Lesson Plan: Making Slime

Summary
In this lesson, students explore the science behind chemical reactions as well as the processes used by chemical engineering principles to develop new materials. The idea that mixing two substances can result in an explosion, the release of gas, and the formation of an entirely new substance is both fascinating and mysterious to most young students. Many students are also attracted to the idea of inventing new substances with different and exciting properties. The lesson begins with a reading of Dr. Seuss’ book *Bartholomew and the Oobleck*. Students then explore what happens when two different substances are mixed and a chemical change occurs. They then extend the investigation further by experimenting with different combinations of substances to make “oobleck” (slime).

This is a simple investigation that introduces or expands on the concept of chemical reactions, but does not go into details of the composition of the substances or the reaction that occurs.

Resource Type
Lesson plan

Grade Level
Elementary school

Objectives
By the end of this lesson, students should be able to:
- Describe and compare physical properties of various substances.
- Explain that when two or more different substances are mixed a new substance with different properties may be formed.
- Identify the difference between a chemical change and a physical change.
- Describe possible negative effects of substances that are engineered by humans.
- Describe ways that chemical engineering can make life better or worse.

Chemistry Topics
This lesson supports students’ understanding of the following topics in chemistry:
- Matter
- Chemical reactions

Time
Teacher Preparation: 30 minutes
Lesson:
- Single Day lesson: 50 minutes
- Multiple Day Extension or Investigation: This topic of study could be easily adapted into a 5-day format
Materials
Single Day Instruction (small sample for each student):
- Water (average class, 1 liter)
- Borax-based detergent (such as 20 Mule Team Laundry Soap) (1/4 cup)
- White glue (2 to 3 oz. per student)
- Stirring sticks (craft sticks or popsicle sticks – 1 per student)
- Small 2-3 ounce paper or plastic cup (plastic bags will also work—1 per student)
- Green food coloring (1-2 drops per student cup; ¾ bottle for 1 gallon of glue)
- Mixing flask or container (for borax solution)
- Eye dropper (for adding borax solution to glue—1 per student or team)
- Science journal
- Optional:
  - for engagement and connections to reading: *Bartholomew and the Oobleck* by Dr. Seuss
  - for engagement, motivation, and atmosphere: Erlenmeyer flasks and graduated cylinders filled with food colored borax solutions; candle; magician or sorcerer’s costume
- Optional: safety equipment such as goggles, gloves, aprons (see safety note)

Multiple Day Extension or Investigation:
- Computers and other resources for conducting research
- Corn starch or other substances as required to produce different types of slime
- Balance
- Graduated cylinders
- Rulers, tape measures, meter sticks, etc. (for measuring)

Safety
- Candle Burning: A hurricane lamp enclosure can be used to surround the open flame. You could also use a battery-operated candle.
- Chemicals: While these are not dangerous chemicals, white glue and borax solution should not be eaten. Students should be instructed that they should be responsible with the slime they create, including instructing younger children not to eat it and putting it away when finished.
- Although this activity is specifically designed for “at home use” with children, the single and multiday activities provide the opportunity to introduce lab safety to young students. For example, it is important that the students be allowed to investigate using their senses. Chemists do not feel, smell, or taste substances unless they are absolutely sure that the substances are safe to examine in this way.
- When running the multiday activity/investigation, the students must wear safety goggles, rubber gloves, and aprons.

Vocabulary Terms
- Chemical change
Chemical reaction
Solid
Liquid
Polymer
Engineering
Chemical engineering

Keywords
Oobleck, slime, silly putty, polymer, polymerization, elastic, non-Newtonian liquid

Teacher Notes
- One box of detergent with borax (such as 20 Mule Team) will last many years.
- Consider buying glue in gallon jugs.
- Throughout the activities, encourage students to record their observations using both words and drawings.

Science Background
The process of making slime involves both physical and chemical changes. Mixing borax with water creates a borax solution. No chemical reaction takes place during this step. Mixing food coloring and water with glue creates a mixture. For the most part, water is just mixing with the glue, but there is some reaction occurring between the water and glue. Mixing the borax solution with the glue mixture, however, involves a significant chemical reaction.

School glue is a substance known as polyvinyl acetate (PVA). PVA itself is a polymer, a long chain of repeating molecules, or monomers. PVA is made of \( \text{C}_4\text{H}_6\text{O}_2 \) monomers.

