 

**ELEMENTARY SCHOOL**

**Sustainable Science**

**Properties of Adhesives:**

**A Sticky Situation**

**Lesson 2: Testing Tape**

**Teacher Background and Overview:**

For a new technology to be considered green chemistry, it must meet three criteria when compared to existing technologies: it must be safer for human health and the environment, it must cost the same or less, and it must work just as well or better. Without performing well in these three areas, a technology may not be sustainable in the marketplace. Consider a “green” dish soap. If this new dish soap is more expensive than the existing dish soaps, most companies and families would not choose to adopt it because of its cost. Similarly, if this dish soap did not work as well as the existing dish soap options, you would likely decide to switch back to your traditional dish soap after being disappointed by the new one’s performance. However, if the “green” dish soap worked just as well or better, cost the same or less, and helped keep the environment and people safe, what would stop you from switching to the new soap? The same logic is true for any green chemistry technology.

In this lesson, students will evaluate different kinds of tape using the green chemistry criteria. Students will learn about properties of adhesives from a short background reading and then test the mechanical properties of various tapes using spring scales to measure force. To conclude, students will use the data they have gathered, alongside information on cost and starting materials of each tape, to determine which tape they would recommend.

**Time Required:**

Optional 15-minute pre-reading in or out of class

2x 30-minute class periods

**Learning Objectives:** Students will…

* Compare the properties of multiple tapes using green chemistry criteria and mechanical property data.
* Measure force using a spring scale.
* Convert units to solve a problem.

**Standards:**

***NGSS***

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

**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.

***Massachusetts Standards***

*STE*

**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**.**

*ELA & Literacy*

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

*Math*

**5.MD.1** Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems.

**5.NBT.5** Fluently multiply multi-digit whole numbers using the standard algorithm.

**5.NBT.7** Add, subtract, multiply, and divide decimals to hundredths, using concrete models or

drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.

**Materials:**

* Multiple rolls of at least three different kinds of tape
* Spring scale (20 N or stronger; one per student pair)
* Hole punch (one per student pair is ideal)
* Copies of Student Lab Report
* Flip chart paper (optional)
* Sticky notes (optional)

**Keys to Success:**

* To introduce students to what makes something sticky, you may wish to assign *The Science of Sticky* blog post as either homework or in-class reading.
* Having multiple rolls of each type of tape will help to expedite experiment setup.
* Having multiple hole punches will also help to speed up experiment preparation.
* Using tapes of the same width—for example, 2”—will help to reduce variables when collecting data and comparing tapes.
* If spring scales are limited, students can just pull the tape off and describe the force they needed as more or less than the other tapes. You could then verify their observations using a scale to prove the force needed.
* Spring scales will likely include options to measure in both Newtons (N) and grams (g). You may wish to clarify for your students which units they should record.

**Prior to lesson:**

* If appropriate, ask students to bring in a variety of adhesive tapes (e.g., masking tape, painter’s tape, duct tape, packaging tape, adhesive tape).
* Assign *The Science of Sticky* blog post as pre-reading or homework prior to the lab. <https://tierneylab.blogs.nytimes.com/2007/07/27/the-science-of-sticky/>

**Procedure:**

Part 1

1. Introduce the topic of stickiness. Have the class list things that are sticky. Ask the class what makes these things sticky.
2. Reflect on the reading *The Science of Sticky* using the PowerPoint provided.
3. Pair up students for the experiment and pass out copies of the Student Lab Report.
4. Go over the Student Lab Report and model and explain the procedure to the class.

* Measure a 30-cm length of tape.
* Fold over 5 cm of one end, reducing the total length of the tape to 25 cm.
* Use the hole punch to place a hole at the folded end of the tape.
* Press the other end of the tape to the top of the desk.
* Hook the spring scale through the hole punched in the doubled end of tape.
* Lift the spring scale and monitor the force needed to peel the tape. Be sure to clearly explain how to identify the force at which the tape begins to move.

