

Indestructible? Inconceivable!

Chemical Properties and Reactions

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Published by *K20 Center*

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Grade Level	6th – 8th Grade	**Time Frame**	220 minutes
Subject	Science	**Duration**	3–4 class periods
Course	Chemistry		

Essential Question

How does the atomic structure of a substance influence its properties?

Summary

Observing a polyurea-coated watermelon dropping from a 148-foot drop as a phenomenon, students will develop an understanding of how the coating is formed via a chemical reaction and what properties make the substance so durable. Through models and observational data, students will explain how the molecular structure of polyurea keeps the watermelon inside from smashing when dropped from a tower. This lesson addresses both MS-PS1-1 and MS-PS1-2 of the Oklahoma Academic Standards for Science. This lesson includes optional modifications for distance learning. Resources for use in Google Classroom are included.

Snapshot

Engage

Students watch a video demonstration of watermelons with and without a polyurea coating dropped from a tower and attempt to explain what they observed.

Explore

Students watch additional video clips showing the chemical reaction that produces polyurea (brand name LINE-X®). Students then draw models to explain what they observe and build additional models to explore the chemical structure of polyurea and its original components.

Explain

Students share their models and discuss how they know a chemical reaction occurred, how polyurea is formed, and describe the relationship between atomic structure and a substance's properties.

Extend

In small groups, students experiment with "Cat's Cradle" string games as a practical demonstration of the characteristics of polyurea that make it virtually indestructible.

Evaluate

Students create a final model that explains how polyurea is formed, why its atomic structure contributes to its near-indestructible quality, and the mechanism for how polyurea protected the watermelon observed in the Engage.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD302: Understand basic scientific terminology
SIN404: Identify similarities and differences between experiments
EMI404: Identify similarities and differences between models

Next Generation Science Standards (Grades 6, 7, 8)

MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Oklahoma Academic Standards (7th Grade)

7.PS1.1 : Develop models to describe the atomic composition of simple molecules and extended structures.
7.PS1.1.1: Substances are made from different types of atoms, which combine with one another in various ways.
7.PS1.2 : Analyze and interpret patterns of data related to the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
7.PS1.2.1: Each pure substance has characteristic physical and chemical properties(for any bulk quantity under given conditions) that can be used to identify it.
7.PS1.2.2: Substances react chemically in characteristic ways.In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Attachments

- Lesson Slides—Indestructible, Inconceivable.pptx
- Student Graphic Organizers—Indestructible, Inconceivable - Spanish.docx
- Student Graphic Organizers—Indestructible, Inconceivable - Spanish.pdf
- Student Graphic Organizers—Indestructible, Inconceivable.docx
- Student Graphic Organizers—Indestructible, Inconceivable.pdf
- Video Timing Guide—Indestructible, Inconceivable.docx
- Video Timing Guide—Indestructible, Inconceivable.pdf

Materials

- Lesson Slides (attached)
- Student Graphic Organizers handout (attached, one per student)
- Video Timing Guide (attached, for teacher reference)
- Model building supplies, such as cotton balls, marshmallows, pom-pom balls, toothpicks, pipe cleaners, straws, ice pop sticks, etc.
- Yarn or string, cut into a variety of lengths
- Pens/pencils

15 minutes

Engage

Teacher's Note: Viewing the Video

The YouTube video used in this lesson (linked below) explains the chemistry behind polyurea coating, specifically the LINE-X® brand. Be mindful of the timestamps listed throughout so you don't give away information you want students to discover for themselves first. Some portions are meant to engage students in observation, while others are meant to be informative. The order and timing are important for the lesson to be most effective and avoid "spoilers." Use the attached **Video Timing Guide** to direct your presentation of the video.

Use the attached **Lesson Slides** to guide the lesson. You may wish to review the essential question and learning objectives on **slides 3–4**. Begin the lesson on **slide 5**. Give students the first page of the **Student Graphic Organizers** handout**.** Have students complete the I Notice, I Wonder strategy while watching the *Indestructible Coating?!* video. The image on slide 5 is linked to the video, and the full URL can be found in the Resources below if needed. ***Be sure to stop the video at the 2:10 mark.*** Then, go to **slide 6** and ask students the following questions:

- What do you think the polymer substance around the watermelon is made of?
- What properties does the material have that make it so strong?
- How do you think it was able to protect the melon?