Borax is sodium borate, \( \text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} \). When borax and school glue are mixed, a more complex polymer forms. The borax molecules bond to the PVA chains, linking them together. This causes the glue to become less like a liquid and more like a solid.

The slime created is a type of non-Newtonian fluid. Newtonian fluids, like water, respond in the same way to stress regardless of the rate at which the stress is applied. Water has the same viscosity (resistance to flow) regardless of how forces are applied to it. It has a very low viscosity whether it is poured slowly or hit hard and quickly with a hammer. Non-Newtonian fluids, however, respond differently, depending on whether the stress is applied quickly or slowly. Slime has a low viscosity and will flow easily under the slow, gradual stress of the force of gravity but a high viscosity, causing it to break under the quick stress of being hit with a hammer.

Additional Resources
- Non-Newtonian liquids

- Polymers: http://pslc.ws/macrog/kidsmac/index.htm
- Slime:
  - *The Incredible Secret Formula Book* by Shar Levine and Leslie Johnstone
  - *Pure Slime* by Brian Rohrig

**Preparation**
- Mixing the borax with water and pouring the solution into eyedropper bottles takes about 20 minutes (multiple small group or individual).
- Organizing the remaining supplies and materials for the reading and activity takes approximately 10 minutes, and is best accomplished before the instruction is to take place.

**Lesson**

**Engage**

**Activity 1: Sorcerers and Scientists**

On a table sits flasks with various colors of borax solutions, a graduated cylinder, and a burning candle. There is with a chair sitting next to the table where the storyteller will sit. Students sit on the floor in a semicircle around the teacher. Classroom lights could be dimmed or out, depending on ambient lighting. The teacher is adorned in a sorcerer’s robe and cap.

- **Do you know what a wizard is? Are wizards real? How do wizards act?**
- **Is there a kind of person who works with chemicals like these that are sitting on the table?**
- **Have you ever wished you could invent something that is brand new, something that has never been seen before?**
- **If you invented something like that could it be good for people? Could it be bad?**

Inform students that today's scientists were like the wizards of old. Long ago, anything that was a new, unknown material seemed like magic, and the people who invented these materials were considered wizards. Today we know that different materials can be changed to make new ones. The people who do that today are scientists and engineers, not wizards, because we understand the science behind the changes. Close this first activity by informing the students that like a wizard or a chemical engineer, they will mix two things together and come up with something that looks and behaves differently than the chemicals they begin with.
Activity 2
Read *Bartholomew and the Oobleck* by Dr. Seuss. During the reading, stop periodically to explain vocabulary words, or further develop some story element to ensure understanding, differentiate instruction, or clarify terms. In other sections of the text, especially where the king calls upon his wizards or where the story talks about the characteristics of Oobleck, discuss the wizards’ actions and how they are similar to those practiced by scientists and engineers.

**Explore**

**Safety Note:** Explain to students that feeling, smelling, and tasting unknown substances is not safe unless a parent or adult says it is OK to do. Chemists do not feel, smell, or taste substances unless they are absolutely sure that the substances are safe to examine in this way.

1. Have the students examine and compare the glue and the borax solution separately by sight, smell, and touch, and record their observations in their science journals.
   - What color is it?
   - Is it a solid, liquid, or gas?
   - How does it feel? Is it thick and sticky or thin and runny? Is it smooth and slippery or rough?
   - How does it move when you touch it?
   - Is it easy or hard to stir?

You may want students to record their observations in a table or in a Venn diagram for easy comparison. Encourage students to make drawings as well as text descriptions.

2. Give students the option of adding food coloring to the glue to make it the color of oobleck in the book, or some other color.
   - What properties of the glue change when you add the food coloring?
   - What properties stay the same?

3. Have students then use the eyedropper to add 3-4 drops of borax solution to the white glue. This can be done in groups of two with one student adding the borax while the other stirs the glue. Students should add one drop at a time, making observations as they go. Instruct students to chant a spell such as “shuffle, duffle, muzzle, muss. Fiesta, wist, mista-cuff” as they stir. (Note: This may seem ridiculous, but you will later discuss whether or not the chant was necessary and why.)

Guide students to observe what happens as the two substances are mixed.
Do the substances have the same properties when they are mixed as when they are separate?

