BIOPLASTICS KIT BETA

MAKE A BIOPLASTIC BAG

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BIOPLASTICS KIT™
MAKE A BIOPLASTIC BAG
instruction manual

Getting Ready

The Experiment

More information

Welcome! Let's get started

This user guide was created to help you get the most out of your Amino Labs experience. Even if you are familiar with making new materials, bioplastics, science or other Amino Labs™ products, please take the necessary time to read through this guide. This will ensure you practice safe science as well as store, use, and get the most out of your kit. It will also let you know what to do in case of a spill or accident.

In the first section, you will learn about your kit's components, how to store them before and during your experiment, as well as a few tips on activities to complete before you get your hands 'wet'. The second section is procedural -- these are the step by step instructions on how to run your experiment. Make sure to follow our tips to ensure your best success! The third section covers "what's next"; how to keep your creations, store or dispose of any leftover ingredients and general clean up instructions. The final section is there to help you -- a glossary, troubleshooting, and our contact information.

Amino Labs is excited to welcome you to the world of Bio-design with the Bioplastics kit! The first in a series of experiment to get you making with biology! **Following this guide will help ensure that you are getting the most out of your current and future experiences to keep on making new creations. Have fun!**

Practicing safe science - Bioplastics

Science is a safe activity when you follow simple guidelines. Read on to ensure you adopt safe practices.

The kit in your hands contains only inert ingredients - no live organisms. The ingredients are all safe to use without any special containment or training. Most of the ingredients will be familiar to you from your kitchen. Even though these are familiar, you should never eat or taste any part of this kit, or any ingredients you use for science experiments. Follow these safety guidelines for your safety and the success of your experiment(s)!

We recommend the system and kits for ages 12+, under adult supervision, and 14+ with or without supervision. The cleaning instructions must be strictly followed for safety and experiment success. Make sure to store the kit per the instructions found in this booklet.

- Do not eat or drink near your experiments. Keep your experiment at least 10 feet from food, drinks, *etc*. Under no circumstances should you eat any of the kit's content.

- Wash your hands before and after your experiment,

- Wear gloves, is recommended even when cleaning your station or handling the kit contents as part of a safe science practice. This will protect you from your experiment, and your experiment from you. Any latex, nitrile, or general purpose gloves you can find at the pharmacy will do. After you put your gloves on, be aware of what you touch. Try not to touch your face or scratch itches with your gloved hands!

- Clean up your work station, spills and work surface before and after use. Use a 10% solution of chlorinated bleach generously sprayed onto a paper towel and rub onto any contaminated surfaces. (Careful! This can discolor your clothes). A chlorinated spray cleaner also works.

- With the Bioplastics kits, all the discarded materials can go in the garbage. Do not pour bioplastic mixture down the sink. Find a container to hold the inactivation bag where you will discard used items. If you are familiar with other Amino Labs kit, you can use a discard container at your station to hold all your materials, just like when doing your genetic engineering experiments.

- **Eye-wear is not provided but can be worn.**

While these also include rules specific to experiments with live organisms, you can still download a biosafety poster for your space from www.amino.bio/biosafetyinaction and complete a short safety quiz at www.amino.bio/biosafety-quiz

If you would like to do a short Online lab safety course for your edification, we recommend a Government of Canada course: www.amino.bio/biosafety

Discover your Bioplastics Kit™

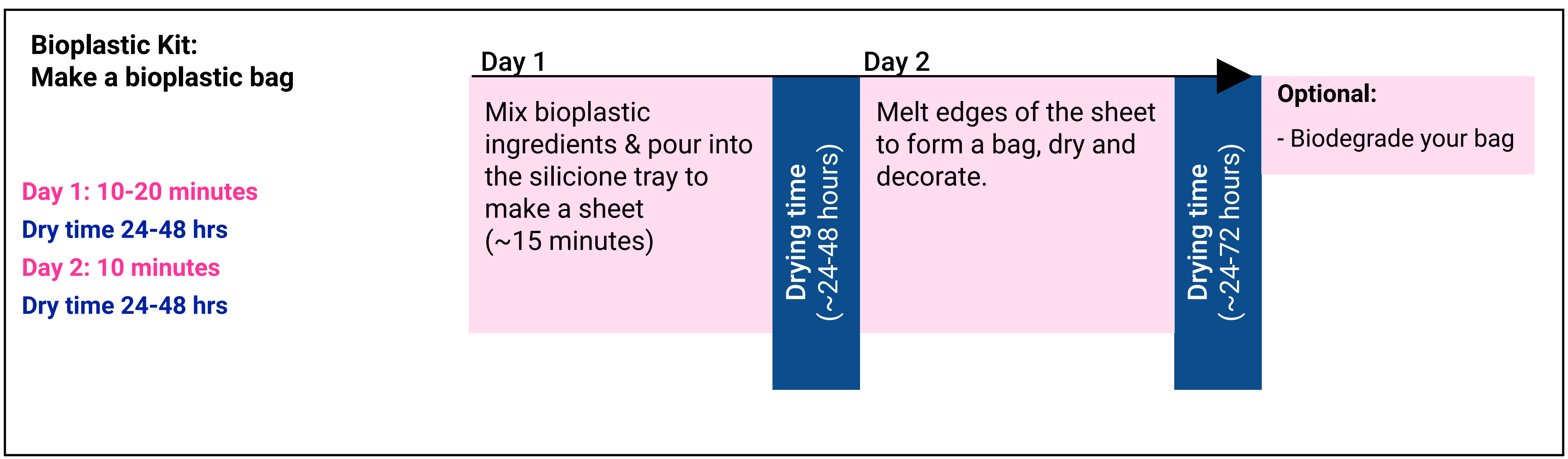
With the Bioplastic Kit series, you'll learn to combine biological ingredients to create new materials: bioplastics. With this specific kit, you'll be using a base of red algae powder to create a flat sheet, which you'll then be able to turn into a small bioplastic bag. Following the kit's instruction will also help you learn some of the basics skills of making materials.

