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How can we recycle plastic more sustainably?

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Abstract

Plastic is all around us: in our toothbrushes, pens, cars, and even clothing! It is very useful. But plastic trash ends up in the environment and is bad for animals and humans. It can take hundreds of years to break down. Recycling this plastic can take a lot of energy and often still leaves waste. We wanted to find a better way to break plastic down and reuse it to make new plastic. We discovered an enzyme that "digests" plastic in the same way that humans can digest food. Using this enzyme to break down used plastic means we will need much less energy to recycle plastic. Plus, we can even use the products of the process to make plastics that are just as good as new ones!

Introduction

Plastic is very important. We use it for food containers, clothing, bags, and much more! Can you count the number of plastic things you use every day?

Unfortunately, most plastic waste ends up in **landfills**. We only recycle a small amount of plastic because it's hard to do. Plastics are separated, melted down, and then reshaped into new plastics. This process needs high temperatures and takes a lot of energy. It also produces harmful pollution. Plus, recycling decreases the quality of the plastic. This means we can only recycle plastic a few times before throwing it away.

A **closed-loop system** would be much better for the environment. In closed-loop recycling, plastic would never end up in a landfill. Instead, it would be recycled forever.

To do this, we need to make sure the quality of plastic stays the same during recycling. We think **enzymes** can help! Enzymes are like little machines working inside your body and in the environment. Enzymes help all kinds of chemical reactions happen, including breaking down **molecules** into smaller molecules. When you eat, enzymes help break down food into smaller molecules your body can use.

We decided to look for an enzyme that could help break down plastic. Then maybe we could use it to create a closed-loop recycling system for plastics (Fig. 1).

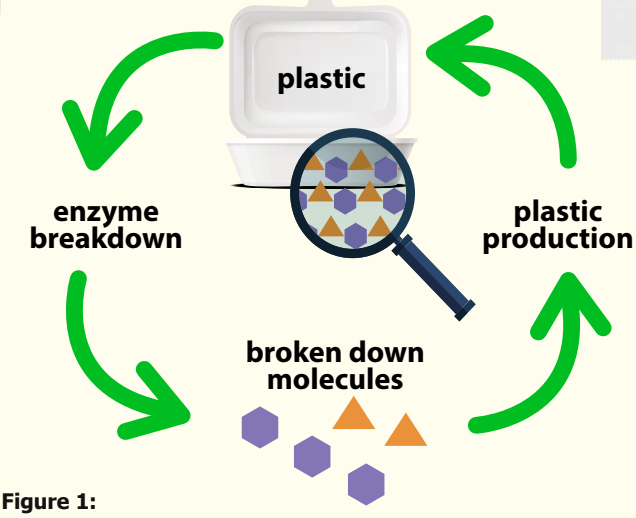


Figure 1:
How a closed-loop recycling system could work. The enzyme breaks down the plastic into molecules that can be reused to make more plastic.

Methods

Plants contain molecules that are similar to the plastic molecules we wanted to break down. In **compost** piles, microscopic organisms produce enzymes that can break down these plant molecules. So we collected several samples from compost sites in Leipzig, Germany.

We looked at the **DNA** in our samples to find enzymes that might help us break down plastic. We found seven different enzymes! So we did some experiments to see how well they worked.

First, we placed each enzyme in a container with plastic. We let the enzymes break down the plastic molecules for 24 hours. We did this at different temperatures, too. Then we measured how much plastic got broken down. We also compared our enzymes to another enzyme that we already know breaks down plastic.

We did more tests using the best enzyme. We tested to see how fast it worked. We looked at its shape and figured out how stable it was as well.

Once we knew enough about the best enzyme, we did one final experiment. We used it to break down a plastic takeout container. Then we used the broken down molecules to make new recycled plastic.

