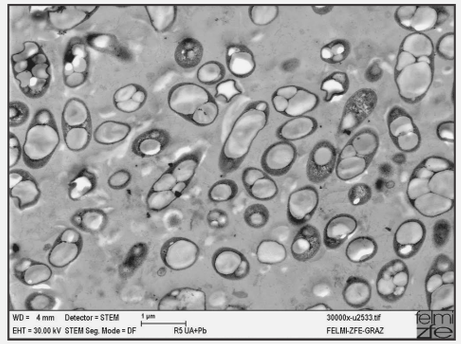

GO!PHA
Global Organization for PHA
We want fish in our oceans, not waste.
PHA. The biodegradable alternative to fossil plastics.

WHAT IS PHA?

The biodegradable alternative to fossil plastics.



PHA producing microorganisms, magnification 30.000 x, pictures prepared and provided by Dr. Elisabeth Ingolić, FELMI/ZFE, TU Graz.

Natural PHA (PolyHydroxyAlkanoate)[1] is a versatile class of biopolymers that provides a renewable carbon-based and biodegradable alternative to the fossil plastics commonly used.

PHAs offer a natural solution to our need for plastic-like materials and should play a prominent role in our regenerative, renewable, bio-based, and circular product ecosystems.

PHAs are an effective way to use nature's toolbox to sustainably tackle and prevent some of the world's most pressing challenges.

WHY PHA?

Using PHAs can help reduce our impact on climate change and plastics pollution.

Plastics free

Naturally occuring PHA-biopolymers, like PHB and a number of its copolymers like PHBV, PHBHx and P3HB4HB are not 'plastics', but are materials made and found in nature, like cellulose or starch.

100% biodegradable

No microplastics or nanoplastics. PHAs degrade harmlessly into the soil or the ocean.

Renewable

PHAs are natural products created using a wide variety of carbon feedstocks that are natural and renewable.

Older than humankind

PHA materials are already used in nature for many purposes and for much longer than the existence of humankind. PHAs are part of the metabolism in all living organisms such as plants, animals, and humans. PHA is a form of nutrition and energy storage for nature - that is part of their core purpose, and nature understands how to use PHA in that manner.

Wide range of applications[2]

PHA materials show a larger application versatility than any other existing material platforms. PHAs are a natural solution to our need for a large variety of plastic-like materials.

1_PHA is a large family of materials, in this context we refer to PHB and its copolymers (P3HB, P4HB, PHBV, PHBH, P3HB4HB, P3HB3HV, P3HB3HV4HV, P3HB3Hx, P3HB3HO, P3HB3HD).
2_PHA biopolymers have been validated in 100s of different applications where fossil plastics are used, and are poised for significant growth.

STOP **PLASTICS POLLUTION.**

Help to reduce the production of fossil plastics.

Torrents of fossil plastics flowing has become one of the most pressing global environmental issues.

Here's why:

8.000.000 tons/year

The amount of plastic escaping into the oceans annually.[3]

Production is doubling

50% of all plastics ever manufactured have been made in the last 15 years. Production is expected to double by 2050.[3]

Decompose in 20-500 years

The years it takes for fossil-based plastic to decompose.[4]

Microplastics harm our health

When plastic enters the ocean, the wind, sunlight, and waves break down the plastic into tiny particles: microplastics are found all over the world. They can be found in the food we eat, in the water we drink and even in the air we breathe.

Harm to wildlife

Millions of animals are killed by plastics every year, mainly through starvation or entanglement. Nearly 700 species are known to have been affected by plastics.[3]

3_Source: Laura Parker, The world's plastic pollution crisis explained (National Geographic)
4_Source: The lifecycle of plastics (WWF)

How does PHA take on plastic pollution?

Plastic products made from PHA are 100% compostable and biodegradable. They break down harmlessly into the soil or the ocean without affecting nature.

PHA can also be turned into renewable energy using the existing incineration procedures.[5]

As a summary, here are the end-of-life options for PHA:

- It can be recycled back to the polymer, ready to be reused for new applications.
- Recycle it organically through industrial or home composting.
- PHA can be used as a renewable feedstock.
- Leaked PHA biodegrades in soil, fresh water and in marine environments.
- PHA is completely biodegradable and can become a nutrient for living organisms.