Embedded video

https://youtube.com/watch?v=DWkYRh6OXy8

Optional Modification for Distance Learning

To make the above activity accessible for online or distance learners, consider creating an EdPuzzle using the video. You can pose questions at specific stopping points in the video for students to answer. You can also clip the video into different sections to use for the different stages of this lesson. Download all attachments to use this lesson in Google Classroom.

Student Responses

If students struggle to come up with answers to these questions, encourage them to take their best guess. Emphasize that they don't have to know the answer right now.

Go to **slide 7** to present the phenomenon goal to the students: "How does the polymer coating protect the watermelon?" During the lesson, they will be trying to explain why the polymer coating is able to protect the watermelon.

30 minutes

Explore

Continue with the *Indestructible Coating?!* video, letting students watch **from the 2:40 to the 3:26 marks**. This section shows the chemical reaction that forms the polyurea coating in real time. Play the clip at least twice to give students an opportunity to pick up on the specific details during their observations. The observable indicators that a chemical reaction has occurred in the video include the release of a gas, change in temperature, and change in consistency (i.e., new properties) of the material in the cup.

Teacher's Note: Teaching Standard MS-PS1-2

Students should already have a basic understanding from 2nd and 5th grades (Oklahoma Academic Standards for Science 2-PS1-4 and 5-PS1-4, respectively) that the properties of substances can change when they are combined. At the middle school level, students should be focused on comparing the properties of these substances before and after they are mixed to assess whether a reaction occurred. **Resist the urge to ask students to distinguish between physical and chemical changes.** These categories can be misleading and are known to interfere with students' ability to distinguish between phase changes and chemical reactions.

Go to **slide 8**. Invite the class to share some of their observations about the video, then ask students to look at the Explore section of the Student Graphic Organizers handout and create a visual representation or diagram that explains how the LINE-X polymer forms. You may choose to draw a model, illustrate a process, or use symbols to depict the formation. Students could share these creations with partners, a few volunteers could share their creation with the class, or you can set them aside without sharing out for now.

Teacher's Note: Authentic Visual Representation of Atomic Structures

The format of the "model" is used as a way to construct knowledge throughout this lesson. This shouldn't necessarily look like an atomic model as traditionally thought of, especially in the early stages of learning. It should be left up to the students (within reason) to allow them enough choice to explain their understanding in a way that makes the most sense to them. Provide them with several choices for how to complete the task.

Optional Modification for Distance Learning

To make the above activity accessible for online or distance learners, consider inviting students to draw their models using an online design tool such as Canva. This design may also serve as the model itself if students do not have materials at home with which they can construct a 3D model. You can substitute a peer review activity with a website such as VoiceThread. With VoiceThread, you can upload students' posters to the site beforehand. Students can then choose whether they would like to make a quick video, a voice memo, or a written note to give feedback on other students' model designs. Download all attachments to use this lesson in Google Classroom.

Go to **slide 9**. Ask students to recall what "Substance A" (clear liquid) and "Substance B" (dark liquid) looked like. Then ask them to explain why the substances are different from each other. If they struggle to develop answers you might ask guiding questions like, "Why is Substance A a clear liquid?" or "What is Substance B made of that causes it to be black?" Have students add those details to their visual representation or diagram.

Discuss the models and the ideas they represent as a whole group. Accept a variety of answers from students but emphasize those ideas that suggest that Substance A and Substance B are made of different particles.

Teacher's Note: Model Building Materials

Now that students have honed in on ideas about the chemical reaction occurring to form LINE-X® and that its individual components (A & B) are different due to the particles they are composed of, have them build a physical model to synthesize these two concepts. A variety of craft materials are appropriate for this activity (pom-pom balls, cotton balls, marshmallows, toothpicks, straws, pipe cleaners, ice pop sticks, etc.). Lego or similar building brick sets would also be effective.