This kit can be used alone or in a small group (adult supervision if you are 14 or under). Follow the instructions on the next pages to:

- discover some ingredients used in bioplastic: agar (powdered algea), glycerol, and water
- gain or improve your making skills like mixing, measuring, molding and assembling bioplastics.
- create a usable bioplastic product.

Timeline

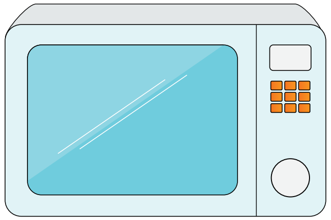
The experiment will take between 15 and 30 minutes over 2 days. In between, and after the second day, you will need to let your bioplastic dry for about 24 hours, depending on your location. By placing the drying plastics in a hot, dry location you can speed up drying.



Unpacking and storing kits

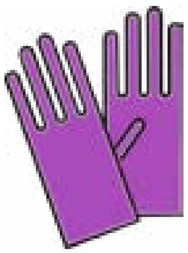
For a better shelf life and a successful experiment, place your kit at **room temperature,** away from the light.

Items you will need



- **Access to a microwave**
- **Marker or pen**
- **Paper towels for clean up**
- **A mixing utensil** like a spoon (metal, plastic or wood is ok!)
- **Distilled or tap water** (~100 mL)

Necessary safety supplies



- **Optional: Latex/nitrile gloves** like those found at a pharmacy. 1 pair/person
- **Soap and/or spray cleaner** bottle for cleanup

Kit components

Silicone tray: This tray will be an extrusion and drying surface for a few of the bioplastics you will make. The tray can be washed with soap and water if needed

Cotton swab: You will use a paintbrush/cotton swab to create your bioplastic product and to oil your molds.

Tube of glycerol: Glycerol (sometimes also called glycerin) is a colorless, viscous liquid that helps softens and reduces shrinkage in bioplastics. This is because glycerol functions as a plasticizer that bonds with the polymer in your mixture. A plasticizer is something that is added to another material (usually a plastic base) to make that material softer or more pliable.

Agar: Agar is a yellowish powder that comes from red algae. It is sometimes used a vegetable replacement for gelatin. Like it, it acts as a binding material and a hardening component in bioplastics. It often functions as the polymer in your mixture. Agar is more flexible than gelatin.

Beaker: A beaker help you measure and heat the water you need to make your bioplastics, and to mix your ingredients in.

Stir stick: wooden stick to mix your bioplastic powders & liquids into a smooth mixture.

Dye bag with red, blue and yellow dyes and 3 plastic pipettes/droppers: 3 tubes of dyes and 3 pipettes to help you dispense them in the bioplastic mixture. Use one pipette per color to prevent contaminating your different dye tubes. With yellow, blue and red dyes you will be able to create all colors.

The Big Plastic Problem & bio-based plastics

Plastics are a well-known material that is used to make our modern world go round. There is a high probability that you have many types of plastics around you right now. Can you spot them? You may see an appliance, electrical cord, clothing, shoes, pet food or water dish, or a garbage bin. You'll likely notice many types of plastics with many different properties. But did you know that all plastics have a similar basic chemical structure?

What are plastics?

Plastics are chains of repeating molecules linked together. These "strings" of repeating molecules are called polymers. Since these chains are called polymers, plastics are also often called polymers. You might have noticed that many plastic names start with "poly ." Now you know why! Different plastic properties are a result of the types of atoms and molecules that make up the polymer chains. These repeating molecules can either all be the same (also called a monomer) or by a few different molecules that repeat in a pattern (a true polymer).

The process of creating plastics is called polymerization. During polymerization, the smaller molecules, called monomers or building blocks, are chemically combined to create the polymers. The first "modern" plastic was Bakelite, a material that could not be melted again when formed. Bakelite was introduced in 1907 by chemist Leo Hendrik Baekland. He also coined the term 'plastics' to describe this new category of material. Since the introduction of plastics, most polymers have been produced with petrol-based compounds because petroleum-based compounds are cheap, easy to obtain and process, and very durable.

Bakelite buttons. Source: Science History Institute, CC BY-SA 3.0, via Wikimedia Commons

Just what is the Big Plastic Problem?

