

Green Glue Lesson Plan



Purpose: To introduce students to biomimicry and have students apply green chemistry tools to create green glue.

Objectives: Students will...

- Understand biomimicry connections
- Create glue using safe cost efficient materials

Supplies: (per student group)

- One set of Biomimicry Matching Game cards
- 1 clear (6-9 oz) cup
- 1 spoon
- 1 fork
- ¼ cup (60ml) hot water (measuring cup)
- 2 tablespoons (30ml) powdered milk
- 1 tablespoon (15ml) white vinegar
- 2 coffee filters
- Paper towel
- 1/8-1/4 teaspoon (approximately 4 pinches) baking soda

(Instructor supplies)

- Hot pot (simplest method) or microwave-safe container for heating water
- Containers for pouring hot water from (measuring cups)
- Waste container (ex. old converted milk jug, bowl, etc)
- Snack size baggies for powdered milk
- Small cups for baking soda
- Small containers with lids for vinegar

Biomimicry

Procedure:

1. Have the students break into groups of 4
2. Hand out sets of the Biomimicry Matching Game cards
3. Each group will need to match the technology/product card to the animal card they believe was the inspiration
4. Give groups approximately 5-10 minutes to brainstorm and match the cards
5. Ask groups to report out their matches and explain their choice
6. Briefly review and clarify any questions using the answer guide

Green Glue

Procedure:

1. Add 30ml (2 tablespoons) of powdered milk to the 9-ounce cup.
2. Measure 60ml (¼ cup) of hot water. Instructors will monitor as one student per group measures the pre-heated water into the measuring cup.
3. Add this water to the powdered milk and stir until dissolved.



4. Add 15ml (one tablespoon) of vinegar to the mixture and stir. The milk will separate into solid white chunks (curd) and a yellowish thin liquid (whey).
 - Stir with spoon until the milk is well separated. (Add more vinegar or heat if the milk does not separate well, separation works best when the milk is hot.)
5. Remove the curd from the whey.
6. Place the curd onto two coffee filters and squeeze some of the liquid back into the cup. Use a paper towel to finish drying curd.
7. While drying, dispose of the whey in waste bowl provided. (Dispose of whey collectively when session has ended)
8. After the cup is empty, drop the lump of curd back in.
9. Use the fork to break the curd into small pieces. (The curd should be as broken up as possible)
10. Add one tablespoon of hot water. (Have students reuse their measuring cups for transport)
11. Add 4 pinches (1/4-1/8 teaspoons) of baking soda.
12. Mix thoroughly. You should see some foaming – continue mixing the curd should be come smoother.
13. The glue is complete.
 - 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 consistency of the final product may vary from a thick liquid to a thick past depending on how much curd, water, and baking soda were used.
14. Use glue for green chemistry collage activity!
15. Cut out newspapers, cardboard, and other recyclable materials to be glued on to your cardstock/construction paper.

Clean Up:

- Dispose of coffee filters and paper towels appropriately
- Wash and reuse disposable cups, forks, and spoons.
- Return unused and uncontaminated baking soda to original box
- **Students can take their glue home in small plastic baggies or you can dispose of it. Glue must be stored in the refrigerator so that it does not spoil, should last for 1-2 weeks.**
- Whey from waste container should be neutralized before being dumped down the drain (use pH paper if available; if not use 1- 1.5 teaspoons of baking soda per “serving” of glue)

Preparation:

- Pre-measure 2 tablespoons (30 mL) of powdered milk into a small baggie
- Heat water enough water for number of students in a hot pot or microwave
- Pre-measure 1 tablespoon (15 mL) of vinegar into small containers with lids
- (ex. 15 mL plastic vials)
- Fill small cups 1/4 of the way with baking soda and set up by stations for kids to pinch from
- Separate out enough sets of two coffee filters
- Prepare green chemistry themed collage materials paper scraps, construction paper, other creative “green” things to be glued on (ex. cardboard, recyclables etc.)

Notes:

This activity was developed and piloted by Gordon College students Lisa Schott, Ben Stewart and Kimberly Spaulding as part of Dr. Irv Levy’s GOlum (Green Organic Literacy Forum) project and Beyond Benign’s Outreach Fellow program, 2009-2010. The Organic Adhesives lesson plan was designed with elementary aged audiences in mind.



Biomimicry

Background Information:

Biomimicry is the science and art of emulating Nature's best biological ideas to solve human problems. The natural world is made up of very good green chemists. Consider animals and how they make their own shelter and get all the food they need from other things in nature. This is all done without having to use any gas or electricity, taking more than they need and producing little waste or rather waste that can be used by other living things.

