Do Bioplastics Have the Same Properties as Synthetic?

Plastics have become a vital part of our everyday existence. Plastic technology has evolved into an exact science with plastics for any use imaginable. Different plastics also have different properties that make them suitable for a variety of uses. Currently, we rely on the use of fossil fuels to produce plastics. In an effort to reduce our dependence on finite resources, new research has discovered natural materials that can be made into plastics. Some of these plastics are comparable to synthetic plastics in their behavior under certain conditions. Do these biopolymers really share enough of the same properties to substitute them for synthetic polymers?

Materials

PLA Bioplastic Group
- L-Lactic Acid in 250 mL beaker
- small paperclip
- Adipic Acid
- triethyl citrate
- 10 mL graduated cylinder
- Teflon nonstick pan (1 per group)
- Polystyrene sample

Cast-Film Bioplastic Group
- Starch
- Gelatin
- Agar
- Sorbitol
- 100 mL graduated cylinder
- 1% glycerol solution
- Polyethylene sample

Shared materials
- Digital balance
- Hot plate with magnetic stirrer
- Plastic weighing dish
- Beryl-type pipets
- Hot-hands or oven mitts

Safety
- Wear goggles *at all times*
- Handle all hot liquids with care. Use appropriate thermal protection when handling
- Turn off electrical devices when not in use
- Take special care when handling corrosive liquids
- If a spill occurs, alert your teacher immediately

PLA group
1. Take the 250 mL beaker of L-lactic acid and place it on the hot plate. Do not turn on the magnetic stirrer until the material has been heated for at least 5 minutes.
2. Follow the chart below to prepare your plastic. Pay careful attention to the heating temperature for each material. You will not have good results if the table is not followed.

Material	Amount	Heating Time	Heating Temperature
L-Lactic Acid	Approx. 20 mL	30 minutes	200 °C
Adipic acid	4 grams	20 minutes	180 °C
Triethyl citrate	1.8 grams	5 minutes	180 °C

3. While you are waiting, take a sample of polystyrene. Observe and record physical properties of the plastic such as color, transparency, thickness. Record these in your data section.
4. Next, perform the tests listed below (see separate sheet for procedures):
   - Density
   - Flexibility in cold/hot water
   - Hardness
   - Acid/Base Test
5. Record all observations from each test in your data section.

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6. When PLA is done, carefully pour the contents of the beaker (using a hot-hand or oven mitt), as even as possible on to a Teflon cookie sheet. Label the cookie sheet with your group names and let sit to cool over night.

Next Class

7. Carefully remove the PLA from the Teflon pan. You might need to use a metal scoopula to chip some of it off. Note its physical properties (color, transparency, thickness). Record in your data section.
8. Perform the tests listed below on the PLA (see separate sheet for procedures):
   - Density
   - Flexibility in cold/hot water
   - Hardness
   - Acid/Base Test
9. Compare the results you obtained for each type of plastic. Share your results with a Cast-Film Bioplastic Group and record their results in your data section.
10. Save all of your PLA in a Zip-lock bag with your name on it.
11. Clean up your area when finished. Answer all conclusion questions.

<u>Cast-Film Bioplastic Group</u>

1. Use the table below to measure the correct amount of materials needed to make your bioplastic. Note any differences in physical properties (color, state, odor) in your data section.

Material	Amount
Starch	1.5 g
Gelatin	0.75 g
Agar	0.38 g
Sorbitol	0.75 g
1% Glycerol	120 mL

2. Once all materials have been measured, mix all of the dry materials in a clean 250 mL flask.
3. Add a small paperclip to the flask and place on to a hot plate/magnetic stirrer.
4. Slowly add the glycerol to the flask while mixing using the magnetic stirrer. Continue to mix until all solid material has dissolved in the glycerol. You may have to break up larger chunks using a glass-stirring rod.
5. Once all solids are in solution, heat the mixture until it begins to froth. DO NOT allow the temperature to go above 95 °C.
6. Turn off the heat after mixture has begun to froth. Continue to stir for 5 minutes. No visible lumps should be present.
7. Once the mixture has cooled slightly, carefully pour the mixture into a level Teflon pan.
8. While you are waiting, take a sample of polyethylene. Observe and record physical properties of the plastic such as color, transparency, thickness. Record these in your data section.
9. Next, perform the tests listed below (see separate sheet for procedures):
   - Density
   - Flexibility in cold/hot water
   - Hardness
   - Acid/Base Test
10. Record all observations from each test in your data section.
11. Pour the mixture as evenly as possible over the surface as a thin layer. Label the pan with your group names and allow it to sit overnight.

