Carbon-Carbon Multiple Bonds: Structure and Function

A Carolina Essentials™ Activity

Overview

In this modeling activity, pairs of students use molecular models to construct a simple 2-carbon alkane, then convert it to a 2-carbon alkene and 2-carbon alkyne. After observing changes in structure among the 2-carbon series, students will use molecular models to investigate the myriad structures for polyethylene, one of the most common, multipurpose plastics.

Physical Science, Chemistry
Grades: 9–12

Phenomenon

All these items are made from the same basic unit, ethylene. What do you think allows for the wide variety of properties among the materials?

Essential Question

Why is the molecular-level structure important in the functioning of designed materials?

Activity Objectives

1. Build models, then describe how double and triple carbon-to-carbon bonds change the structure of ethane.
2. Using the monomer ethylene, design 3 polymer molecular structures and explain how the structure may influence properties and functions.

Next Generation Science Standards* (NGSS)

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical).	**PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

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TIME REQUIREMENTS

PREP	ACTIVITY
15 min	165 min

Teacher Prep: 15 min
Student Activity: 30-45 min
Student Research: 120 min

SAFETY REQUIREMENTS

No PPE is required for the activity.

MATERIALS (PER GROUP)

Molymod® Molecular Model Set
Colored pencils

HELPFUL LINKS

Forces at Work in a Lava Lamp
Flipping Molecular Structures

REFERENCE KITS

Molecular Structure

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Teacher Preparation and Disposal

Copy or upload the student activity pages. There is no disposal of waste materials.

Student Procedure

1. Build a model of the **ethane molecule C_2H_6**. All valence level electrons are accounted for in bonds.
2. Make a 3-dimensional sketch of the model.
3. Build a model of the **ethene molecule C_2H_4**. All valence level electrons are accounted for in bonds.
4. Make a 3-dimensional sketch of the model.
5. Build a model of the **ethyne molecule C_2H_2**. All valence level electrons are accounted for in bonds.
6. Make a 3-dimensional sketch of the model.
7. Design polyethylene structures that would function as a foam, film, and rigid solid. To simplify your design, use 10 to 15 monomers of ethylene. See the monomer structure for ethylene in the background.

Teacher Preparation and Tips

As students build the models, remind them that all electrons must be bonded. There will be no vacant holes on the carbon atoms.

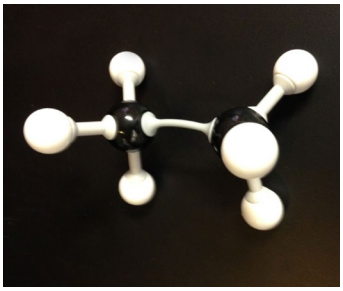
Use the longer, flexible bonds for the carbon-to-carbon bonds.

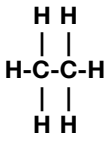
You may also ask students to include a structural model with their sketch.

Tell students to be creative. Think about the functions of the items in the collage. If a material stretches, will it have a complex network design? What does it take to make a rigid solid? Check for the bonding between ethylene monomers.

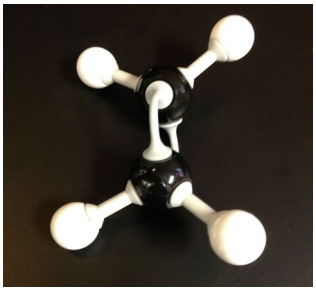
Data and Observations

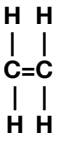
Ethane



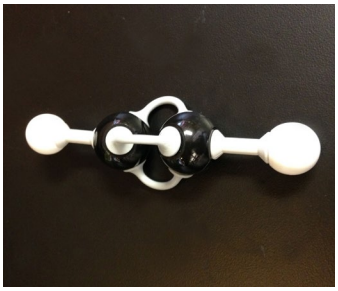


Ethene





Ethyne



Polyethylene

Drawings will vary. Guide students toward a long chain, a chain with a couple of branches, a chain with many branches, or a chain with cross-links. Bonding rules still apply.

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Analysis and Discussion

1. Moving from ethane to ethyne, describe what happened to the ratio of carbon atoms to hydrogen atoms and how the change affected the structure of the molecule. You may insert your diagrams as evidence of changes. *From ethane to ethene, 2 hydrogens were lost. The ratio went from 2C:6H (or 1:3) to 2C:4H (or 1:2). From ethene to ethyne, another 2 hydrogens were lost, making the ratio 2C:2H (or 1:1). Structurally, ethane is a 3-dimensional molecule and looks like 2 pyramids (tetrahedrons) stuck together. Ethene has the double bond that flattens the molecule, making it look planar in the model. Ethyne has the triple bond and 2 less hydrogens. Its structure looks linear.*

2. In a well-written statement, explain why each of your polyethylene structures will function as a foam, film, or rigid solid. *Student answers will vary. They may say a long single chain of monomers should be stretchy, highly cross-linked molecules should be rigid, and structures with lots of open space or pore space should be a foam. Students will investigate the actual polymer shapes in question 3 and evaluate their own designs.*

3. Check your design skills. Research the types of polyethylene and their structures and uses. Write a detailed explanation of at least 3 types. Evaluate the design of your ethylene polymers for structure and function based on your research. *Student answers will vary. Check for 3 different polyethylene variations. Some options include:*

   - *Ultra-high-molecular-weight polyethylene (UHMWPE)*
   - *High-density polyethylene (HDPE)*
   - *Cross-linked polyethylene (PEX or XLPE)*
   - *Medium-density polyethylene (MDPE)*
   - *Linear low-density polyethylene (LLDPE)*
   - *Low-density polyethylene (LDPE)*
   - *Very low-density polyethylene (VLDPE)*

   Look for an evaluation of all the designed polymers.

TEACHER NOTES