 

**ELEMENTARY SCHOOL**

**Sustainable Science**

**Properties of Adhesives:**

**A Sticky Situation**

**Lesson 3: Battle of the Glues**

**Teacher Background and Overview:**

Tape provides a way to quickly hold two materials together using adhesives of varying strengths. However, despite the wide-ranging applications of tape, there will always be situations in which using the adhesive directly, as glue, would be more appropriate. Though there are glues that are safe for human health and the environment, like Elmer’s School Glue, there are many adhesives that have high-energy manufacturing processes and are harmful for people to be exposed to. For example, most wood glues, like those that hold together particle board, are made with formaldehyde, a compound that is very toxic to humans. In recent years, biomimicry and green chemistry have helped scientists design glues that work better than traditional glues without the use of the same hazardous materials. Columbia Forest Products won the Presidential Award for Green Chemistry in 2007 for a wood glue designed to imitate the chemistry of blue mussels, which was highlighted in the matching game in Lesson 1.

In this lesson, students will make two different glues using household materials that undergo a chemical reaction when mixed. They will then compare the two glues using the same green chemistry criteria that they used in Lesson 2. This lesson is designed to reinforce their ability to differentiate between mixtures and chemical reactions.

**Time Required:**

Optional 30 minutes (pre-reading during ELA time)

60 minutes (activity)

**Learning Objectives:** Students will…

* Create a new substance with new properties by mixing two or more substances.
* Evaluate and compare two glues using green chemistry criteria and properties of matter.

**Standards:**

***NGSS***

**5-ESS3-1**Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.

**5-PS1-3** Make observations and measurements to identify materials based on their properties.

**5-PS1-4** Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

**3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

**3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

***Massachusetts Standards***

*STE*

**5-ESS3-1** Obtain and combine information about ways communities reduce human impact on the Earth’s resources and environment by changing an agricultural, industrial, or community practice or process.

**5-PS1-3** Make observations and measurements of substances to describe characteristic

properties of each, including color,hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility**.**

**5-PS1-4** Conduct an experiment to determine whether the mixing of two or more substances results in new substances with new properties (a chemical reaction) or not (a mixture).

**5-PS1-2** Measure and graph the weights (masses) of substances before and after a reaction or phase change to provide evidence that regardless of the type of change that occurs when heating, cooling, or combining substances, the total weight (mass) of matter is conserved. *(Optional extension)*

*ELA & Literacy*

**WS.5.1** Write opinion pieces on topics or texts, supporting a point of view with reasons and information.

**WS.5.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

**SL.5.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others’ ideas and expressing their own clearly.

**Materials:**

* Optional pre-reading: *Bartholomew and the Oobleck* by Dr. Seuss (or use audio book)
* Electric tea kettle (simplest method) or microwave-safe container for heating water
* Containers for pouring hot water (measuring cups)
* Waste container (for liquid whey)
* Snack-size baggies (for powdered milk)
* Small cups (for baking soda)
* Small containers with lids (for vinegar)
* Popsicle sticks (1 per student pair)
* Scrap paper or cardstock
* Baking soda (11-16.5 g (1-1 ½ tsp) per student team for waste treatment)
* Copies of Student Lab Report

Glue 1: (per student team)

* 1 clear (9 oz) cup
* 1 tablespoon
* 1 teaspoon
* 1 fork
* 60 ml (¼ C) hot water
* 30 ml (2 tbsp) powdered milk
* 15 ml (1 tbsp) white vinegar
* 2 coffee filters
* Paper towel
* ⅛-¼ tsp (~4 pinches) baking soda

Glue 2: (per student team)

* 1 clear plastic cup (9 oz)
* 1 tablespoon
* 5 g (1 tbsp) cornstarch
* 30 ml (2 tbsp) water
* 10 g (2 tbsp) flour
* 2 drops of witch hazel (optional)

**Safety and Disposal:**

* Whey is acidic and must be neutralized before disposal. Use 11-16.5 g (1-1½ tsp) baking soda per “serving” of glue.
* Hot water may pose a hazard to students if spilled or splashed.

**Teacher Preparation:**

* Set up a waste station to collect acidic whey.
* Prepare water to be heated. Each team will need 60 ml (¼ C). The water will need to be hot when given to the students, so plan when you will need to heat the water during class time. The water should be hot but **not** boiling.