You are probably aware that many scientists, innovators, and students like yourself are now looking to biology to solve the big plastic problem. But why? Traditional plastics have three significant impacts on the environment: they use fossil fuels, have a large carbon footprint, and stay in the environment for hundreds of years. One major problem with plastic that needs to be addressed right away is that it is too durable! Most petroleum-based plastics are not biodegradable; instead, they degrade so slowly that they stay in the environment, landfills, beaches, and oceans for decades up to hundreds of years. While several factors impact the timeline to degrade plastics, like the polymer it is made from and the environment it is discarded in, on average, single-use plastic bottles will take about 450 years to degrade, while a plastic bag can take anywhere from 10 to 1,000 years to degrade in a landfill!

Plastic debris disintegrates over time into smaller particles of various sizes and shapes under natural processes like UV radiation and mechanical abrasion. These are referred to as secondary microplastics and form more than 80% of microplastics found in the environment. Source: Oof.cc, CC BY-SA 4.0, via Wikimedia Commons

Unfortunately, the problem doesn't end here. As we continue to learn about the presence of plastic in the environment, science indicates that some of these petroleum-based plastic actually do not entirely go away. If they are not recycled into new plastic products, petroleum-based plastics like PVC will break down into smaller pieces that stay in our environment, water systems, and soil. These are sometimes referred to as "forever plastics" or microplastics, and they've been found in all our oceans, marine life, drinking water, and even in human bodies! While the impacts of these microplastics on living organisms, plants, animals, and human health are still being studied, there is just no escaping them. Scientists have seen microplastics in most places they have looked: In deep oceans, in Arctic snow and Antarctic ice, in shellfish, table salt, drinking water, human blood, and even drifting in the air or in the rain.

This is why more and more people are looking at ways to degrade existing petroleum-based plastics. Others are working to create new types of plastics made with biological materials that can degrade quickly, do not rely on fossil fuel as a source of the monomers, and have a smaller carbon footprint.

Gelatin-based bioplastics dyed with algae extract.

What are bioplastics?

These new types of plastics made with biological-based ingredients are called bioplastics. Early research indicates that they could be a significant improvement over petroleum-based plastics. To clarify, bioplastics are plastics made at least in part with renewable biological matter (like vegetable fats and oils, corn starch, woodchips, sawdust, and food waste), or they are plastics that can degrade in a reasonable time.

It might surprise you to learn that bioplastic production is much older than the plastics we use today! In 1500 BC, people in Egypt were already using materials made of gelatin and casein (a protein found in milk) for furniture constructions. And it's not all ancient history either; in the 1940s, industrial pioneer Henry Ford experimented with soya bean plastics. Cool! The history and potential of bioplastics are rich and inspiring.

Today, bioplastics are being developed and tested as sustainable replacements for single-use plastics for packaging, utensils, food containers, 3D printing, fashion, and even medical implants. But since bioplastics have different properties than their petroleum-based counterparts because they are mostly made from biodegradable ingredients, it can require an innovative mindset to use them industrially. For example, since some bioplastics use ingredients that can dissolve in water, the plastics themselves can also dissolve in water! This property can be an advantage in some situations, but it can also limit its use. For example, bioplastic utensils and bowls that dissolve in contact with liquid will not help bring hot leftovers home and eat them. Like any technology, bioplastics will have their ideal use cases, current limitations, and potential for improvements.

And it is now your turn to join bioplastics innovators! Let's learn how to make bioplastics. Further, you'll learn about some typical bioplastic ingredients and how bioplastic properties compare to the traditional plastics you already know.

A key pitfall to avoid!

In the next pages are detailed, step-by-step instructions to complete the experiment. **It is helpful to read through all of the steps for each part of the activity before starting that day's activity.**

While all the steps outlined in the experiment are important and should be followed as described, the MOST IMPORTANT consideration for success is:

Always make sure that the water is boiling before adding any powder or liquid to make sure the ingredients will fully dissolve.

You have to see the water bubbling! Be careful, the bottle or bowl will be hot!

Experiment Protocol

Prepare your space

Goal Set yourself up for success.

Materials from the kit	Materials not in your kit
	Spray cleaner Paper towels Pair of gloves

Make sure you have the necessary materials as described on page 6, including access to a microwave or kettle to boil your water, and that you have a source of water before you start. Also make sure that you have read and understood the safety guidelines.

1. If you have them, put on your gloves, and an apron or lab coat.
2. Remember that you can dispose of used items in the garbage but that you **should not pour liquid bioplastic mixture down the drain as it could solidify in the drain**. When you are ready to dispose of your used bioplastics or any extra mixture, you can let it dry before scooping it out into the garbage, or you can pour it directly in a garbage bag.
3. Choose a work surface that is stable, non-porous and easy to wipe (non-porous surfaces are smooth and sealed so liquid cannot go into them, like glass, plastic, varnished wood). Wipe down your work surface with a spray cleaner before starting
4. You will need to let some of your bioplastics dry for up to ~72 hours in the mold/containers provided in your kit. Once the hot bioplastics are poured into the molds, try to avoid moving the containers for about 20 minutes until the mixture solidifies. This will help avoid spills. After that time, the mixtures will be solid enough for you to move the molds to a more convenient location for longer-term drying.

1. Make a bioplastic sheet. Day 1, 10-20 minutes

Goal Gain bioplastic skills by making a bioplastic product.

Materials from your kit
Silicone tray
1x Bag of agar (9 g)
1x Tube of Glycerol (10 mL)
Beaker
Colored dyes

Materials you provide
Microwave
Paper towels
300 mL water

You will first create an agar bioplastic sheet. Then, once dry, you will turn it into a bag or wallet.