1. Prior to collecting any data, instruct students to fill out their predictions on their Student Lab Reports.
2. After students perform each trial, they will need to capture their data in the Student Lab Report.
3. Students will repeat the test two more times for the **same** type of tape to find an average force needed.
4. Students will repeat the testing procedure with each **different** tape.
5. Collect Student Lab Reports at the end of class and save them for Part 2.

Part 2

1. Have students complete the assessment of each tape by filling out the remainder of their Student Lab Reports.

**Wrap-Up /Assessment:**

1. Consider using one of the following options for assessment:

* Have students discuss why we have tapes with different strengths. Have them share a use for each tape. Facilitate a discussion on what types of animals produce adhesives and why those adhesives are different strengths. Examples include blue mussels, frog tongues, snails, barnacles, etc.
* On flip chart paper, create three columns—one for each kind of tape. Place a sample of each tape at the top of its respective column. Have students write a use for each type of tape on sticky notes and place each of their ideas in the appropriate column. Reflect on student ideas as a class, highlighting common themes and identifying unique ideas. This flip chart may be saved to reflect on during later lessons. Alternatively, this may be done on a white board and erased at the end of the class.

1. Collect Student Lab Reports for assessment.

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

***Testing Tape: A Sticky Situation: Lesson 2 Student Lab Report***

In this experiment, you will evaluate three different kinds of tape using the three criteria of green chemistry: cost, safety, and performance. You will measure performance in Part 1 by determining the force needed to remove each kind of tape from your desk. In Part 2, you will use the information recorded in Tables 2 and 3 to do an overall comparison of each of the tapes. Read the procedure carefully before beginning your experiment. Make sure to capture all your data and include units of measurement.

**Materials:**

* 3 30-cm samples of 3 different tapes
* Spring scale

***Part 1***

**Prediction:**

Which tape do you predict will require the most force to be removed from the desk?

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Which tape do you predict will require the least force to be removed from the desk?

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**Procedure:**

1. Measure a 30-cm length of tape.
2. Fold over 5 cm of one end, reducing the total length of the tape to 25 cm.
3. Use the hole punch to place a hole in the folded end of the tape.
4. Press the other end of the tape to the top of the desk.
5. Hook the spring scale through the hole punched in the doubled end of tape.
6. Lift the spring scale and monitor the force needed to peel the tape.
7. For each trial, capture your data in Table 1.
8. Repeat the test two more times for the **same** type of tape to find an average needed force.

**Table 1: Force Needed to Remove Tape from Desks**

Packing tape’s performance rating is based on 3 trials. Record the force needed to peel the tape and calculate the average in the final column. Remember to include units in your recording!

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of tape | Trial #1 | Trial #2 | Trial #3 | Average |
| Packing tape |  |  |  |  |
| Masking tape |  |  |  |  |
| Duct tape |  |  |  |  |
| Other tape |  |  |  |  |

**Discussion:**

When would you want a tape that is less sticky?

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When would you want a tape that is more sticky?

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**Conclusion:**

Based on the data you have collected in Table 1, which tape do you believe works the best? Explain your answer. Does this agree or disagree with your initial prediction?

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***Part 2***

**Table 2: Environmental Impact and Cost Information for Each Type of Tape**

|  |  |  |
| --- | --- | --- |
| **Type of Tape** | **Environmental Impact** | **Cost (from Amazon.com)** |
| Packing Tape | Made from polymers (plastics) which are made from oil. Oil is a non-renewable resource. | $2.94 for a 25.3-meter roll |
| Masking Tape | Made from paper, which is made from trees. Trees are a renewable resource. | $6.49 for a 45-meter roll |
| Duct Tape | Made from cotton fabric coated in plastic with a rubber-based adhesive. Both renewable and non-renewable resources are used. When a tape is made with more components, it is likely to require more energy to be made. | $7.95 for a 27.4-meter roll |

*Safety*: All of the tapes are safe to use and pose no threat to humans when used appropriately.

**Procedure:**

1. The safety evaluation will be based on the environmental impact of the tape’s manufacturing process—specifically, energy and starting material resources. Rank each tape with a 1, 2, or 3. Use 1 to represent the tape that the uses the highest amount of energy and non-renewable starting materials and 3 to represent the tape that uses the least amount of energy and non-renewable starting materials.

