Landfills Problem Activity

Introduction

Municipal landfills are closing at an increasing rate because space is simply running out. Recycling will help, but even the best-case predictions tell us that it simply won't be enough. Other solutions need to be found. In this exercise the properties of two space-filling packing materials will be examined and the results considered in light of what their respective environmental costs and benefits might be.

Concepts

- Solubility
- Biodegradable

Theory

Expanded polystyrene "peanuts," commonly known by the trade-name Styrofoam™, are familiar to all of us as a space-filling packing material. They are used to occupy empty space in packages to cushion, immobilize, and protect the package contents. Polystyrene, the raw material for these peanuts, is synthesized from petroleum byproducts (benzene, ethylene) and formed into beads. These beads are transformed into the ultra-low density peanuts by a process requiring the use of "blowing agents." Blowing agents are chemicals added to a substance (polystyrene in this case) for the purpose of generating gas to produce a foam.

When the polystyrene peanuts are added to the acetone, the peanuts seem to dissolve. They do not really dissolve in the acetone, but go through a process called "swelling" that allows the trapped gases to escape. To put it another way, the polystyrene is "de-foamed." If the bulk of the acetone is decanted off and the residual polystyrene/acetone is allowed to dry, the result is a solid polystyrene disk. As an added exercise, the before and after volumes of the polystyrene can be estimated and students can calculate the approximate proportion of air in the peanuts.

An alternative packing material that has been developed and became popular is starch-based peanuts. These peanuts are manufactured from a completely renewable resource—cornstarch! The cornstarch used must be slightly altered by the addition of a small percentage (5% or less) of an agent which increases its capacity to trap and hold air and to resist compression. The expansion method is similar to the production of "puffed" breakfast cereals and requires only heat and steam—a comparatively benign process.

Starch-based peanuts have the added benefits of being water soluble, non-toxic upon combustion, and 99+% biodegradable. It should be pointed out, however, that once a material is placed in a landfill, very little natural degradation takes place. Landfills isolate materials from the air, light, and moisture that catalyze and support the breakdown of substances. Frequently, claims of biodegradability are not at all realistic if the item or material in question will be immediately buried in a landfill. The starch-based peanuts can be dissolved in water and flushed down the drain as an easy alternative means of disposal. Despite their solubility in water, the starch-based peanuts have been shown to withstand extended periods of warm temperature/high humidity. Currently the cost of the starch peanuts is approximately 50% greater than that of their polystyrene counterparts.

Following this exercise students should have a good foundation for evaluating these materials on the basis of their environmental costs and benefits. Perhaps they can suggest other pairs of alternative materials for a similar evaluation.

This activity can also be performed as a teacher demonstration to teach solubility rules, such as like dissolves like. If the identity of the peanuts and solvents are kept secret, this activity can be an excellent teacher demonstration to teach observation skills and scientific method—why do some peanuts dissolve and others don't?

Materials (for each lab group)

Polystyrene (Styrofoam™) peanuts, approximately 50
Starch-based peanuts, approximately 25
Acetone, 10 mL
Beakers, 100-mL, 2
Stirring rods
Latex gloves
Warm tap water

Safety Precautions

Provide adequate ventilation for this activity! Acetone is highly flammable and should be protected from sparks and open flame. Prolonged inhalation of acetone vapor is potentially toxic and should be avoided as should prolonged skin contact. Gloves must be worn

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if handling the polystyrene-acetone mixture. Do not ingest any components of this activity. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Distribute the items listed above to each lab group. Each group should have two beakers, one with 10 mL of acetone and the other with 40 mL of warm tap water. Beakers should be clearly labeled.
2. Instruct the students to visually inspect both types of peanuts and to note any apparent differences.
3. Have the students touch one of the polystyrene peanuts to the warm tap water and note what happens. Next they should touch the same peanut to the acetone and note what happens.
4. Now have them touch a starch peanut to the acetone and note the result. Next, test the starch peanut in the warm water.
5. Add the remaining polystyrene peanuts to the acetone one at a time, yet doing so as quickly as they dissolve. A stirring rod may be used to aid the process.
6. Next add the remaining starch-based peanuts to the warm water. Again one at a time, yet as quickly as they dissolve. A stirring rod will be essential for this task.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Allow the acetone to evaporate in an operating fume hood or rebottle for later use. The polystyrene should also be allowed to dry in the hood and then be discarded according to Flinn Suggested Disposal Method #26a. The dissolved starch-based solution may be rinsed down the drain with clean water according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter
Content Standard F: Science in Personal and Social Perspectives, environmental quality

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Materials for the *Landfills Problem Activity* are available from Flinn Scientific, Inc.

Catalog No.	Description
A0009	Acetone, 500 mL

Consult the Flinn Scientific website for current prices.