Prepare

1. Set your silicone tray on a level, stable surface.

Make the bioplastic mixture and pour into the sheet mold

2. Measure **300 ml** of water in your beaker. Use the graduated lines of the side of the beaker to help measure.
3. Microwave your beaker of water until you see the water boil (big bubbles), around 2 minutes. It is better to microwave longer than not enough.
4. Take your beaker out of the microwave. Careful! The beaker will be hot.
5. Add the content of **one tube of glycerol** and **one bag of agar** into the beaker and stir with your mixing utensil - it's okay if there are some clumps for now.
6. Microwave the mixture for another 25 seconds, or until you see it foam.
7. Stir until the mixture is smooth. If there are still clumps, microwave again for 5-10 seconds and stir. Repeat until smooth. You can also add ~10-15 mL water and microwave again, if the clumps won't dissapear simply by mixing and microwaving.
8. If you would like a colored bioplastic bag, add a few drops of dye and stir it in with the stir stick. Repeat until you are happy with the color. If you want a tye-dye effect, add the dye only after the next step.
9. Pour all of the mixture into the silicone tray and tilt it to make sure the mixture covers it evenly. Make sure you are on the most level surface you can find!
10. Wash your beaker, and stirring utensil with hot water in the sink, and dry with a paper towel.

Leave to dry for ~24 hours

11. Dry at room temperature for 24-36 hours, or until it is paper-thin and mostly dry to the touch. It should not feel like jelly anymore. You'll know it is ready for the next step when it is thin and resembles plastic food wrap (a.k.a. Saran Wrap or cling film).

Note: If you lift the sheet and it breaks, microwave ~10 mL of water until it boils. Overlap the sheet where there are tears. Dip the cotton swab in the hot water and run it over the tear. This will 'glue' the sheet back together as it dries.

2. Make a bioplastic bag using the sheet. Day 2, 10-20 minutes

Goal Gain bioplastic skills by making a bioplastic product.

Materials from your kit	Materials you provide
Cotton swab	Microwave
Your bioplastic sheet	Paper towels
Beaker	50 mL water

Now that you have your bioplastic sheet, you'll turn it into a bioplastic bag.

Prepare

1. Once dry, peel the bioplastic from its tray by running your hands or a toothpick along the edge of the tray and gently taking one corner of the bioplastic to slowly peel up the entire sheet of bioplastic. Congratulations! You made a bioplastic sheet from red-algea!

Remember you'll know it is ready for the next step when it is thin and resembles plastic food wrap (a.k.a. Saran Wrap or cling film). It will be paper-thin and mostly dry to the touch. It should not feel like jelly anymore. If you lift the sheet and it breaks, microwave ~10 mL of water until it boils. Overlap the sheet where there are tears. Dip the cotton swab in the hot water and run it over the tear. This will 'glue' the sheet back together as it dries.

Create your bag

2. Fill your beaker with ~50 mL of water and microwave until it reaches a rolling boil, about 30 seconds.
3. Place your sheet in front of you, on a clean, dry surface. You can use the silicone tray or do this directly on a table.
4. You will use the hot water as a glue to seal the edges of your bag. There are two ways to do this:
   - **Dipping the sheet in water:** Fold the bioplastic sheet in half, and dip one of the sides of the folded sheet into the hot water, making sure about ~1 cm/0.5 in in in the water. Wait for about 10 seconds, then pull it out of the water and carefully press down on the wet edges to seal them. Repeat this on the other side of the folded bioplastic sheet so that you end up with 3 sides of the bag sealed: the folded side, and the two you are sealing.
   - **Painting the sheet with water:** Fold the bioplastic sheet in half, and dip the cotton swab into the hot water. Run the cotton swab along the two of the three edges of the folded sheet, so that you end up with a bag. Make sure to keep dipping your cotton swab in water as you go, to make sure enough water goes onto the edges.
5. Reheat the water if it gets too cool.

Leave to dry for ~24 hours

6. Leave your folded sheet to dry so that the wet edges fuse together. Depending on the amount of water used this could take a few minutes to half an hour. If sections of the edges don't glue together, repeat the steps above with the cotton swab to seal them, making sure your water is boiling hot.

3. Evaluate & Make more bags! Day 3, 20-30 minutes

You’ve now made a bioplastic bag, congratulations! In this page, you’ll learn how to evaluate it, make more bags, or decorate yours further.

Evaluate: How can this bag be used?
Could it hold your snacks? Would it do well in the rain? Could the same material be used to make a bigger shoppping bag ?
Bioplastics are a new type of material that might also have fun new applications. You can explore what that means by testing your bag out in different situations. How does your bag compare to a regular plastic bag? Note your observations and compare them with your colleagues.

Evaluate: Is your bag zero-waste?
Head to the next page to continue the experiment further by seeing if your bag will biodegrade faster than a regular bag.

Make new bags:
You’ll notice you still have agar and glycerol in your kit. Use them to make a new sheet and create a new bag, or use the sheet to make something completely different. You now know how to make and assemble bioplastics. Be creative!

Did you know you can also melt down your existing bag to make a new sheet? Place your bioplastic bag in 300 mL of boiling water. Wait a few minutes, then mix and microwave until it the smooth mixture you remember. Color and pour it into your silicone tray. Using two sheets of bioplastics will allow you to make a much bigger back using the same ‘glueing’ technique as above.

