Chemical Wonders, L1, Activity 3:The Plastic Test

Subject Area(s) **Physical Science, Chemistry, Science and Technology**

Associated Unit **Introduction to Engineering**

Associated Lesson **Chemical Wonders**

Activity Title **The Plastic Test**

Header Insert image 1 here, right justified to wrap

Image 1

ADA Description: In this activity students will determine the physical characteristics of different plastics such as elasticity.

Caption: Figure 1. Student stretching plastic

Image file name: Student_Plastic_Image_1.jpg

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Grade Level	4 (3-5)
Activity Dependency	None
Time Required	40 minutes
Group Size	4 to 5
Expendable Cost per Group	$5

Summary

Students are presented with a brief history of plastics and examine the abundance of different types of plastics found in our day-to-day lives. They will be introduced to the mechanical properties of plastics which make them useful for industrial applications including: stress/strain relationship. These physical properties allow for plastics to be fabricated into different products. Students will be able to recognize the different roles that plastics play in our lives and the effects that plastics have on our environment. Finally, the students will act like industrial engineers and based on the cost and physical properties, they will determine which plastics will be the most cost effective for given applications.

Engineering Connection

Arguably plastics, as a material, have had a greater influence on our daily lives than any other synthetic compound. Plastics provide physical properties which are far superior to traditional materials; plastics are able to keep liquids cold longer then metal or glass, they are less breakable and generally lighter. Plastics are used in everything from aircrafts to automobiles to the plastic cap on a soda bottles. To be able to carry out all these different roles, plastics have unique physical properties. In designing new plastic materials engineers need to take into consideration the stress and strain properties of the plastic.

Engineering Category
(1) Relates science concept to engineering

Keywords
Plastics, materials, Stress/strain test, chemistry

Educational Standards
- New York Science (1996): 4.3, 4.5, 1.1, 7.1, 7.2
- New York Math (1996): 3.PS.12

Pre-Requisite Knowledge None

Learning Objectives
After this activity, students should be able to:
- Understand that different plastics have unique physical properties
- Test the stress-and-strain of the plastic
- Determine the hydrophobic nature of different types of plastics
- Identify several limitations to the use of plastics on a material and ecological level
- Based on the physical properties and cost, determine which plastics will be most cost-effective for unique applications

Header Insert Image 2 here, left justified to wrap

Image 2

ADA Description: Plastic is an ambiguous term used to describe a variety of different polymers. Despite the recycling efforts, many plastics still find their way to garbage dumps.

Caption: Image 2. Several different types of plastics found in a garbage dump.

Image file name: Plastic_Dump_Image_2.jpg

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Materials List
Each group needs:
- 1) Equally sized pieces of plastic from dry cleaning bags, labeled A
- 1) Equally sized pieces of plastic from grocery store bags, labeled B
- 1) Equally sized pieces of plastic from department store bags, labeled C
- 1) Equally sized pieces of plastics from a plastic milk container, labeled D
- 1) Plastic medical examiner gloves, labeled E
- 1) Ruler

Introduction / Motivation

In a historical perspective, human eras are often defined by the feedstock which is commonly used to fabricate materials (i.e. the Golden Age or the Bronze Age). Can we define this human ear as the Age of Plastics? Plastics extensively permeate our daily lives; from the housing of our alarm clocks, to the container which holds our orange juice, to the seats in our cars. Often plastics are less expensive and more durable then alternative materials. The benefits of low-cost plastic are obvious; in drought stricken parts of the world, plastic

containers have replaced the traditional heavy stone or clay-based containers, reducing the burden of water transport.
Commercial plastics play an enormous role in our economy, in 2002 the plastic industry accounted for more $300 billion of production. A majority of these plastics were fabricated for packing materials including (bubble wrap, packing peanuts and water bottles). As internet shopping has blossomed and the disposable nature of our products has increased, we can assume that the $300 billion spent in 2002 has significantly increased.

The primary ingredient of plastics are polymers, a substance consisting of repeating molecules (as analogy we may consider a string of pearls as a polymer and the individual pearls as the monomeric subunits). Monomers are often composed of similar atoms: carbon (C), hydrogen (H), oxygen (O) and chlorine (Cl). However, the arrangement of these molecules leads to the unique mechanical properties of the polymer (Figure 1).

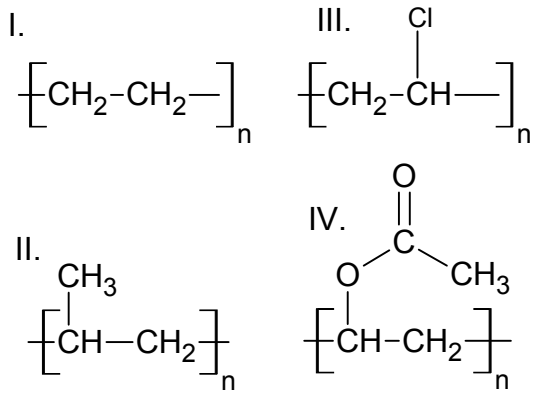

Figure 1.

ADA Description: The molecular structure of the bulk of the synthetic polymers currently used in industry. (I) Polyethylene, (II) Polypropylene, (III) Poly (vinyl chloride) and (IV) Poly (vinyl acetate).