**Keys to Success:**

* If you do not have access to a physical copy of *Bartholomew and the Oobleck* by Dr. Seuss, a free audiobook is available on YouTube: <https://www.youtube.com/watch?v=GUKd5cq17nc>.
* This lesson takes more time than the other lessons in this unit as it heavily emphasizes many of the Grade 5 Physical Science Standards.
* You may want to have students measure and graph the weights (masses) of materials before and after making the glue to demonstrate conservation of mass in chemical reactions. This aligns with MA STE 5-PS1-2.
* Glue 1 takes longer to make than glue 2. We recommend that each pair of students make both glue recipes so all of the students are engaged throughout the class period.
* Pouring hot water for each team can be a limiting step in the procedure. You will want the water to be very hot—though not boiling—for the glue, so you will want to heat it during class time. If you have a responsible student who can be your “helper,” you may have them pour water for the teams while you continue explaining the procedure.
* To save time, you may wish to pre-measure amounts of materials and pass these out to the students.
* You will mostly likely want to walk the class step-by-step through the laboratory procedure while they make each glue.
* Speed is very important in making glue 1. Remind the students to **quickly** stir the powdered milk until dissolved, while taking care not to splash the hot water, and then **immediately** add the vinegar.
* For glue 1, if the mixture is too thick, add a bit of hot water. If it is too lumpy, add another pinch of baking soda and stir.
* If the glues will be used for more than 1 day, add a few drops of witch hazel, a natural preservative, and stir well.
* For the glue comparison, instruct students to use similar amounts of glue and stick together similarly sized paper for comparison. This will decrease variables between the two tests.
* Consider leaving the glued paper overnight and checking back on it the next day when it’s fully dry. Students can compare their observations the next day to their conclusions from the first day.
* Alternative procedure:Instead of making glue with your class, you can purchase wheat paste (available at hardware stores for wallpaper, papier-mâché, or craft projects) as an easy alternative and compare effectiveness to readily available school glues. For more information, go to: <https://en.wikipedia.org/wiki/Wheatpaste>

**Extension Options:**

* Have students measure their own materials for each glue procedure.
* For pre- or post-reading, refer to *Hungry Frogs Snatch Prey With Their "Ballistic Tongues"* from the Los Angeles Times, adapted by Newsela staff 06.23.2014. You will need to create a free Newsela account. [http://www.Newsela.com](http://www.newsela.com)

**Procedure:**

1. Optional: As an activator, read *Bartholomew and the Oobleck* by Dr. Seuss together as a class.
2. Reintroduce students to green chemistry criteria from the previous lesson (cost, safety, and performance).
3. Explain that in this lesson they will evaluate the two glues based on green chemistry criteria.
4. Start by introducing the topic of glue by discussing a few questions:
   * What makes a good glue?
   * What are some different types of glue?
   * Why would you use one type of glue over the other?
5. Pair up students for the experiment and pass out the Student Lab Report.

*Glue 1:*

1. Model how to measure the materials for the class and have supplies accessible for each student team.
2. Make sure water is hot and ready to be used.
3. Walk the students through the following procedure for Glue 1:
   * Add 10 g (2 tbsp) of powdered milk to the 9 oz cup.
   * Measure 60 ml (¼ cup) of hot water (Note that the student procedure instructs students to obtain hot water from the teacher).
   * Add the hot water to the powdered milk and quickly stir until dissolved.
   * Immediately add 15 ml (1 tbsp) of vinegar to the mixture and stir vigorously. The milk will separate into solid white chunks (curd) and a thin yellowish liquid (whey) once the vinegar is added. This is the same process for making cheese. If the water is NOT hot enough, this will not work well.
   * Place the curd on a paper towel and dump the whey into the waste container. Show students the waste collection station where they will put their waste.
   * Place the curd back into the cup and use the fork to break the curd into small pieces. The curd should be broken up as small as possible.
   * Add 7 ml (1 tsp) of water.
   * Add 4 pinches (⅛-¼ tsp) of baking soda.
   * Mix thoroughly. Instruct students that they should see some foaming and should continue mixing once they have added the water and baking soda. The curd should become smoother. Note: if the mixture is too thick, add a bit of hot water. If it is too lumpy, add another pinch of baking soda and stir.
   * The resulting consistency should be somewhere between a glue stick and toothpaste. It will not be gooey like Elmer’s glue (note that the consistency of the final product may vary from a thick liquid to a thick paste, depending on how much curd, water, and baking soda were used).
   * The glue is complete and ready to be evaluated.
   * Before moving on to glue 2, have students fill out the chart for glue 1 on their Student Lab Report.

*Glue 2:*

1. Set aside glue 1 and walk students through the following procedure for glue 2:

* Add 5 g (1 tbsp) cornstarch to the plastic cup.
* Add 10 g (2 tbsp) flour to the plastic cup.
* Add 30 ml (2 tbsp) water to the cornstarch and flour.
* Stir until the mixture is gooey. This final product’s consistency is much closer to a liquid than that of glue 1. Note: if the mixture is too thick, add a little water. If mixture is too watery, add a little flour. If the glue will be used for more than 1 day add a few drops of witch hazel, a natural preservative, and stir well.
* The glue is now done and ready to be evaluated.
* Before moving on to the evaluation procedure, have students fill out the chart for glue 2 on their Student Lab Report.

