Packing Peanuts for the Future

Objectives

- Explore differences between man-made and natural polymers.
- Make scientific observations of the behavior of polymers.
- Investigate the environmental impacts of degradable and non-degradable polymers.

Skill Level: Middle school and High school	**Prep time:** More than 24 hours **Class time:** 45 minutes

Materials

- Styrofoam (polystyrene) peanuts
- Cornstarch peanuts
- Package of frozen corn
- Mixing bowl
- Iodine
- Tablespoon and teaspoon
- Piece of cheesecloth
- Paper cups
- Wax paper
- Slotted spoon
- Potato masher
- Stir stick
- Water
- Spoon
- Stopwatch
- Eggs

Next Generation Science Standards

Disciplinary Core Idea:
MS-PS1.A: Structure and Properties of Matter
HS-ETS1.B: Developing Possible Solutions
Performance Expectations:
MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from

natural resources and impact society.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Practices	**Crosscutting Concepts**
☐ Asking questions / defining problems	☐ Patterns
☐ Developing / using models	☐ Cause and effect: Mechanism / explanation
☐ Planning / carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing / interpreting data	☐ Systems and system models
☐ Math / computational thinking	☐ Energy / matter: Flows, cycles, conservation
☒ Constructing explanations / design solutions	☒ Structure and function
☐ Engaging in argument from evidence	☐ Stability and change
☒ Obtaining / evaluate / communicate	

Background Information

Packing peanuts are a useful material when it comes to moving and shipping fragile items. There are two types of packing peanuts that can be used: Styrofoam, also known as polystyrene, and cornstarch. Both polystyrene and cornstarch packing peanuts are made from polymers that are long-chain molecules that are made of smaller individual units known as monomers. Even though each of these materials are polymers, there is a large difference between the molecules that make cornstarch and polystyrene.

Cornstarch Packing Peanuts **Styrofoam Packing Peanuts**

Figure 1 shows the two variations of packing peanuts. Ref.

Packing peanuts made from cornstarch are natural polymers or polymers which occur in nature. Polystyrene or Styrofoam peanuts are a synthetic polymer, which means that they are man-made. Because the Styrofoam peanuts are man made the factory they are made in have a harmful environmental impact. Styrofoam packing peanuts do not degrade like the cornstarch peanuts, which, makes them harmful to the environment. Cornstarch packing peanuts can dissolve in water

and have little environmental impact. They also have no electrostatic charge so they do not stick to clothes.

Sadly there are some cons to cornstarch packing peanuts. They are heavier than their Styrofoam counterparts and could cost more to the shipper. Producing cornstarch peanuts is also more expensive. Each have their pros and cons and in this activity students will get to experiment and test these out for themselves.

Engage

In this activity, students should be interested in learning about the two different packing peanuts. Big businesses and corporations consider the pros and cons of each. They either decide to help the environment but pay more for it for the cornstarch packing peanuts, or the other way around for Styrofoam peanuts. Besides environmental and financial elements, students will look at the peanuts strength and ability to protect items, which are also customer requirements.

Explore

Experiment Questions:

- What are the advantages and disadvantages of biodegradable packing peanuts?
- Create an argument for which peanut is the best to use for packaging.

Procedure:

Basic tests:

Water test

1. Place a handful of Styrofoam peanuts in a bowl.
2. Place a handful of cornstarch peanuts in a second bowl.
3. Slowly add water a spoonful at a time. Stir the peanuts to distribute the water.
4. Have students observe and discuss experiment questions.

Packability test:

1. Add Styrofoam peanuts to a bowl.
2. Count the number of Styrofoam peanuts needed to fill the bowl
3. Empty the box/ bowl and repeat with cornstarch peanuts
4. Compare the two numbers to determine which requires more peanuts to fill the bowl.

Advanced tests:

Compressibility:

1. Have students take one of each peanut and test how easy they are to crush between their thumb and pointer finger
2. If the peanuts do not break, continue having students experiment with loading the peanuts with increasing weight until they compress.
3. Students can also test the compressibility of the peanuts by packing an egg in a small box and standing on the box.