Caption: Figure 1. The molecular structure of commonly used plastics (I) Polyethylene, (II) Polypropylene, (III) Poly (vinyl chloride) and (IV) Poly (vinyl acetate)

Image file name: Polymers_Figure_1.pdf

Plastic bags are generally composed of polyethylene (I), worldwide and estimated 80 million metric tons are produced each year making it by far the most commonly produced plastic. PE comes in a variety of different flavors; the most common are high-density polyethylene (HDPE) and low-density polyethylene (LDPE). HDPE are used in the generation of shopping bags from department stores, LDPEs are used for low grade plastic such dry cleaning bags. Plastic bags which are typically obtained at your local grocery store are generally a blend between the two.

The molecular composition and geometry of the individual monomers imparts unique mechanical properties to individual plastics. In this activity the students will investigate the mechanical properties of different plastics and how the knowledge of these properties allows engineers to select the correct plastic for the correct task.

One of the fundamental parameters which engineers use to investigate materials is the Young's modulus. The Young's modulus is a measure of materials stiffness. The Young's modulus is determined by a stress-strain test, where the stress is the amount of force applied and the strain is the measure of how much the object is stretched.

Vocabulary / Definitions

Word	Definition
Elasticity	A materials ability to be strained and to recover its size and shape after deformation
Monomer	A chemical compound which can undergo polymerization
Polymer	A chemical compound or mixture formed by polymerization, essentially repeating subunits
Strain	How much a material is stretched
Stress	The force applied to stretch a material
Young's Modulus	The measurement of a materials stiffness

Image: Insert Image 3 here, left justified to wrap

Image 3
ADA Description: Students stretching the plastic sheets
Caption: Image 3: Student stretching plastic
Image file name: Stretching_plastics_Image3.jpg
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Procedure

Background

We know that plastics are used for several different applications. Who can name a few types of applications (Answers include: milk or juice containers, clothing, shopping bags and medical devices). What are the physical differences between these different types of plastics? (Review these key points: Plastics are composed of different monomers and these monomers yield different physical properties of the end-product). These materials are constructed for their end function, for instance the juice container is used to hold liquids while the grocery bag is used to carry groceries. What are the physical differences between these materials? Which material is more flexible and which one is more rigid? How does that physical property play a role in its end function?

Before the Activity

- Divide the class into groups of three to four students
- Distribute to each of the five plastics to the groups
- Distribute one copy of the data collection sheet to each student in the group.

With the Students

1. Discuss different types of plastic and their applications with the students. Ask the questions described in the pre-activity assessment. Tally the student's responses on the board.
2. Distribute the different plastics and the work sheet to the students.
3. Have the students describe the physical characteristics of each of the plastics on the Data collection sheet
4. Demonstrate to the students how the plastics should be stretched. Explain to the students that some plastics are elastic, after stretching they retain their original shape, similar to a rubber band.
5. Ask the students to record the length of plastic sheets and record the data on the data collection sheet
6. Have the students apply force to each of the sheets of plastics and again record the length of the individual sheets.
7. The students should then independent answer the questions on the bottom of the data collection sheet.

Image: Insert Image 3 here, left justified to wrap

Figure 4
ADA Description: Photo of three different types of plastics used for this activity
Caption: Figure 4: These plastics all have different Physical/mechanical properties
Image file name: Different plastics_Image3.jpg
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Attachments

Data_collection_sheet.pdf

Safety Issues

- When cutting the plastic milk container you may encounter sharp edges, you can simply run a low grade piece of sandpaper along the edge to smooth them.
- As the students are performing the stress-strain tests, they should be reminded to pull the plastic in a controlled manner.

Troubleshooting Tips

The students may find that both the dry cleaning bag and the plastic bags from the grocery store both loss their structural integrity after only a mild force is applied, this generally stems from uncontrolled pulling..

Investigating Questions

None

Assessment

Pre-Activity Assessment

Voting & Demo: Ask students to vote by a show of hands their opinion on the following questions. Tally the votes and write them on the board.

- Which plastic is the strongest?
- Which plastic is the most elastic?
- Which plastic would be the best for making a water bottle?
- Which plastic would be the best for making a sandwich bag?

Activity Embedded Assessment

Prediction: Before each test, students are asked to predict and rank the outcome of each plastic and write the in a hierarchal order on the board (best performer to worst performer)

Post-Activity Assessment

Engineering: Based on the results from their experiments students are again asked to vote and tally the questions asked in the Pre-Activity Assessment

Activity Extensions

The students are asked to examine the negative aspects of plastics. After assessing the physical properties of these materials, the students are asked to think of other materials which may perform the same task (i.e. brown paper bags instead of plastic sandwich bags). The students openly discuss the difference between paper and plastic. The steps in this discussion should be as follows 1) How plastics are made (petrochemical feedstock) as compared to how paper bags are constructed 2) The physical properties of these materials 3) The degradability of these two different materials

Activity Scaling

- For lower grades, remove the section of the worksheet that addresses with the cost benefit analysis and carry out the procedure as a group discussion
- For upper grades, apply the same test to more types of plastics and examine the molecular arrangement of the plastic and how that arrangement influence the physical characteristics

Additional Multimedia Support

None

References

Stevens, E.S. Green Plastics (2002), Princeton University Press

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