Polymer Characteristics (Gabby Cole)

Subject Area(s) chemistry, physical science

Associated Unit N/A

Associated Lesson N/A

Activity Title Testing a Polymer

Grade Level 11 (9-12)

Activity Dependency

Time Required 30 minutes

Group Size

Expendable Cost per Group US $0

Summary

Students will learn how polymers are formed by linking many monomers together. They will observe how the structure of polymers affect their properties.

Engineering Connection

Polymer engineers are a materials engineers who create and study new products, such as plastics. They can work on the molecular level to study new plastics or at a production level to create polymers in an industrial setting.

Engineering Category

1. Relating science and/or math concept(s) to engineering

Keywords

monomer, plastic, polymer, polymerization, stiffness, technology

Educational Standards (List 2-4)

Source, year, standard number(s)/letter(s), grade band and text (its unique ID# is optional)

State STEM Standard CT Core Science Curriculum Framework (2005) D16, grades 9 and 11, explain how simple chemical monomers can be combined to create linear, branched, and/or cross-linked polymers

ITEEA Standard ITEEA 2007, grades 9-12: 5.K

Standard 19. Students will develop an understanding of and be able to select and use manufacturing technologies.

M. Materials have different qualities and may be classified as natural, synthetic, or mixed.

NGSS Standard Science [2013], grades 9-12: HS-PS2-6
Students who demonstrate understanding can communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

**CCSS Standard** Math [2010], grades 9-12: CCSS.MATH.CONTENT.HSN.Q.A.2

Define appropriate quantities for the purpose of descriptive modeling

**Learning Objectives**

After this activity, students should be able to:

- Describe how monomers are linked to form polymers
- Explain how the stiffness of a polymer is changed when the polymer changes

**Materials List**

Class needs:

- Computer access
- Optional: large scale palpation materials
  - plastic coffee stirrer (1/group)
  - pen/pencil (1/group)
  - yellow car sponge (1/class)
  - Mr. Clean sponge (1/class)
  - Gelatin, set according to package directions in a petri dish (1 dish/class)
  - Rubber eraser (1/class)
  - Scotch tape (1 roll)

**Introduction / Motivation**

A multitude of polymers exist in nature and our everyday lives. In our bodies alone, we have DNA and RNA carrying our genetic information, starches storing energy, and the proteins performing a myriad of cellular functions. Additionally, there are many synthetic polymers that create plastics, fibers, and other household materials. While these materials have an endless list of applications, they all have one thing in common – how they are formed. Linking together individual subunits, called monomers, forms polymers. Most often, these monomers are hydrocarbons or hydrocarbon derivatives. By making very simple changes – for example, substituting a hydrogen for a fluorine, chlorine, nitrogen, or benzene ring, quickly modifies the functional properties of the simple plastic, polyethylene, to make Teflon, PVC, acrylic fibers, or Styrofoam, respectively.

Polymers do not just form straight chains with one monomer linked after another. Branched polymers form irregular bends that look similar to tree roots while cross-linked polymers line up straight chains parallel to each other with occasional linkages holding them together. These two types of polymers behave differently. Branched polymers are often stronger than linear polymers at a specific temperature range, but soften and deform when the temperature changes. On the other hand, cross-linked polymers are both strong and stable because the covalent bonds forming the cross-linkages are significantly stronger than intermolecular forces present in other types of polymers.

The materials used in this activity are made of polymers of many different types. Yellow car sponges are made from cellulose, a straight chain carbohydrate that has many monomers linked together. This linear polymer is very flexible, making the sponge very malleable. Mr. Clean sponges are made from melamine resin, which is a branched polymer. The branching is at regular intervals and created by bonds and not intermolecular forces, making it a stronger polymer than cellulose. Gelatin is a more complicated substance made up of linear chains that coil into a triple helix. However, when the polymer is heated, the coils separate and the gelatin loses its structure. Rubber erasers are typically made from vulcanized rubber. Rubber itself is just a hydrocarbon chain, but when heated with sulfur, very strong cross-linkages are created between the chains that hold the rubber together.
Stiffness testing like students will be performing is important to many different engineering fields. Mechanical engineers study the stiffness of constructed objects, such as bridges, and can simulate how forces would affect different building materials. Biomedical engineers could study the stiffness of tissues with many different applications. For example, perhaps a softer tissue would be more permeable to drugs than a stiffer tissue, changing the efficacy and influencing how to create a better drug target.

**Vocabulary / Definitions**

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
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<tr>
<td>Cross-link</td>
<td>A bond, atom, or group connecting the chains of atoms in a polymer.</td>
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<tr>
<td>Deform</td>
<td>To mar the original form or shape of, misshape, or disfigure.</td>
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<td>Monomer</td>
<td>A molecule of low molecular weight capable of reacting with identical or different small molecules to form a polymer.</td>
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<tr>
<td>Polymer</td>
<td>A compound of high molecular weight formed either by the addition of many smaller molecules or by the condensation of many smaller molecules with the removal of water.</td>
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<tr>
<td>Polymerization</td>
<td>The act or process of making a polymer.</td>
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**Procedure**

**Before the Activity**
- Prepare gelatin according to package directions and allow to set.

**With the Students**
1. Have students punch out equal-sized samples from each substance (sponges, eraser, gelatin).
2. Set up the “tweezers” – on the right hand side, tape down the pencil or pen as the immobile side of the tweezer. Place a sample to the left of the top of the pencil and use this size as a guide to set the coffee stirrer on the left hand side of the sample at a 30-45° angle from the pencil.
3. Gently apply pressure to the coffee stirrer and observe the relative deformation of the sample.
4. Record observations and repeat for the other substances.
5. Try to correlate the observations with the structures of the substances.

**Image** Insert Image # or Figure # here (use Figure # if referenced in text)

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<th>Figure 1</th>
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**Attachments**

**Safety Issues**
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**Troubleshooting Tips**

**Investigating Questions**

**Assessment**
Pre-Activity Assessment
Descriptive Title: ___?

Activity Embedded Assessment
Descriptive Title: ___?

Post-Activity Assessment
Descriptive Title: ___?

Activity Extensions

Activity Scaling
• For lower grades, ___?
• For higher grades, ___?

Additional Multimedia Support

References


Other

Redirect URL

Contributors
Gabrielle Cole

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Classroom Testing Information
James Hillhouse High School, New Haven, urban comprehensive school, 11th grade chemistry, insert month here, insert number of students here