Decorate your bag:
Get creative! Not sure where to start? Here are some ideas:

- Create different pockets by sealing more sections together using the hot water technique to glue.
- If you have the Bioplastic Kit: Extrude Sequins & Strings, use them as decorations: ‘glue’ the sequins and strings with the hot water technique or use sewing sewing thread to secure them to the bag surface.
- To create ombre or tye-dye looks, let your bioplastic cool a few minutes before adding in different drops of dye and mixing gently until you get swirly patterns or gradient patterns. If you over mix, you can melt the plastic back up and try again with different (darker) colors.
- Create polka dot patterns inside the bioplastic itself by dropping sequins into freshly made clear/colored bioplastic once the bioplastic mixture has cooled a bit, but not yet solidified.
- Embed strings, twists, braids and weave into bioplastic sheets using the same technique. Leave to dry.

Congratulations! You are officially “making” with bioplastics! Have fun! Don’t forget to wash your tools and beaker with hot water when you are done.

Degradability

Degrade your bioplastic(s) in water and/or in soil

Goal **Can we degrade some of our bio-plastics so they leave no trace in the environment?**

Learn from your experience

Now that you've experimented with and analyzed bioplastics, you may be curious as to what happens to bioplastics once they have fulfilled their purpose. You'll remember from the introduction that the term bioplastics refers to a broad category of materials that includes bio-based plastics like the ones you created; a bio-based plastic can either be fully made from biological matter (like the ones you made), or partly made from biological materials. Confusingly, bioplastics can also refer to plastics that are biodegradable, whether they are made with bio-based ingredients or not. Let's see if we can make sense of all these terms.

A biodegradable plastic is a plastic that can be broken down by microorganisms in a reasonable time frame. While all plastics can eventually degrade once thrown away, we saw earlier that for most of the plastics we use, it can take decades, hundreds or thousands of years before this happens. As they degrade they can create microplastics that linger in the environment for even longer, possibly forever.

Biodegradable plastics aim to resolve this issue by ensuring that microorganisms can break down the plastics quickly. Beyond biodegradable plastics, you can also find **photo-degradable plastic** which are mostly petroleum-based plastics to which chemicals are added to help them break down faster in the presence of sunlight. Other additives can be added to help plastics degrade in water (**hydro-degradable plastics**), or through oxidation, so by reacting to the oxygen in the atmosphere (**oxo-degradable plastics**).

Which category of bioplastics do you think our bioplastic experiments fall under? Are they bio-based? Biodegradable? Photo-degradable? Oxo-degradable or even hydro-degradable?

The plastics you made are definitely bio-based because all their components derive from biological material. We did not add any special chemicals to help them degrade in the presence of oxygen, or in the presence of sunlight, so they are neither photo-degradable nor oxo-degradable. However, it is likely that our plastics could be hydro-degradable since most of the ingredients we used to make them are soluble in water. It is also possible that they are biodegradable since most of the ingredients we used come from organic matter. Why not test out our hypothesis?

If you'd like to test the biodegradability and/or hydro-degradability of the some of the plastics you created, have a look at the next two activities which will show you how to test your bioplastics degradability in water and in soil. You can try one or both of these methods with the bioplastics you have. Cut them in half to try both. Keep in mind that this last experiment can take weeks or months before you see results. If you are ready to end the experiment now, or at any point in the future, just skip ahead to the "Storage, disposal and clean-up" page.

Are bioplastics hydro-degradable?

4. Degrade your bioplastic(s) in water

Goal **Can we degrade our bio-plastics in water so as to leave no trace?**

Materials you provide

Paper towels
Marker/pen
Your bioplastics
Mixing beaker
~400 mL of water

Degrade your bioplastics in water

When plastics end up in the ocean or other water bodies, the water is cooler than the water we used to make them. Let's test if your bioplastics would dissolve in room temperature water.

1. Add 400 mL of tap water in your beaker.
2. Choose one or more of your bioplastic you want to test for hydro-degradation. You can cut them in half if you also want to test their degradability in soil.

Note: To compare with a regular plastic bag, find a second container and add 400 mL of water from the same source in it and add a piece of plastic bag that is the same size as your bioplastic.

3. Weigh the sample(s). Note the measurement in the table below, alongside the time and day you start your degradation experiment.
4. Add your sample(s) to the water. Your experiment is underway!
5. We recommend taking your sample out of the water every 2 or 3 days to weigh it and take notes on it, until you can no longer collect it from the water.

Hydro-Degradation Bioplastic Experiment Table

Material sample:____

Time / Date									
Weight									
Notes									

Verify your water for the presence of plastics.

6. If/when your water looks clear, take your last measurement and notes (you can mark the weigh as 0 if there is no sample left).
7. Is there any plastics left behind? You can verify by pouring the water through a coffee filter or paper towel as you dispose of it.

What did you find? You can share your findings with us!

Are bioplastics biodegradable?