What properties does the new substance have?
  - What color is it?
  - Is it a solid, a liquid, or a gas?
  - Is it thin and runny, thick and sticky, or something else?

Do you think you could easily separate the borax solution from the glue now?

How do the properties of the new substance change as you add more borax solution?

What kind of change is this? Is it a physical change or a chemical one? Why do you think so?

Note that as more borax is added to the glue, it will lose the “tacky-look” and take on an appearance that it is solid. It will have a roundish shape as it sits on the end of the stirring stick. Have the students investigate this quality by rolling the substance with their hands. Have them bounce it. You might hear observations such as: Hey, it changed from liquid to solid. It started out sticky but as you added more borax, it became less sticky. It changed into a ball.

4. Have students talk with a neighbor about what state of matter this new substance is. Is it a solid, a liquid, or a gas? What makes you think so?

5. Just before lunch, recess, or some other activity outside the classroom, have the students lay a pencil in the middle of their desk, roll the slime into a ball, and place it balanced on the flat edge of the pencil. When students return, they will likely observe that the slime has begun to flow. Have students revisit the question of whether the slime is solid, liquid, or something in between.

  - What happened to the slime while you were out? [it flowed]
  - What force caused the slime to flow? [gravity]
  - Did gravity act on the slime suddenly and with great force all at once, or evenly and slowly [evenly and slowly]
• How does the slime behave differently when you apply a force to it suddenly (hit it) with your hand? Is it more like a solid or more like a liquid? [it behaves more like a solid when a sudden stress is applied]

Once students have shared their ideas, explain that the slime is a special kind of liquid called a “non-Newtonian fluid.” Other examples of non-Newtonian fluids include toothpaste, custard, jelly or jam, and mayonnaise. Non-Newtonian fluids behave like liquids in some circumstances and like solids in other circumstances.

**Explain**

**Chemical Reactions**

Have students work in groups to prepare a description and explanation of their observations for their parents, siblings, or another class. The explanation can be in any form that you or they decide on, including: an essay, a pamphlet, a multimedia presentation, a comic strip or graphic story, a short video, an interview, etc.

The work should answer the following questions:

- What materials did you start with?
- How did you examine the materials and what did you find out about them? (Describe their properties.)
- How did you combine the materials?
- How did the materials change when they were combined?
- How did you examine the new material?
- Did a chemical reaction occur when they were combined? Did only a physical change take place? How do you know? What is your evidence and reasoning?
- Do you think that the weight of the slime was more, less, or the same as the weight of the glue plus the weight of the food coloring plus the weight of the borax solution that you added? Why do you think so?

**Non-Newtonian Fluids**

The details of Newtonian fluids versus non-Newtonian fluids are beyond the scope of this grade level. However, this should not stop students from asking deep questions about the substances. Have students come up with a list of questions about slime or non-Newtonian fluids in general. For each question, students should think about how they could go about finding the answer. For example, students might wonder: What are some other examples of non-Newtonian fluids? Why are they called “non-Newtonian”? What makes them behave the way that they do?

**Elaborate**

This activity can easily be extended in a number of different ways, depending on your and your students’ interests.

**Investigate Properties**

- Have students investigate what happens if you add borax to school glue, but do not stir it.
• Have students measure the masses of the two substances separately and then again when they are combined to see if combining them changed the total mass or weight.
• Compare the “bounciness” of the slime. Using a meter stick, commercial bouncy balls, and a ball of slime, students can investigate the elasticity characteristics of each object by dropping them from a known height and observing how high each rebounds.

Environmental Concerns
• Have students discuss whether or not slime is good or bad for people and/or the environment. Students should consider what they already know and what they would need to find out to answer the question. In what ways can new materials be good? In what ways can they be bad?

Chemical Engineering
• Encourage students to alter the ratio of borax to glue to obtain the quality of slime they desire.
• Provide students with materials to engineer other types of slime. To engage them in the engineering process, encourage students to create and test various ratios to optimize for a specific property (like bounciness, stickiness, resistance to flow). See resources like The Incredible Secret Formula Book by Shar Levine and Leslie Johnstone and Pure Slime by Brian Rohrig for ideas.