*Glue Evaluation and Comparison:*

1. Both glues are now complete and ready to be tested. Invite the students to share ideas about how to test the glues, and about what types of properties they should be considering in their comparison.
2. Provide students with scrap paper and popsicle sticks to test their glue. Remind them that they should use about the same amount of each type of glue so as to reduce variability in their results.

**Wrap-Up/Assessment:**

1. Instruct students to fill out the rest of their Student Lab Reports, then collect them for assessment.

**Name(s)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

***Battle of the Glues: A Sticky Situation: Lesson 3 Student Lab Report***

In this lab, you will create two different glues. At the conclusion of the lab, you will evaluate the two different glues using green chemistry principles and criteria of cost, safety, and performance.

**Prediction:**

Looking at the materials lists below, which glue do you predict will be more sustainable?

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Looking at the materials lists below, which glue do you predict will work more effectively?

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*Glue 1*

**Materials:**

* 1 clear cup
* 1 tablespoon
* 1 teaspoon
* 1 fork
* 60 ml (¼ C) hot water (in measuring cup)
* 30 ml (2 tbsp) powdered milk
* 15 ml (1 tbsp) white vinegar
* 2 coffee filters
* Paper towel
* ⅛-¼ tsp (~4 pinches) baking soda

**Procedure:**

1. Add 10 g (2 tbsp) of powdered milk to the cup.
2. Obtain 60 ml (¼ C) of hot water from your teacher.
3. Add the hot water to the powdered milk and quickly stir until dissolved.
4. Immediately add 15 ml (1 tbsp) of vinegar to the mixture and stir vigorously. The milk will separate into solid white chunks (curd) and a thin yellowish liquid (whey) once the vinegar is added. This is the same process for making cheese. If the water is NOT hot enough, this will not work well.
5. Place the curd on a paper towel and dump the whey into the waste container at the waste collection station (your teacher will show you where the waste goes).
6. Place the curd back into the cup and use the fork to break the curd into small pieces. The curd should be broken up as small as possible.
7. Add 7 ml (1 tsp) of water.
8. Add 4 pinches (⅛-¼ tsp) of baking soda.
9. Mix thoroughly. You should see some foaming; continue mixing once you have added the water and baking soda. The curd should become smoother. Note: if the mixture is too thick, add a bit of hot water. If it is too lumpy, add another pinch of baking soda and stir.
10. The resulting consistency should be somewhere between a glue stick and toothpaste. It will not be gooey like Elmer’s glue (note that the consistency of the final product may vary from a thick liquid to a thick paste, depending on how much curd, water, and baking soda were used).
11. The glue is complete and ready to be evaluated.
12. Before moving on to glue 2, fill out the chart for glue 1 on your Student Lab Report.
13. Set glue 1 aside while you make glue 2.

*Glue 2*

**Materials:**

* 1 clear cup
* 1 tablespoon
* 5 g (1 tbsp) cornstarch
* 10 g (2 tbsp) flour
* 30 ml (2 tbsp) water
* 2 drops of witch hazel (optional)

**Procedure:**

1. Add 5 g (1 tbsp) cornstarch to cup.
2. Add 10 g (2 tbsp) flour to cup.
3. Add 30 ml (2 tbsp) water to cornstarch and flour.
4. Stir until the mixture is gooey. This final product’s consistency is much closer to a liquid than that of glue 1. If the mixture is too thick, add a little water. If mixture is too watery, add a little flour.
5. The glue is now done and ready to be evaluated.
6. Before comparing your glues, fill out the chart for glue 2 on your Student Lab Report.

*Comparing Glue 1 and Glue 2*

1. Obtain scrap paper or cardstock from your teacher.
2. Glue one set of paper together using glue 1. Glue a second set of paper together using glue 2.
3. Evaluate the effectiveness of each of your glues. Think about stickiness, how fast each dries, and other properties that are important for glue.

**Observations and Data:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Describe properties of starting materials | Describe how materials change | Describe properties of final product | Did a chemical reaction occur? Why or why not? |
| Glue 1 |  |  |  |  |
| Glue 2 |  |  |  |  |

**Discussion:**

Which glue uses the least amount of energy? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Which glue creates the least amount of waste?

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Which glue was stickier? Explain how you know one glue was stickier.

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**Conclusion:**

Is there one glue that can be classified as “greener” than the other? Why? Use the 3 criteria of green chemistry (cost, safety, and performance) to justify your answer.

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Compare your observations to your initial predictions related to the sustainability and performance of each glue.

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Explain how the materials were used to create a new product.

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