5. Degrade your bioplastics in soil

Goal **Can we degrade our bio-plastics in soil, so as to leave no trace?**

Materials you provide

Paper towels
Marker/pen
Your bioplastics
A small shovel/garden trowel or similar
A location where you are allowed to dig a small hole in dirt
A marker for the location you chose to find it again

Degrade your bioplastics in soil

Because our bioplastics are mostly made with food-like ingredients, we can hypothesize that they would biodegrade in a reasonable time frame. Temperature, humidity and soil organisms all play a role in the biodegradable process. Let's see if we are correct in assuming our sample(s) will biodegrade and what that time frame would be.

1. Choose the bioplastic(s) you want to test for biodegradability. If you want to compare it to a regular plastic bag, use a piece that's the same size as your bioplastic.
2. Weigh the sample as it is now. Note the measurement in the table below, alongside the time and day you start your degradation experiment.
3. Dig a small hole in the dirt of your yard, or any location you are allowed to use. You will need a hole about 4 inches across and 2 to 4 inches deep. You can also fill a large container with soil if that's easier.
4. Place your sample in the hole, and cover it with dirt. Identify the location with a marker - if you are in a private yard, a large rock or stick can work. If you are in a public location like a school yard, you can make a small sign to announce your experiment location, as long as you have permission. Your experiment is underway!
5. If you can, we recommend taking weight measurements and notes on the plastic sample and soil condition every week. Depending on the environment, soil, and temperature where you test, you may need to extend this table to add more columns if your bioplastics take longer to degrade.

Biodegradability Bioplastic Experiment Table

Material sample:________________________________

Time / Date									
Weight									
Notes									

Analyze your results.

6. Are you noticing any weight decrease in your sample? Can you make a graph that predicts when the sample will be fully degraded after you've measured for a few weeks? What did you find? You can share your findings with us!

CONGRATULATIONS

You have now joined the global community of bio-designers and material innovators! Happy with your results? There are many opportunities to share it online and in your community. You can also share your results with friends and our growing community: find us on Instagram, Twitter, TikTok and Facebook @aminobiolab

Don’t forget, you can use these recipes again and again using ingredients you may already have at home, or that you can find at the grocery store, or at Amino Labs. For now, let’s make sure you dispose of and store your remaining material correctly.

Storage, Disposal, Clean Up

After you see your results and end the experiment, it is time to clean up, dispose of and store away your materials. Disposing of experiment materials is an integral part of experimental protocols.

A. **Preserving your bioplastic(s):** If you want to preserve your bioplastics for future reference, you can place your samples/work with an identifying labels in a container. Or, you can attach them in a binder along with any experiment notes and material property analysis.

B. **Disposing of your bioplastics:** If you would like to dispose of all or some of your bioplastics samples, you can place these in the garbage, melt them down, or place them in the compost pile. Unfortunately, the bioplastics you've made cannot go into the traditional recycling stream as the recycling industry is not ready to deal with these.

C. **Disposing of your other kit material:** All tubes, bottles, containers and plastic packaging can be disposed of in a recycling bin or garbage. Of course, they can also be washed and kept for reuse. Wash with soap and water and kept for reuse around the house/classroom.

D. **Unused ingredients/items:** If you did not use all of your ingredients, you can keep them in a sealed bag for reuse later. If the ingredients are in powder form, make sure the lid of the container/tube is tight to prevent the powder from humidity. Do not eat or cook/bake with any of your science kit ingredients!

E. **Clean your workspace:** Use a spray cleaner, wipes, or hot, soapy water to clear up your work area and equipment. If you are using a bleach cleaner, always wear gloves and remember that the bleach cleaner can discolor clothes and fabrics.

Glossary

Acetic acid: You'll have noticed that acetic acid is a clear, colorless, organic liquid with a pungent odor similar to household vinegar. Indeed, acetic acid is the main component of vinegar apart from water and trace elements. Regular vinegar is around ~4% acetic acid.

Acetic acid has a variety of uses, including as raw material and solvent in the production of other chemical products, oil and gas production, and in food and pharmaceutical industries.

The acetic acid in the recipe helps the starch fully dissolve in the mixture because starch dissolves better in the presence of electrically charged ions which the acetic acid provides.

Large cellulose molecules, like starch, are long-chain polymers. In this experiment, two ingredients change the properties of the polymer plastic. By adding a small amount of acetic acid, you break up some polymer chains, making the plastic less brittle.

Algae/Agar Bioplastic: Agar is a yellowish powder that comes from algae. It acts as a binding material and a hardening component in bioplastics. In addition, it functions as a polymer in bioplastic mixtures.

Agar is a polymer created from the agarose and agaropectin found in the cell walls of red algae. It is often used as a vegetable replacement for gelatin. It is used as a thickening or gelling agent in cooking. However, agar is more flexible than gelatin. You can combine gelatin powder with agar powder to make a more flexible/hybrid material.

Agar bioplastics are a suitable replacement for disposable single-use packaging, including snack packaging and dry food packaging. And, if you've done any biotechnology or microbiology, you'll recognize agar from the substrate that microorganisms grow on. It's the same ingredient, used differently. A fun fact about agar: it affects touch capacitive screens! You might be able to make an agar bioplastic stylus for your tablet!

For agar to work successfully, it first needs to absorb water which it does by being brought to a boil (100°C) It becomes a gel at room temperature since it solidifies at 32–40 °C. Solid agar gels will start melting at 85 °C.