Next Class

12. Carefully remove the Cast-Film from the Teflon pan. You might need to use a metal scoopula to lift some of it away from the pan. Note its physical properties (color, transparency, thickness). Record in your data section.
13. Perform the tests listed below on the Cast-Film (see separate sheet for procedures):
   - Density
   - Hardness
   - Flexibility in cold/hot water
   - Acid/Base Test

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14. Compare the results you obtained for each type of plastic. Share your results with a PLA Bioplastic Group and record their results in your data section.
15. Save all of your Cast-Film in a Zip-lock bag with your name on it.
16. Clean up your area when finished. Answer all conclusion questions.

Plastic Tests

Materials

- Penny
- Triangular file
- 100 mL graduated cylinder
- Digital balance
- 2 M HCl
- 2 M NaOH
- Tongs
- 250 mL beaker (2)
- Watch glass
- Plastic pipet
- Wooden stir stick

Safety

- Safety goggles should be worn at all times
- Extra care should be taken when handling corrosive materials. If a spill occurs, alert your teacher immediately
- Extra care should be taken when handling hot liquids. Use appropriate thermal protection when handling

Procedure

Density; Quantitative

1. Using the electronic balance, find the mass (in grams) of the sample to be tested.
2. Fill a 100 mL beaker to the 40 mL mark. Place a piece of the plastic sample in the water.
3. Observe whether the plastic sinks or floats. Make sure there are no air bubbles sticking to the plastic.
4. Record the new volume of water. Subtract the original volume from the final volume.
5. Determine the density of the sample by using the equation: D=m/v.

Hardness

1. You are testing the ability of the material to be scratched. A scratch is defined as groove on the surface that can easily be seen.
2. Use the following materials to scratch the surface of the plastic: fingernail, penny, triangular file. Rate the hardness of the material on a scale of 1-5 (1=softest, 5=hardest).

Flexibility

1. Take the sample of plastic and fold it in half. Check for any folds, creases, cracks, or a color change in the sample.
2. Repeat this test after exposing the sample to ice water (for 5 min) and hot water (for 5 min). The hot water should be at least 80 °C. Remove the sample using tongs.
3. Record your results for the three temperatures.

Acid/Base Test

1. Place a small sample of the plastic (at least the size of a penny) on the watch glass. Fill a pipet with 2M HCl. Count the number of drops it takes before the sample begins to change. Check the sample using a wooden stir stick. Record your results. Rinse the sample with large amounts of water and dispose of in the trash.
2. Take another of the same size of the sample. Repeat the same test using the 2M NaOH. Record your results. Rinse the sample with large amounts of water and dispose of in the trash.
3. Wash your hands thoroughly.

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Teacher's Notes

PLA preparation
1. Fill 6 beakers (250 mL) with 40 mL of L-Lactic acid. Heat for 1.5 hours at 200 °C. Use small paperclips as magnetic stirrers during heating.
2. Allow material to sit overnight. There should be approximately 20 mL of poly(lactic acid) remaining in each beaker.
3. After students have poured their PLA into the Teflon pan, place them in a safe place for drying. To speed up the drying process, place the pans in a drying oven at 40 °C.

Cast-Film preparation
1. Make a stock solution of 1% glycerol solution by mixing 10 mL of glycerol for every liter of distilled water.
2. After students have poured their Cast-Film into the Teflon pan, place them in a safe place for drying. To speed up the drying process, place the pans in a drying oven at 40 °C

References
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