Go to **slide 10**. Pose the following prompt to students: "Use the provided materials to create a physical representation of how Substance A and Substance B combine to make the LINE-X coating." Allow time for students to build their models. The model the students create doesn't necessarily need to be a "molecular" model. Encourage them to get creative in representing the molecule and to think about the reason they chose certain materials (why marshmallows? why pipe cleaners?) and how those materials represent atoms and their bonds.

Teacher's Note: Teaching Standard MS-PS1-1

Students should already know that substances are made of particles too small to be seen from 2nd grade (Oklahoma standard 2-PS1-3) and 5th grade (Oklahoma standard 5-PS1-1). At the middle school level, students should be further developing their understanding from a "particle model" to an "atomic model." Students should come to understand that the particles that make up substances are called **atoms,** and that when atoms bond with each other they form **molecules**. Specific details about neutrons, protons, and electrons **should not** be taught at middle school. Research shows that students are not yet cognitively ready to make sense of those abstract details. That content is covered for the first time in high school (Oklahoma standard HS-PS1-1).

40 minutes

Explain

Go to **slide 11**. After the models are complete, ask students to share their models with the class. Through class discussion, have students compare their creations—identifying similarities such as the types of atoms present (Do you have three types of elements? Are there more hydrogen atoms than nitrogen atoms?) and why they chose the materials they used. By doing so, they "see" the overall concept of atoms combining and rearranging to form molecules. You may choose to have this sharing be formal or informal. Ask students to record their ideas somewhere all students can see to help them draw conclusions and connect ideas (such as in a lesson slide, in a Google Doc, on poster paper, or similar). If students' creations do not represent all the major concepts they need to discover, it may help to make those observations yourself for the class (e.g., "I notice in most of your creations that all three substances are shaped differently," and "When I look at your creations I see that many of you built LINE-X® out of the same parts you used for Substance A and B."). If this is necessary, be sure to ask students to explain why they built their creations in these ways.

Teacher's Note: Model Concepts

The physical models are primarily aimed at helping students observe that, in a chemical reaction, the particles that make up the original substances are the same particles that make up the product. They should also take away the idea that each substance has a different structure, and the combination of atoms and how they are put together contribute to the properties of those substances. Students should connect this concept to the fact that, since LINE-X® is constructed differently than either Substance A or B, it will have different properties, which is an indication that a chemical reaction has occurred. This may confirm the observations they made earlier watching the video in the Explore phase.

Following the discussion of the students' models, show the *Indestructible Coating?!* video **from the 2:10 to the 4:05 marks**. Go to **slide 12**. From the combination of model sharing, the video explanation, and a class discussion of content, students should have built a conceptual understanding of the content.

Go to **slide 13**. Conclude this portion of the lesson by asking students to explain how polyurea/LINE-X® forms. Re-voice student answers to formally summarize how polyurea forms.

Go to **slide 14** to introduce students to relevant vocabulary. (Note that the video uses the word "exothermic," but students do not need to know or remember this term since the video defines the word every time it is used.)

Optional: Using Anchor Charts for Vocabulary

One way of introducing vocabulary is to use an Anchor Chart. This strategy keeps the words visible as a reference throughout the rest of the lesson. As you add or reveal each word, ask students to identify where that component is found or represented in their models.

Introduce the following vocabulary terms to students (displayed on slide 14):

- **Atoms:** the particles that make up matter
- **Elements:** different types of atoms; the elements and the ways they react with each other are what give substances their unique properties
- **Molecules:** two or more atoms bonded together; they can be the same type of atom, or combinations of different types
- **Polymers:** substances made of many copies of the same type of molecule bonded together
- **Reactive:** describes substances with strong chemical reactions. This is a video-specific word (~2:18) and is not necessary for students to remember, but for the purpose of this lesson, they need to know that Substance A makes very strong bonds with other molecules.

40 minutes

Extend

Go to **slide 15**. Ask students if they have enough information yet to explain why the LINE-X® coating was able to protect the watermelon. At this point, the answer is probably no. Let them know that the activity they are going to do next will help them fill in the gaps in their knowledge by investigating further.

