. They design a conveyor belt scheme that uses tools such as magnets, straws, and water to separate small pieces of the actual recyclable materials or appropriate alternatives (e.g., glass marbles instead of small pieces of glass).

Background

Students are usually oblivious to the fate of discarded materials, and particularly how recyclables must be processed in order to re-enter the manufacturing stream. Sorting is the first step in this process. There are engineering and safety concerns as well as chemical concepts that must be considered when designing a system to separate recyclables. Some plants employ workers to hand-separate trash. Others use various kinds of technology. These include sieves to separate large from small items, shaker tables to separate heavy from light items, vacuum hoses to pull off films (such as plastic bags), and magnets to attract steel cans. Most people are surprised to learn that magnets can also be used to remove non-magnetic (but conductive) substances. This is done using “eddy current” separators, which consist of permanent or electro-magnets on a fast-moving wheel. When a conductor such as an aluminum can is in the vicinity, a current is induced in it; this causes the item to be repelled from the magnetic field and pushed from the commingled line.

Some recycling companies prefer commingled trash because it tends to increase the amount of recycling received by making it more convenient for consumers (Figure 1). Other recycling companies prefer households to sort their recyclables into separate containers before the truck arrives at the curb because this diminishes the steps in handling the materials stream. Smurfit-Stone Recycling handles recyclables for our part of St. Louis. Their customers place all recyclable items in large plastic bags for curbside pickup. The Supplemental Material contains a presentation, “Where does Recycled Trash Go?” that contains photographs taken at Smurfit-Stone.

There are seven categories for plastics and these are identified with the familiar triangle of arrows embossed on the bottom or sides of containers (Figure 2). The codes merely identify the plastic and do not imply that they can be recycled (1). Most recycling centers accept #1 PETE, polyethylene terephthalate (such as soda bottles), and #2 HDPE, high density polyethylene (such as milk jugs). Recycled PETE can be made into fibers for making fleece jackets and carpeting, while HDPE is often made into plastic “lumber”.

Almost all recycling centers take clear glass bottles. These must not be mixed with other kinds of clear glass such as window glass, light bulbs, Pyrex, or auto glass if they will be recycled into new bottles. However, mixed, crushed glass can be used for road surfaces. Metallic items are most valuable. Aluminum cans and steel cans require a great deal of energy to make, but recycling means that new ore need not be refined. Both glass and metal are processed at high temperatures to make new containers, so bacterial contamination from the recycled containers is not a concern. Lower temperatures are used in the processing of recycled plastic; this is one of the reasons that consumer food products are not packaged in containers made from recycled plastics.

The largest-volume component of the recyclables is newspapers. Most companies also accept white office paper and magazines (staples are not a problem for them). Some paper items that cannot be recycled are food-contaminated paper, waxed paper, oil-soaked paper, carbon paper, thermal fax paper, stickers, laminated paper, and juice boxes. Paper can be recycled only a limited number of times because fibers are broken during processing, causing the potential products to be limited to paper towels, newsprint, or cardboard, rather than writing paper. A short movie is available that shows the recycling of paper and how it is processed (2).

Some consumer items are not recycled in the conventional processes, but require special disposal because they can contaminate surface water, groundwater, or the atmosphere. They should not be placed in commingled recycling bags nor should they go into household trash that will be dumped into a landfill. These include rechargeable batteries (cadmium), motor oil (heavy metals), old air conditioners (chlorinated fluorocarbons,
CFCs), herbicides, solvents, and prescription drugs. Other recycling information is on the World Wide Web (3).

**Flow Chart and Conveyor Belt Diagrams**

In the Description of Activity for Students on page 210, students are required to create a flow chart and a conveyor belt diagram. Both the chart and diagram illustrate the students’ plans for how they will separate the recyclables, but in slightly different ways. A flow chart is a diagram to show the sequence of steps of a process in an easy-to-follow, pictorial manner. The conveyor belt system illustrates the separation of the materials based on the flow chart. Examples of a flow chart and conveyor belt system are shown (Figures 3, 4), illustrating the separation of the seven recyclable items used in the activity.

**Conclusion**

In this activity, students gain an appreciation for what happens to their recyclable trash after it has been taken to a recycling center. Both the students, in their simulated center, as well as real-life centers, must consider how the physical properties of the recyclables allow them to be sorted and what tools make that sorting possible and most efficient.

**Supplemental Material**

An Adobe Acrobat PDF containing the photographic presentation, “Where does Recycled Trash Go?” is in this issue of *JCE Online*.