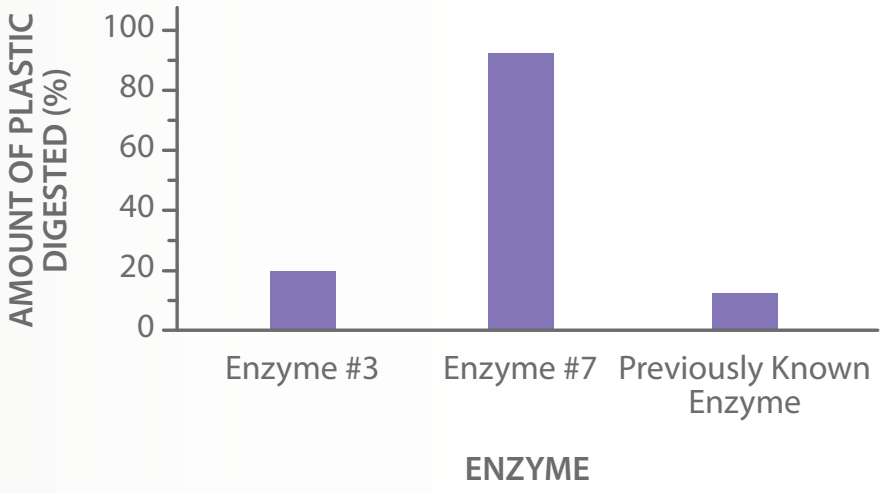
Results

Our experiments led to the following key results:

1. The best enzyme was the one we named "Plastic Hydrolase Leipzig 7", but we'll call it Enzyme #7 here. After 24 hours Enzyme #7 had digested almost 100% of the plastic! (See Figure 2.)
2. Enzyme #7 works best at 70°C (158°F).
3. Enzyme #7 can work really fast! It worked the most quickly between 4 and 8 hours after it started breaking down the plastic.
4. Enzyme #7 can break down plastic into very pure molecules. We were then able to create new, high quality plastic from those molecules. This is an example of closed-loop recycling.

Figure 2:
Percentage of plastic digested in 24 hours at 70°C by Enzyme #7, another enzyme from the landfill in Leipzig, and an enzyme previously known to digest plastic.

How many times more effective was Enzyme #7 than the second most effective enzyme?



Discussion

Enzyme #7 is a great enzyme to try using for plastic recycling. Enzyme #7 broke down a lot of plastic compared with the other enzymes. It is also **thermostable**, meaning that it can work at a variety of temperatures. It worked even at 70°C, about the same temperature as the air inside a hot clothes dryer. This is a lower temperature than we usually use to recycle plastic. Recycling at a lower temperature can save a lot of energy!

Enzyme #7 also breaks down plastics quickly. That means it could also help recycling processes go faster.

Finally, Enzyme #7 breaks down plastic into very pure chemical molecules. We can recycle these to make new high quality plastics. We won't have to use additional materials from the environment. So, Enzyme #7 could help us achieve a closed-loop system of plastic recycling

Conclusion

It is important to make sure you are recycling any plastics you can. But it can be even more important to reduce how much plastic you use. Here are a few ideas:

- Try to reuse plastic containers. They can be great for drawer organization, gift boxes, or even small planters!
- Bring your own reusable shopping bags to the grocery store.
- Choose to buy items that have no or reduced amounts of plastic packaging.
- Consider joining an environmental group or start one at your school. You can help raise awareness about actions that we can take to reduce the use of plastics!

Glossary of Key Terms

Closed-loop system – a system that circulates resources so nothing is wasted. Everything is used and then remade into a useful product again without needing any new materials.

Compost – decayed organic material (pieces of plants, leftover food, etc.) that is used as fertilizer.

DNA (deoxyribose nucleic acid) – the genetic material found in all of our cells. This information gets passed on from organism to organism.

Enzyme – a structure that speeds up chemical reactions. They exist in every living organism. Enzymes help you digest food and help plants with photosynthesis.

Landfill – a place where large amounts of trash are buried in the ground.

Molecule – the smallest unit of a substance that has all the properties of that substance. A single water molecule, H_2O, has the properties of water.

Thermostable – when a molecule maintains its structure at a wide range of temperatures.

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Check your understanding

1 What is an enzyme? Why are they important?

2 What are some chemical reactions that happen in your body?

3 Why is it important that Enzyme #7 is thermostable?

4 How could a closed-loop system for plastics help to reduce our impact on the environment?

5 Why is it important to reduce how much plastic we use? Come up with five ideas for using less plastic in your own life.

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