Agar does not hydrate (absorb water) well in acidic liquids, making gelling difficult. To use agar alongside an acidic bio-plastic ingredient, first hydrate the agar in water, allowing it to dissolve, before adding it to your acidic ingredient.

Agar shrinks a lot in size and thickness over time, and if left in a mold where it's connected to wooden edges, it will form cracks in the center. So make sure to cut the agar free from the edges of the mold after the first 24 hours of setting.

Agar bioplastic should decompose for two months in summer temperatures, taking approximately four months in cooler climates.

Biocomposites bioplastic: Biocomposites are made from a matrix of plastic and renewable fillers. Biocomposites can be made entirely of bio-based ingredients (biocomposite bioplastics) or with bio-fillers to replace some of the petroleum-based content of traditional plastics. In adding bio-fillers to traditional plastics, non-renewable ingredients can be drastically reduced.

Bio-fillers: are organic materials that are ideally waste by-products of other industrial processes like agriculture or paper processing and combined into plastic recipes to provide different properties or limit the number of other ingredients. They are sometimes referred to as biomass. Fillers can help the material keep its shape and reduce the natural shrinkage in most bioplastic.

You can use different bio-fillers in biocomposite to obtain different materials properties. Popular bio-fillers are dried peels, eggshells, dried plant leaves, shredded paper waste, seafood wastes like shells, starch, or wood dust. You can add natural colorant by choosing naturally colorful bio-fillers.

You can also try to mix in your bio-filler to a gelatin-glycerol bioplastic recipe instead of a pectin recipe to obtain different properties.

Cornstarch: see starch

Drying: when a material dries, it can shrink and deform as the water leaves the mixture. You can remedy this by placing heavy objects on your drying plastic to compress it into the desired shape. You should always dry your bioplastics indoors and away from direct sunlight and pets, insects, and younger siblings. While many ingredients in bioplastic can be found in foods, you should never eat any of your experiments.

Gelatin: is a colorless powder derived from collagen. It acts as a binding material for bioplastic mixture and a hardening component. It also provides transparency to the piece. Gelatin functions as a polymer in bioplastics.

Gelatin bioplastics are clear, strong, oxygen permeable, and hygroscopic. The properties of gelatin bioplastics are influenced by drying temperature. When Gelatin bioplastics are dry, especially when exposed to the sun, they often get quite brittle. Even when adding more glycerol to the recipe, it is still one of the stiffer bioplastics to work with. Gelatin bioplastics can also be heated up or whetted to shape them over forms/molds and melted back down for reuse.

Gelatin is primarily used as a gelling agent in food, pharmaceutical, and cosmetic industries. When it comes to gelatin bioplastics, they can be used for alternative packaging, to create a folder/pocket, to replace stiff plastic materials you might use in your daily life.

Gelatin is often an animal-based ingredient. Some might find it problematic to use resources that require killing an animal because of religious or animal welfare beliefs. Arguments are also made that as long as there's a meat industry, it is better to use products from the entire animal, including skin and bones. Some might consider gelatin a product that comes from a waste stream, but this is considered controversial by others. To avoid using animal-based gelatin, use agar or vegetarian gelatin.

Glycerol: is a colorless viscous liquid that helps give shape, softens, and reduces shrinkage in bioplastics. Glycerol functions as a plasticizer that bonds with the polymer in your mixture. Sometimes also called glycerin, although glycerol is a pure form, while glycerin is a mixture that contains 95% glycerol.

Glycerol is a sugar alcohol derived from animal products, plants, or petroleum (as a by-product of bio-fuel). It can also be obtained from micro algae oils, and it can be recovered from used cooking oil.

Glycerol has a low melting point (18°C) and high boiling point (290°C), which makes it suitable as a plasticizer in bio-materials. As a plasticizer, glycerol "lubricates" the plastic. If you want the plastic more pliable, add more glycerol. If you want the plastic to be stiff, add less glycerol. However, higher glycerol concentration makes the bioplastic weaker (low tensile strength), more fragile, and easier to degrade under wet and dry soil. But the flexibility of your glycerol bioplastic will make it easier to peel them out of their drying containers.

In biomaterials, glycerin can be used as a plasticizer for more flexible bioplastics, as moisturizer or softener in tanning (e.g., bacterial cellulose), as an additive for bubbling textures/mixes, and as a solvent for pigment extraction. It has antimicrobial properties.

Material sample: in general, a sample is a limited quantity of something intended to show what the whole is like. A material sample of bioplastic is then a small piece of bioplastics that you can use to understand how a larger quantity of the material would behave and what it could be useful for.

Material samples library: is a resource for material research, exploration, and experimentation consisting of an expanding collection of material samples, analysis, and notes.

Mold: a mold is a hollowed-out shape filled with a liquid or pliable material like plastic, glass, metal, or ceramic. The liquid hardens or sets inside the mold, adopting its shape. Molds are sometimes called forms or negative forms and are often used to replicate a "master" item. The mold you select will affect both the shape of your material as well as the drying process. For example, thicker materials will take longer to dry.

Pectin Bioplastic: You may have heard of pectin before and might even have made some while making jams. Pectin is a colorless powder typically obtained from fruit. It is a polysaccharide starch found in the cell walls of fruits, vegetables, and plants - it is the second most abundant component of the cell wall of all land plants. Pectin functions as the polymer in bioplastic mixtures and is what makes jams jelly!