Research
• Have students use the Internet or other resources to find out more about what is actually happening on the molecular scale. What are glue and borax made of? What changes when the two are mixed?

Evaluate
Assess the quality of the student’s response to tasks you assigned in both Explain sections. Further assessment can be made using any of the following items.

Multiple Choice Items
1. You started out with two substances and when they were combined they formed a third substance. What state of matter were the first two substances?
   a. Solid
   b. Liquid
   c. Gas
   d. Plasma

2. You started out with two substances and when they were combined they formed a third substance. What state of matter was the substance you made?
   a. Solid
   b. Liquid*
   c. Gas
   d. None of the above
**Discussion Questions**

1. Magicians and wizards (in books and in the movies) often say special words to make a rabbit appear or to make water disappear after they have poured it into a hat. Do you think it was important to chant a “spell” in order to make the slime? Why or why not? [Students should recognize that chanting does not make the reaction occur. It is what the borax and the glue are made of, and perhaps other conditions like temperature, that cause them to react.]

2. In the experiment, you added borax to glue. What would happen if you added glue to borax? Would the results be the same?

**Open-Ended Questions**

1. There are a number of different types of chemical reactions. In a combustion reaction, heat is given off. In a decomposition reaction, a substance breaks down into two or more different substances. In a synthesis reaction, two or more substances combine to form a new substance. What type of reaction occurred when you mixed the borax solution with the glue? How do you know? [Students should be able to infer (through the process of elimination, if nothing else) that this was a synthesis reaction). Explain that in fact the borax combined with the glue to make a new substance.]

2. When we mixed white glue with borax solution, we came up with a substance, a chemical, that was much different from what we began with. Is the slime a solid or a liquid? Why do you think so? [Students should recognize that slime is sort of like a solid and sort of like a liquid. Solids keep their form and slime does too (a rubber ball and slime will bounce) for a little while. But if left alone, the rubber ball will stay round while the slime will assume the shape of its container (after sitting by itself for a while). If opposite ends of a ball of slime are grasped and pulled slowly (adding small amounts of stress), the slime can be stretched into a rope or string, but if it is pulled fast (adding a lot of stress quickly), the slime will tear.]

3. During one part of the procedure, you added borax solution to white glue. You each added borax repeatedly. What do you think would happen if you poured borax solution to the white glue but did not stir the two together? Would the experiment come to the same conclusion? [The top surface part of the white glue would change. Maybe the borax would find a way to the bottom of the container if given time, but I am not really sure.]

4. If the slime you made fell from the sky like rain, snow, or hail, would it be good for Earth, bad for Earth, or neither good nor bad for Earth? Explain why you think what you do. [Answers will vary. Students may note that the slime could harm plants, animals, and the water supply.]
Performance Task

- Obtain two samples of slime. Roll each sample into a “snake.” Place one snake in a plastic bag and then in a freezer. Place the other snake in a plastic bag and allow it to float on a bed of very warm (almost hot) water. Have students compare and contrast the two findings after one hour, using a Venn diagram, comparison chart, or similar visual method.

Cross-Disciplinary Extensions

Connect to Math

- When students conduct the Elaboration activity of comparing elasticity, have them perform additional calculations:
  - Compare rebound heights in terms of exact difference, ratios, fractions, and percentages.
  - Calculate the ratio of the rebound height to the drop height (this is known as the coefficient of restitution)
- If students experiment with various combinations of ingredients to create different types of slime, have them describe the amounts in terms of ratios, fractions, or percentages

Connect to Reading

- After completing the investigation, have students return to the Dr. Seuss book. How is their slime similar and different to Oobleck? Have them think about where the two substances come from, the properties of the substances, and how people interact with them.

Connect to Writing

- Have students write a variation on *Bartholomew and the Oobleck*, using scientific concepts they have learned in the lesson.

Connect to Social Studies

- Have students investigate where borax comes from and how it is mined.

Next Generation Science Standards

This lesson supports the following:

Practices of Science and Engineering
- Asking questions
- Planning and carrying out investigations
- Analyzing and interpreting data
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information
Crosscutting Concepts
- Cause and Effect: Mechanism and Explanation
- Stability and Change

Disciplinary Core Ideas, Grades 3-5

Physical science
- When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4)

Earth science
- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth’s resources and environments. (5-ESS3-1)

Engineering Design
- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)