Many scientists looking for green solutions are turning to nature for answers to some of our problems with chemical processes. For example, the spider's web is coated with one of nature's strongest adhesives. So scientists have recently done studies of what we call "Spider Web Glue." It is made with proteins with sugars attached to the molecule (glycoproteins). It is the DNA and enzymes in the spider that synthesize this glue and scientists are doing work now to find ways to mimic this process (2).

Blue mussels are also inspiration for greener adhesive alternatives. The byssus threads of the blue mussel enable them to attach to wet surfaces due to their unique adhesive chemistry. The presence of the amino acid 3,4 dihydroxyphenylalanine with its reactive catechol functional group (two hydroxyl groups sticking out from a benzene ring) forms strong bonds with the catechols on adjacent molecules and with metal atoms present in the surface of most natural solid substrates. The combination has scientists studying this mechanism in order to make waterproof adhesives without utilizing hazardous chemicals such as formaldehyde. So far they have been able to produce wood glue used in plywood using this technology among other advances. (7)

Biomimicry and green chemistry complement each other incredibly well. For more information and the inspiration for this segment of the lesson please check out: <http://www.biomimicryinstitute.org/> and www.asknature.org.

Reminder: Biomimicry Matching Cards can be found on the Beyond Benign website www.beyondbenign.org

Kangaroo	Landfill
Blue Mussel	Toxin-free, waterproof glue
Termite	Electricity-free air conditioning for buildings
Gecko	Velcro
Chimpanzee	New sources of natural medicines
Shark	Faster boats and submarines
Blue Morpho Butterfly	Toxin-free paints



Biomimicry Card Matching Answer Guide:

A-5) Kangaroos have special bacteria in their stomachs neutralizes the digestive process of gasses to not release methane gas. Methane is a green house gas and is linked to global climate change. Landfills and several manufacturing processes release methane gas. The bacteria in kangaroos could hold the key to transforming methane producing systems into a more benign gas.

B-7) Blue mussels live in the water and have to stick to the sides of rocks and hold on through stormy waves. The blue mussels are able to cling to the rocks thanks to their unique adhesive chemistry. Advances in the glue used in plywood have already occurred and the hope is to create alternative waterproof adhesives that do not contain any harmful chemicals like a lot of glues used today.

C-1) Termites build their homes in a way that allows the space to stay cool all the time, even in really hot weather, without any air conditioning. Architects are copying the way termites build their homes to make buildings that stay cool in very hot weather without any air conditioning.

D-4) Geckos are very good climbers with special bristles on their feet that allow them to walk on almost any surface, even upside-down, without falling. Even though their feet can hold onto any surface, they are not sticky and don't leave any sticky residue behind.

Velcro uses a very similar mechanism to that of the geckos and scientists are looking to the geckos to help develop even better types of tape in the future.

E-2) Chimpanzees are very similar to humans. They get injured and sick just like we do but they don't have any hospitals or medicine. Instead, they get better and stay healthy just by using things in their habitat. Doctors want to find out what the chimps eat to stay healthy and cure illnesses so they can make natural medicines by identifying and emulating the process in the lab.

F-3) Sharks are very good swimmers. Part of the reason is because they have special scales on their skin that reduce the amount of turbulence in the water, this allows them to swim faster while using less energy. So sharks are not only fast, but efficient.

G-6) Similar to many things in nature, blue morpho butterflies are very colorful. We use pigments for our paints and dyes that often contain hazardous materials. Scientists are learning how to use structural color, like that of the morpho butterfly to make safer paints.



Adhesives Background Information

What are adhesives?

Adhesives are products that are used to create a bond between two materials. These materials can be either the same substance, or they can be different substances, and the materials involved determine what type of adhesive should be used. Related to adhesives are sealants which are materials used to make a barrier that substances such as water and gas cannot get through (4).

Adhesives can be either natural materials or synthetic. An example of a synthetic adhesive is the class of adhesives called acrylic adhesives. These are polymer adhesives. Polymer adhesives are adhesives made from chains of molecules called monomers. These are similar to the chain links in a metal chain like the ones used to hold dogs to a leash. (see VOC section and supplemental teaching material below) Acrylic monomers are the same general molecules used to make things like glasses lenses and eye contact lenses but when used differently they can be used for their adhesive properties.

Where do we see adhesives today?

Adhesives and sealants are used to attach materials in all kinds of areas of life. In order to assemble a car, the use of sealants and adhesives is essential to join materials. (Question: What are ways you can think of to use adhesives?) Some other uses of adhesives are apparent in construction. For example, in order to build a house or a chair, pieces of wood must be attached using adhesives. Making railroads and airplanes require the use of adhesives, and without them it would be much more difficult to make these products. Sealants prevent outside materials from getting inside structures like cars and airplanes, and they allow materials such as glass to be connected to other parts of the car such as metals. Adhesives are also used to package materials and in offices around the world.