Cost

1. Determine the cost per volume for each peanut types
2. What could be done to reduce the costs of the biodegradable peanuts?

Temperature test

1. Freeze the peanuts and repeat the compressibility test. Do the properties change?
2. Heat the peanuts (to 120 degrees) in an oven or under a light. Do the properties change?

Fragility test:

1. Pack the cardboard box, milk or juice carton half full with the packing materials.
2. Secure the egg in a plastic bag and place in the middle of the packing materials. Finish packing the rest of the box with the packing materials.
3. Once the egg is inside of the packing materials, close the cardboard box and use masking tape to close the open flap of the box.
4. Drop the cardboard box from 1 foot. Open the box and find the egg, record the results (egg is broke or still in tact). If the egg is broken, replace it with a new egg and continue testing.
5. Repeat 2 additional trials.
6. Drop the cardboard box from 4 feet. Open the box and find the egg, record the results (egg is broke or still in tact). If the egg is broken, replace it with a new egg and continue testing.
7. Repeat 2 additional trials.
8. Drop the cardboard box from 8 feet. This may be done outside. Open the box and find the egg, record the results (egg is broke or still in tact). If the egg is broken, replace it with a new egg and continue testing.
9. Repeat 2 additional trials.

The following procedure is optional. For best results have at least 5 groups of students make the following recipe to yield the best results. Otherwise, use pre-made cornstarch packing peanuts that can be found at any moving store.

Advanced activity – Making cornstarch:

1. Thaw a package of frozen corn and place in a bowl.
2. Crunch up the corn with a potato masher until all of the corn pieces are well mashed. Cover the mashed corn with a layer of water. Let stand for 24 hours.
3. Remove from bowl with a slotted spoon and place on waxed paper. Allow water to stand for another 15 minutes.
4. Gently pour off the water through a piece of cheesecloth, allowing the starch to become trapped in the cloth.

5. You can see and feel the starch that is left in the cheesecloth. Use a small portion of the cheesecloth to determine if there is starch left in the cheesecloth by placing the iodine on that portion. If starch is present, the iodine changes from reddish- brown to blue-black. Allow the remainder of the cheesecloth to dry overnight.
6. Once the starch is dry, it will turn into a powder, which you can feel and taste.
7. Now, take 1 tablespoon of the corn powder that you made and mix it with 1 teaspoon of water in a paper cup. Stir with a stick until it becomes a workable paste. If you microwave the mixture on high for 15 seconds, it will provide a more consistent product for examination. You have made a biodegradable packing peanut.

Explain

Have students be able to answer the following questions:

- Which size and shape would be best for packing small items?
- Which would be best for packing large items?
- From the recipe, did you notice anything a similarity about the ingredients for cornstarch packing peanuts?
- What are some of the characteristics? Similarities? Differences?
- How does each type of peanut behave in water?
- Do any of the peanuts dissolve in water?
- If so, what happens to these peanuts as they dissolve?
- How fast did they dissolve?
- Put some cornstarch packing peanuts in water again and time how fast they dissolve. How long did it take?
- After the water was added, which of the packing materials took up more space? What would be the advantages of replacing all Styrofoam packing peanuts with cornstarch based peanuts?
- Would it be practical to replace all the Styrofoam used for Styrofoam cups and picnic plates with the cornstarch material used in some packing peanuts? Why or why not?

Elaborate

1) Determine the compression that occurs on the peanuts when they hit the ground in an egg drop experiment. Derive an equation (using physics) that determines the force the egg exerts on the peanuts when it hits the ground. Estimate the amount of compression that the peanuts experience at impact. The amount of compression can be found experimentally by using a recent iPhone (5C or greater) that has slow motion capability. If you can capture the moment of impact in a clear container with a ruler in the shot, it is possible to measure the

actual compression the foam will experience. Which type of peanuts would reduce the amount of impact?

2) NOTE: This website provides the derivation of the equations as well as a handy calculator if students don't have the physics knowledge.
3) Have students brainstorm other packaging materials and designs that could be used. What advantages and disadvantages would each have?

Resources

Additional Resources:

- Live Physics

Resources Used:

- Penn State
- Heritage Pioneer