**Literature Cited**

One Successful Conveyor Belt Scheme

<table>
<thead>
<tr>
<th>Place seven pairs of components on the belt.</th>
<th>Use a magnet to remove paper clips. (1)</th>
<th>Use a conductivity test to remove aluminum. (2)</th>
<th>Lightly blowing with a straw will remove LDPE and newspaper.</th>
</tr>
</thead>
</table>

**Part Two of the conveyor belt.**

<table>
<thead>
<tr>
<th>Place the other three components in a cup of water.</th>
<th><strong>Note:</strong> The table salt listed in the equipment section was not used.</th>
<th>Place LDPE and newspaper in a cup of water.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remove HDPE since it floats. (5)</td>
<td>Remove LDPE since it floats. (3)</td>
<td>Remove LDPE since it floats. (3)</td>
</tr>
<tr>
<td>Remove PETE since it deforms in hot water. (6)</td>
<td>Remove the glass marble. (7)</td>
<td>Remove newspaper since it sinks. (4)</td>
</tr>
<tr>
<td>Remove 6 and 7 and place them in hot water for one minute.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4. The conveyor belt uses the scheme of the flow chart (Figure 3) to separate the seven recyclable items, (1–7). For example, the first item separated is the paper clip, which is removed with a magnet.

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Purpose

In this open inquiry activity, students design a recycling plant system that constitutes an “automated” process of sorting recyclables. There is no single “right” answer. Knowledge of physical properties of the recyclable components must be applied in the design. Some properties to consider are density in various liquids, attraction to a magnet, mass of the objects compared to others in the mixture, and reaction to temperatures higher than room temperature but below the boiling point of water. Teams are given four pieces of each type of recyclable material. Teams may test two pieces of each type for physical properties. They then design a flow chart and conveyor belt system that they will use to separate a collection of the remaining pieces of recyclable materials. Students are given various equipment to use in the separation, such as magnets and straws for blowing jets of air. Students are not allowed to separate items by hand in their designed conveyor belt system. A student is allowed to transfer components, by hand, to other parts of the system for more separation.

Materials for a Group of Four

One plastic bag containing (Figure 5)
- four 2 cm × 2 cm pieces of #1 polyethylene terephthalate (PETE) (from plastic soda bottles)
- four 2 cm × 2 cm pieces of #2 high density polyethylene (HDPE) (from plastic milk jugs)
- four 3 cm × 3 cm pieces of #4 low density polyethylene (LDPE) plastic (from produce or dry cleaner bags)
- four glass marbles
- four 3 cm × 3 cm aluminum pie pan pieces
- four metal paper clips
- four 3 cm × 3 cm pieces of newspaper

One set of the following “equipment”
- Paper towels (These serve as a “conveyor belt” for the separation of the recyclables as it moves through the plant. Participants are allowed to pick up a group of components on one towel and place it at a different location in the plant.)
- magnet
- conductivity tester (this could be a simple battery/bulb or a homemade device such as one made from available plans (4))
- 4–6 plastic screens (8 cm × 8 cm)
- 4–5 straws (for hygienic reasons, the straws should not be shared)
- 3 400-mL beakers or bowls
- source of hot water
- table salt
- 7 cups for the separated recyclables

Teams may request more equipment, which then requires instructor approval.

Classroom Organization

Students may work in pairs or small groups. In small groups it is sometimes most efficient to assign roles to each member of a group of four. The following job descriptions may be helpful for classroom management:

Laboratory Technician: tests physical properties of components and records them in a data table (density, mass, etc.); allows only two of each component to be tested for properties

Engineer: creates a flow chart for separation of the components (flow chart definition is located in a separate section); clean-up monitor; helps the Reporter with the conveyor belt design; helps present the flow chart to the class along with the Reporter

Safety Manager: handles hot water; conveyor belt supervisor; safety monitor; watches for the use of hands during the activity; helps Laboratory Technician with tests of components

Reporter and Quality Control Supervisor: group spokesperson to explain how the group created the conveyor belt; designs, draws, and shows the diagram of the conveyor belt; helps explain the flow chart; watches for appropriate use of equipment; helps the Engineer with the Flow Chart

Reporting and Assessment

Each group’s reporter tells the class how their group separated the recyclables, explains the flow chart, and shows the conveyor belt design. Each group is assessed on its flow chart and conveyor belt designs, as well as its members’ ability to answer questions about their designs.

Figure 5. Students separate a mixture of seven types of “recycled” items in their simulated recycling center. Items used are (from top center, clockwise) glass marbles, aluminum pie pan pieces, LDPE film (produce baggie), newspaper pieces, HDPE (milk jug pieces) steel paper clips, and PETE (soda bottle pieces).