Teacher's Note: String Games Prep and Examples

Provide pairs of students with yarn or string of at least three different lengths—pre-cut or with guidance for the students to choose and cut the lengths. The Cat's Cradle Playlist (the full URL is also provided in the notes on slide 16 and in the Resources below) provides many examples with step-by-step demonstrations of "Cat's Cradle" string games and instructions for making many different shapes with the strings.

Optional Modification for Distance Learning

If students do not have string or a substitute at home to participate in this activity, consider inviting them to use the video playlist above to make observations while others demonstrate the string games. Download all attachments to use this lesson in Google Classroom.

Provide pairs of students with yarn or string of at least three different lengths, pre-cut or with guidance for the students to choose the lengths. Go to **slide 16.** Assign students specific "Cat's Cradle" string game designs or let them choose one for themselves. Student pairs might choose to try two different designs of varying complexity, or a single design with the complexity distributed across the classroom. Pairs should attempt to create the same design with their strings and make observations about the experience (e.g., which length was easiest to use, how the length of the string related to the complexity of their design, what happened to the string during the activity).

Teacher's Note: Accommodations and Modifications

If you have students with physical disabilities who are unable to complete the string games, there are several possible alternatives. Depending on the extent of their physical coordination, they could use shorter lengths of string and count how many knots they can make in each length. They could be provided with (loosely) pre-knotted strings and count how many each has. Both would help them connect the idea that longer strings can become more tangled than shorter ones. You might also pair them with a student who can complete the game so they can make observations of it, though this is a less-preferred option.

Go to **slide 17.** In students' pairs or in small groups, have students summarize what they learned while playing string games (i.e., longer threads get tangled more easily and can make more complicated designs; shorter threads are difficult to make designs with and aren't as easy to tangle). Continue with the questions on **slide 18**, then play the rest of the video **(4:05–6:50)** for students.

Additional Video Vocabulary

Note that there are several video-specific vocabulary words in the remainder of the video that students do not need to remember but should understand for the purpose of the lesson. Add them to the Anchor Chart if necessary. These words are listed below.

- **Cross-link:** (~5:20 video mark) For the purpose of this lesson, students need to understand that different polyurea chains can bond with each other and become "tangled" or "knotted."
- **Tensile strength:** (~5:54 video mark) For the purpose of this lesson, this can be defined as how much you can stretch/deform a substance without it breaking.

Teacher's Note: Discussion Questions

Go to slide 18. After viewing the rest of the video, ask students to explain why LINE-X® is so strong, based on what they learned in the video and their conclusions from the game (i.e., the long chains form strong bonds among each other ["cross-link"] and get tangled; the tangled polyurea chains can stretch and go back to their original shape without breaking). Then ask them to explain why this property protected the watermelon (i.e., the polyurea redistributes the force so that less of the impact reaches the watermelon—student answers likely won't be so technical).

The Claim, Evidence, Reasoning (CER) strategy would fit well with the discussion. Students' claim would be about the strength of LINE-X®; their evidence would be what they observed during the string games, and their reasoning would be the scientific explanation for how the watermelon is protected. Give students the second page of the Student Graphic Organizers handout if you wish to use this activity.

20 minutes

Evaluate

Go to **slide 19**. Students should create a final model that illustrates how the LINE-X® forms **and** how its structure protects the watermelon when it is dropped. If students need more prompting to understand this activity, ask: Where on your model does the reaction/interaction occur? What happens in that specific spot...and what does it encompass that allows a dropped watermelon to be protected?

This model might be drawn or constructed as was previously done in the lesson. It could also be created digitally, or students could demonstrate it with a kinesthetic model. In addition, each student should provide an explanation, either written or oral, of their model and how it represents the concepts they learned during the lesson. It would be reasonable for students to work in pairs or small groups, especially for a kinesthetic model, since the explanations are independent.

Resources

- inDOOR hobby. (2014, July 30). *Cat's Cradle Playlist* [Videos]. YouTube. https://www.youtube.com/playlist?list=PLD36uxtvOyM5AQmzGfajBFtB06iGHQYTx
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