Bioplastics design challenge

Focus question	Can plant-based materials be used to engineer a biodegradable plastic?
Vocabulary	Renewable resource, nonrenewable resource, synthetic, persistent organic pollutant (POPs), nonpersistent pollutant, biodegradable

The first fully synthetic plastic, Bakelite, was invented in 1907 by Leo Baekeland. Its popularity grew significantly after WWII due to its low production cost and versatility of use both in and out of the home. Currently, humans produce an average of 460 million metric tons of plastics. 99% of this plastic is composed of both organic and synthetic materials that are malleable and can be molded into solid or flexible objects.

Plastic most often originates from petrochemicals like crude oil. This is a nonrenewable resource that cannot be replaced once depleted. Refined oil is combined with other substances that make plastics persistent, or 'forever' materials, unable to naturally break down over time. Petroleum-based plastics will begin to change from their original form after 10–500 years, depending upon their composition and the environment that the material is in. In reality, the plastic is only breaking apart into smaller and smaller particles. These smaller plastic particles enter our ecosystem to become a part of the worldwide food web which leads to heterotrophic consumption. On average, humans consume 50,000+ plastic particles each year.

Materials

- Cornstarch
- Soy flour
- Sorghum flour
- Water
- Glycerin
- White vinegar
- Paper cups or bowls
- Microwave
- Spoons or mixing stick
- 5- or 10-ml serological pipets
- Pipette pump
- Safety goggles
- Wax paper
- Digital scale
- 50-ml graduated cylinder
- Force meter
- Magnifying glass
- Washers or hook weights
- Ruler

Procedure

Day 1

1. Create one plant-based plastic at a time with your group. Choose one set of the following materials and create the plant-based plastic as per the instructions below. Repeat this procedure for the remaining two plant-based plastics.

Corn plastic
- 15 ml cornstarch
- 15 ml water
- 1.25 ml white vinegar
- 1.25 ml glycerin

Soybean plastic
- 15 ml soy meal
- 30 ml water
- 1.25 ml white vinegar
- 1.88 ml glycerin

Sorghum plastic
- 15 ml sorghum meal
- 22.5 ml water
- 1.25 ml white vinegar
- 1.25 ml glycerin

2. Combine all ingredients in a mixing bowl or cup, adjusting ratios as specified for each base material.
3. Slowly heat the mixture in the microwave 10 seconds at a time, stirring in between each heat burst, until it thickens to a gel-like consistency.
4. Let the mixture cool slightly, then pour it onto wax paper and shape it as desired.
5. Label each plant-based plastic with the base material used on the wax paper.
6. Allow plastics to dry overnight or place back in the microwave for 10 second bursts to dry out each mixture.

Day 2

Test each plant-based plastic with all of the following tests: clarity, durability, flexibility, and strength.

Clarity test

a. Hold each plastic sample up to a light source.
b. Record how much light passes through.
   - 1: fully transparent
   - 2: partially translucent
   - 3: opaque

Durability test

a. Lightly scratch the surface of each plant-based plastic with a fingernail or a coin. Note any visible scratches or signs of wear.
b. Rate each sample on a scale.
   - 1: easily scratched
   - 2: slight scratch
   - 3: no scratch

Flexibility test

a. Bend each sample slowly to see if it can flex without breaking.
b. Record observations on how far each can bend and whether it feels brittle or pliable. Use a protractor to check the angle at which it bends.
c. Rate each sample on a scale.
   - 1: breaks easily
   - 2: slight cracks
   - 3: very flexible

Strength test

a. Place each plant-based plastic in an open space with the edges of the plastic supported by each edge of the open space (ie, between the edges of two books or two tables, with the plastic acting as a “bridge”).
b. Place small weights or washers on top of each plant-based plastic until it starts to tear or sag.
c. Record the number of weights each can bear without failing.
d. Use a force meter or a digital scale to determine measurement.
e. Rate each sample on a scale.
    - 1: low strength
    - 2: medium strength
    - 3 high strength

Data table

Plant-based plastic	Clarity	Durability	Flexibility	Strength
Corn				
Soybean				
Sorghum				

Reflection

1. What differences did you observe between plant-based plastics and petroleum plastic?

2. What did you notice about the plant-based plastic’s properties?

3. What challenges might scientists face in developing plant-based plastics?

4. Which plant-based plastic base showed the highest durability, clarity, flexibility, and strength? Why do you think that is?

5. How might different applications (like packaging or single-use items) require different plant-based plastic properties?

6. What are the environmental benefits of using plant-based plastics instead of traditional plastics?

Rubric for self-assessment

Skill	Yes	No	Unsure
I understand that traditional plastics are persistent organic pollutants and do not break down naturally.			
I actively contributed to the success of the engineering group.			
I was able to compare and contrast plant-based plastic materials effectively in order to modify our plant-based plastic bag.			
I understand that materials used in traditional plastic products have an impact on the environment and food web.			