Pectin is often used as a gelling agent in desserts, but it also has wide applications in various fields due to its use as a gelling, emulsifying or stabilizing agent and its non-toxic, bio-compatible, and biodegradable nature.

In terms of biomaterials, pectin can have different applications, including food packaging, pharmaceutics, nutraceuticals, drug delivery, tissue engineering, and cosmetics.

The properties of pectin can be improved and modified with bio-fillers or in a mixture of other gelling ingredients (polymers). For example, adding a bio-filter like peels can help keep your bioplastic shape and reduce shrinkage.

Petri dish: A petri dish is a small plastic container. It is usually used to culture (grow) microorganisms in a controlled environment but can also be used as molds for material science experiments like you just did. Petri dishes come in several sizes, including 6 cm and 10 cm. They are sometimes called "plates."

Polymers: Plastics are chains of repeating molecules linked together called polymers. Whether natural or artificial, polymers are long molecules made by linking up smaller repeating molecules. Wool, cotton, and silk are natural polymer-based materials. Cellulose, the main component of wood and paper, is also a natural polymer, as are the starch molecules made by plants. Learn more about polymers here: https://www.sciencenewsforstudents.org/article/explainer-what-are-polymers

Shrinking: See drying.

Starch: is a white flour-like powder typically obtained from corn or potatoes. Starch itself is a polymer made by plants to store energy. It can be used as the polymer in your mixture or an additive to another polymer mix.

Troubleshooting

Here are some possible common issues:

My bioplastic does not solidify/gel.
When done correctly, the bioplastic will harden into a sheet. If it is not:

1. You likely did not heat (boil) the water before or after adding the ingredients

2. You might not have added all the powder from the tube, resulting in too much water vs. ingredient(s).

3. You may not have fully dissolved the powder, meaning it cannot turn into a gel and will look cloudy. You can practice by making Jell-O! Next time heat and swirl longer to ensure the powder is fully dissolved.

My bioplastic breaks:
Don't worry; some of the bioplastics recipes give thin, brittle plastic sheets. If your sheet or sample breaks, you can:

1. Melt it back down! Go back to the recipe and add the same amount of water to your mixing bowl! Add your broken plastic sheet and microwave until boiling. Stir and pour into an oiled mold. Note that bioplastics are hard to melt back down. Try the method below to repair them instead. Note that trying to melt the biocomposites might not work depending on the filler you used.

2. You can repair most bioplastics by dipping or coating the two edges of the break with boiled water and then pressing the edges together again. Leave to dry.

If anything else causes you issues, please contact us : help@amino.bio

More Information

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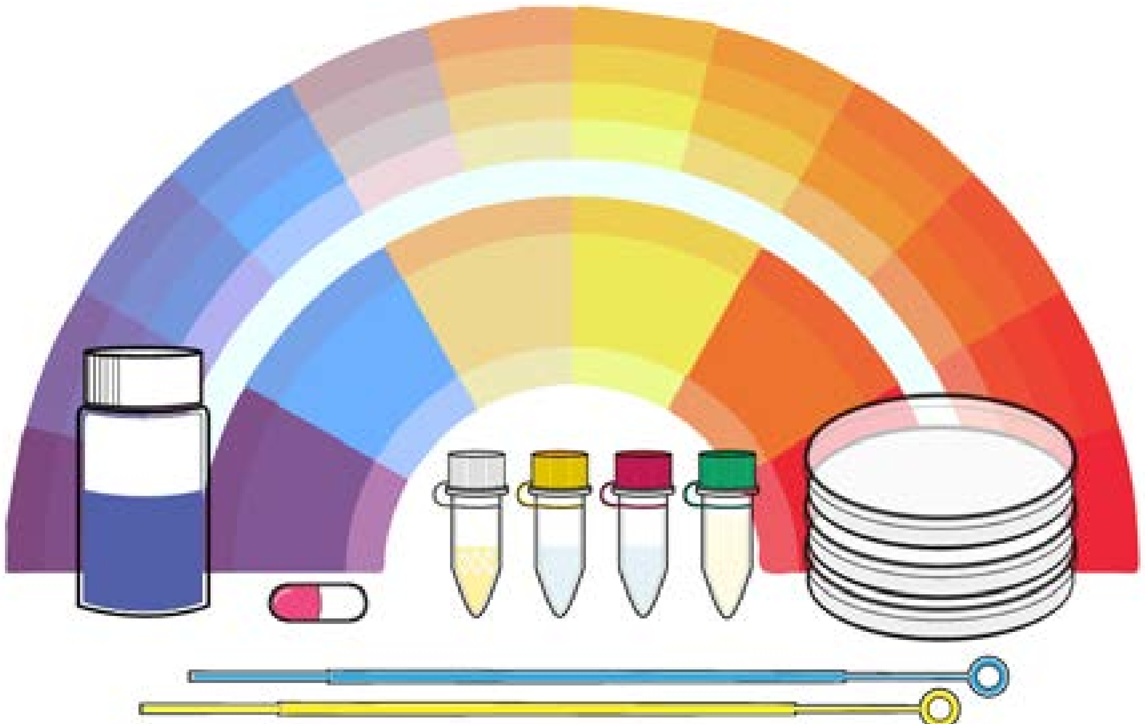

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