How are adhesives made?

There are three different types of processes used in making polymer adhesives today; solution, emulsion, and UV polymerization.

Solution polymerization (Figure 1) makes use of hazardous solvents to get the molecules to dissolve in them then combine to form the desired polymer.

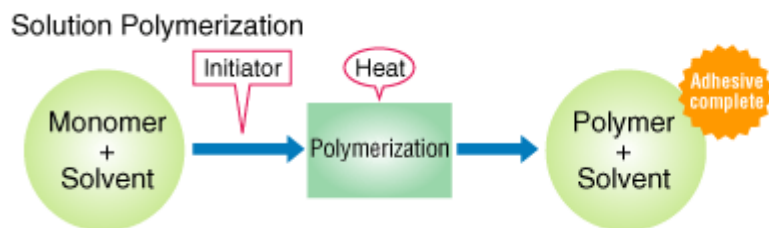


Figure 1. Flow chart showing the chemical processes used in solution polymerization. (3)



Emulsion polymerization (Figure 2), instead of using hazardous solvents makes use of water and surfactants (which can be generally defined as soap) to dissolve the desired molecules in solution so that these molecules interact more freely with each other thus combining to form a useful product.

Emulsion Polymerization

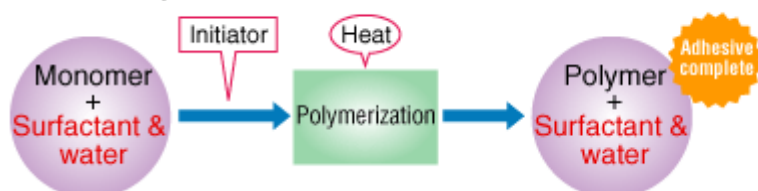


Figure 2. Flow chart showing the chemical processes used in emulsion polymerization.(3)

UV polymerization (Figure 3) is when a monomer combined with a radical producing initiator is shined on with UV light producing a prepolymer which can be coated on to something then shined on again producing the adhesive desired.

UV Polymerization

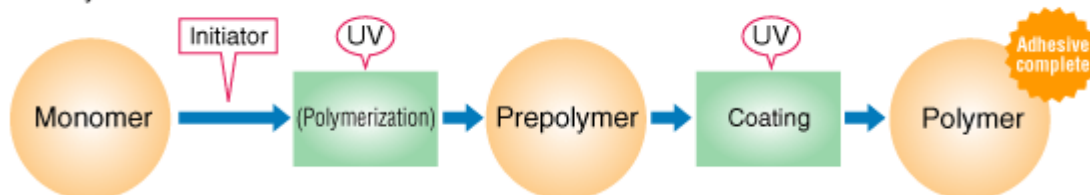


Figure 3. Flow chart showing the chemical processes used in UV polymerization.(3)

What's the problem?

One of the biggest concerns in the development of adhesives involves something called volatile organic compounds, or VOCs. These are chemicals that can escape from a substance into the earth's atmosphere, and at times can be harmful or toxic. They have a high vapor pressure and low water solubility, which allows them to easily escape the substance they are in and to easily dissolve in water. Some of these chemicals have been found to cause cancer in humans, and some cause sensory irritation and central nervous system symptoms. Developing products that don't release such chemicals is, therefore, of great importance (5), (6).

A major trouble regarding VOC's is their ability to persist and migrate in ground water. The long-term effects of these chemicals on the environment and their impact on human health if ingested are unknown at this time. The National Water-Quality Assessment Program of the United States did a large scale study and analyzed the occurrence of VOC's in the nation's ground water. VOC's were found to occur in most major aquifers across the United States, but did not occur

frequently in many wells. While the concentration of VOC's in the aquifers was not at levels to cause alarm, they could increase to harmful levels if they continue to be produced. (1)

Adhesives are usually made of large molecules called polymers. Sometimes a monomer is toxic even though the polymer that results from it is not, and it is important to create a product that does not use toxic or hazardous chemicals if possible. Adhesives can be made from similar chemicals to plastics, and one of the concerns about plastic is that it does not degrade well after use. It can also produce toxic chemicals when it is burned.



Reference

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Portions of the lesson plan were developed by Simmons College student Amanda McLaughlin in conjunction with her Organic Chemistry class with Dr. Nancy Lee and Beyond Benign Outreach Fellow Program project (2009).