Activity: Mystery Polymer

Subject Area(s)  Environments, Engineering  
Associated Unit  Environments, module 4
Associated Lesson N/A
Activity Title   Activity: Identify a Mystery Polymer
Grade Level  6 (3-7)
Activity Dependency  None
Time Required  40 minutes
Group Size  Classroom
Expendable Cost per Group  One diaper per classroom

Summary

Disposable diapers have the single largest impact landfills – disposable diapers make up anywhere from 16-30 percent of our domestic landfill waste. An estimated 27.4 billion disposable diapers are used each year in the US, resulting in about 3.4 million tons of used diapers adding to landfills each year. About 3.5 billion gallons of oil are used to produce the 18 million disposable diapers that end up in landfills each year.

Still, disposable diapers remain the overwhelmingly popular choice for diapering babies because of their super-absorbant qualities and convenience. In this demonstration, students will try to guess what a ‘mystery’ polymer is by testing its properties in a scientific procedure.

Engineering Connection
Engineers have designed materials that we use everyday that are intended to make life easier and more convenient. Some examples of these materials include the plastic in our disposable soda
bottles, the nylon in our umbrellas, and the padding inside a baby’s disposable diapers. All of these materials are examples of polymers, or long repeating chains of carbon-based laboratory made materials. However, engineers sometimes cannot foresee the total environmental impact of these non-biodegradable polymers given how hugely popular their use has become. In this exercise, students will participate in a classroom demonstration to guess the identity of a mystery polymer, along with some discussion of what is a polymer, and the pros and cons of their widespread use.

Keywords
Chemical engineering, polymers, landfills, scientific inquiry

Educational Standards

Pre-Requisite Knowledge
None.

Learning Objectives
After this lesson, students should be able to:

- Describe what a polymer is
- Express the difference between qualitative and quantitative data
- Describe some of the desirable and undesirable properties of polymers

Materials List
Each individual needs:
- Diaper
- Gram weights
- Balance
- Pipets

Introduction / Motivation

How do we quantify the physical properties of a material? In this demonstration, students will learn about the difference between qualitative and quantitative descriptions of a material's physical properties. Students form a hypothesis about an "unknown" material, experiment upon it, take measurements, and estimate its physical properties. Students will be asked if they observe what they expected to observe.
<table>
<thead>
<tr>
<th>Vocabulary / Definitions</th>
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<tbody>
<tr>
<td><strong>Word</strong></td>
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<tr>
<td>physical property</td>
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<td>qualitative description</td>
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<tr>
<td>quantitative description</td>
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<tr>
<td>polymer</td>
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<td>super absorbent</td>
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<td>sodium polyacrylate</td>
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**Procedure**

**Background**

Discuss three types of engineering:

Chemical Engineering: Chemical engineers are involved in the design and production of products including high performance materials needed for aerospace, automotive, biomedical, electronic, environmental and military applications. Examples include ultra-strong fibers, fabrics, adhesives and composites for vehicles, bio-compatible materials for implants and prosthetics, gels for medical applications, pharmaceuticals, and films with special properties (self-cleaning class, digital televisions).

Materials Engineering: An interdisciplinary field involving the study of the properties of matter and its applications to various areas of science and engineering. It includes elements of physics and chemistry, as well as chemical, mechanical, civil and electrical engineering. In materials science, rather than haphazardly looking for and discovering materials and exploiting their properties, a materials engineer instead aims to understand materials fundamentally so that new materials with the desired properties can be created.

Nano Engineering: The practice of engineering on the nanoscale. It derives its name from the nanometer, a unit of measurement equaling one billionth of a meter.

**Before the Activity**

Discuss the properties of some materials:

a. Some substances form a gel when combined with water.
b. Some chemical substances, called polymers, consist of long chains of repeating subunits.

Review the vocabulary.
With the Students

Step 1: Ask for two volunteers. The volunteers will come to the front of the room where they will pretend to be chemical engineers who have invented a material in their lab. One morning, the engineers spilled a cup of tea next to their invention and observed that the tea 'disappeared' into the material. The engineers have decided to experiment on the material's physical properties.

Step 2: Form a hypothesis about one physical property of the material with regard to its absorbency.

Step 3: Ask the class if they can name some other physical properties of the material simply by observing it.

Step 4: Estimate the water absorbency of the material (take estimates from each of the two demonstrators). Specify units of the quantity.

Step 5: Calculate the volume of water to be absorbed per volume of water. Compare the results of the two experimenters. Are they the same? Construct a ratio table to find out.

Step 6: Propose some uses for the material.

Safety Issues

- Make sure students do not touch the diaper material (it crumbles), and if they do, to wash their hands immediately (to avoid contact with eyes, nose).

Troubleshooting Tips

Students are often frustrated on competition day because they did not test the design first. The best way to help ensure success is to test each iteration of the design, and to keep a notebook of what they think or observed to have succeeded and failed about each design.

Remind students who might be bickering about design ideas that they should build them and test them by throwing the eggs to simulate the drop. If more than one competing design survives the “drop,” then they can evaluate the designs on weight and size parameters (remember, awards are given for lightest and smallest designs surviving the drop).

Investigating Questions

Question: Did both experimenters arrive at the same conclusions about the material's absorbency? Why or why not?
Assessment

Pre-Activity Assessment
Perform a quick oral quiz of the vocabulary.

Activity Embedded Assessment

Question: What are some other physical properties we might have experimented upon? (Does the sample hold more hot or cold water? How long does it take to absorb a volume of hot versus cold water? Is the material toxic to dogs? Does the material retain the water for two hours? Two days? If salt is present in the water, do the same properties hold true?)

Post-Activity Assessment

Students will be evaluated on a scale from 0 to 4 on:

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<th>Participation</th>
<th>Task Completion</th>
<th>Math Correctness</th>
<th>Quality of Analysis</th>
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Activity Extensions

Question 1: What are some problems that polymers present to the environment? (by the mid 1990s, over ½ of the volume of U.S. landfills was occupied by disposable diapers. They neither decompose nor compress in anaerobic landfills. It takes centuries for a synthetic diaper to decompose.) If you were an engineer, what is one way we could address this problem? (Invent biodegradable super-absorbent materials – soy-based super absorbent polymers, lysine animal (carp)-based proteins.) Do you think these materials are more expensive to produce? How do you think the cost affects how pervasively they are used?

Question 2: What are some other uses for super-absorbent materials besides diapers? (Cat litter, contact lenses, absorbing rain water runoff, hydrating plants, fire-retardant sprays, hair products). A firefighter in Florida noticed that a used super-absorbent diaper was the only object that survived a dumpster fire unburned

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