* *Hint*: Renewable resources are things that can be created over and over again—like when you *renew* a book at the library, you are getting the book again. Non-renewable resources are ones we cannot get again; once we run out of them, they are gone forever.

1. Calculate the estimated cost of each tape per test. Tip: 30 cm of tape was used for each trial. Remember to work within the same units! (100 cm = 1 m)

* *Hint*: Use this formula for your cost:

*dollars per roll of tape ÷ meters per roll of tape = dollars per meter of tape*

1. Use the data from Tables 1 and 2 to complete Table 3 below.

**Table 3: Compiled Green Chemistry Criteria for Each Tape**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of tape | Cost  (cost per trial) | Safety  (environmental impact) | Performance  (force average) | Use |
| Packing tape |  |  |  |  |
| Masking tape |  |  |  |  |
| Duct tape |  |  |  |  |
| Other tape |  |  |  |  |

**Discussion:**

Why is it important that we have tapes of different strengths?

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Name three animals that use stickiness as a tool to help them survive (for eating, protection from predators, protection from their environment). Why is it important that nature makes different-strength adhesives?

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**Conclusion:**

Based on Table 3, which tape would you choose to ship a present to your cousin across the country? Why? Use the three green chemistry criteria (cost, safety, performance) to help explain your answer.

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<https://tierneylab.blogs.nytimes.com/2007/07/27/the-science-of-sticky/>

**The Science of Sticky**

By [KENNETH CHANG](https://tierneylab.blogs.nytimes.com/author/kenneth-chang/) July 27, 2007 6:23 pm

Question of the day: why is something sticky?

Short answer: viscoelasticity.

Longer answer: a whole blog entry.

Five years ago, 3M sent out a packet of press releases celebrating its 100th anniversary. One of the items was “The Surprisingly Hi-Tech World of Making Things Stick.” I thought that would make a neat Science Times article.

It’s been sitting in my pile of neat ideas for a while.

Last week, [an article in the journal Nature](http://www.nature.com/nature/journal/v448/n7151/abs/nature05968.html) reported a neat new adhesive, combining the sticking power of geckos with that of mussels. [I wrote about that.](http://www.nytimes.com/2007/07/24/science/24geck.html?em&ex=1185681600&en=ce02ca9064d97eee&ei=5087%0A)

Still, I wondered, why are some things like molasses and tar sticky while others — glass, water — are not sticky? I called 3M, maker of Scotch Tape, Post-Its and other sticky things.

Alphonsus V. Pocius, a scientist at 3M’s laboratories in St. Paul, Minn., said, “Viscoelasticity.” He added, “It’s best described by Silly Putty.”

A ball of Silly Putty is elastic, like a rubbery solid. But over time, it’ll also flow like a viscous liquid. The flowing part is important, so that the material makes its way into all the nooks and crannies of a surface. That enables many chemical bonds to form between the material and the surface.

“It has to come into intimate contact with the surface,” Dr. Pocius said.

However, that is not enough for it to be sticky. Water, for example, sticks very well to surfaces, but it is not sticky. That is because water lacks internal stiffness and can be easily pulled part. A truly sticky material needs some strength that resists breaking. Molasses is sticky because it bonds well to a surface, and it takes some effort to stretch it until it finally separates into two.

Stiffness is measured by a unit called a pascal (named after the French scientist and mathematician Blaise Pascal, who also has a computer programming language named after him). Aluminum has a stiffness of order 100 billion pascal. Rubber is 1 million to 10 million pascal. A sticky material — one that is “viscoelastic” — has a stiffness of less than 300,000 pascal. Above that, a material loses its tackiness.

There’s lot more to the science and history of stickiness. The first recorded use of adhesives was in 1500 B.C. in an Egyptian tomb, but sticky tape is a fairly modern invention, from the 1920s. (The innovation there was a polymer that remains sticky without wetting.)

I’ll save the other fun stuff for a longer article…