How does PHA compare to other biodegradable materials?[6]

Legend

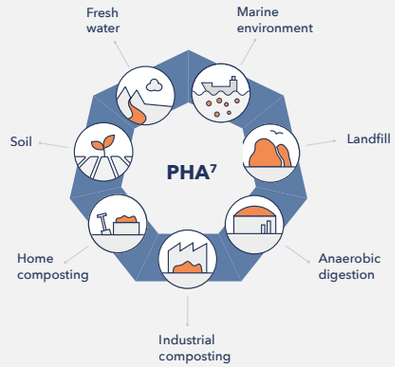
Compostable and biodegradable

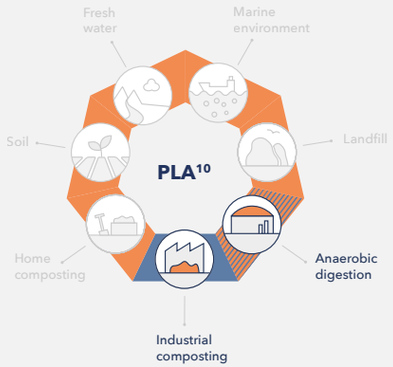
Compostable or biodegradable under specific conditions

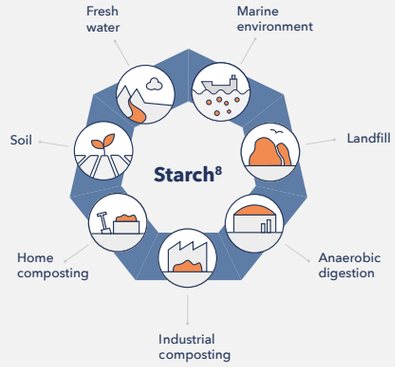
Not compostable nor biodegradable

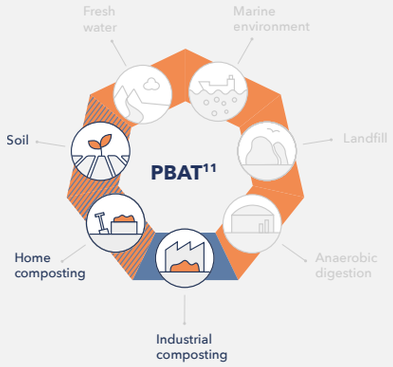
5_The least favorable option for our climate.
6_Adapted from 'Biodegradable Polymers in Various Environments According to Established Standards & Certifications Schemes' (nova-Institut et al.)

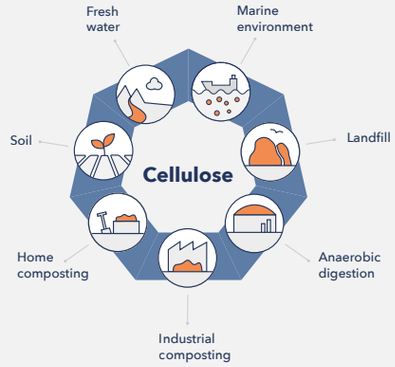
7_PHA is biosynthesised and made via fermentation, similar to beer and mead
8_Natural but chemically modified
9_Partially renewable, partially fossil-based
10_Chemically synthesized
11_Fossil-based

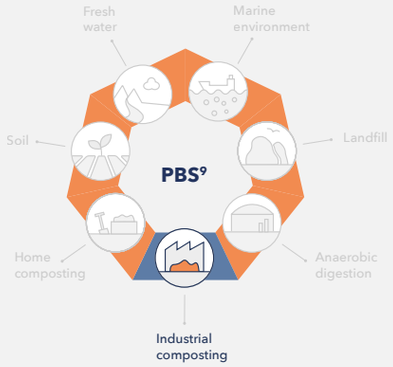












REDUCE IMPACT ON **CLIMATE CHANGE.**

How does PHA contribute to climate change prevention?

Lower CO2 emissions

There's a direct link between the concentration of greenhouse gases in our atmosphere and the average global temperature.

- There's a direct link between the concentration of greenhouse gases in our atmosphere and the average global temperature.
- CO2 accounts for ca. two-thirds of greenhouse gas emissions.
- Human activities are the main cause of CO2-generation and hence global warming.
- Since industrialization, the acidity level in the oceans has increased by 30%, causing less oxygen production by phytoplankton.[12]

Restore natural carbon capture processes

Our oceans are estimated to have captured a quarter to a half of all human-derived CO2 from the atmosphere in the last 200 years. Marine scientists have found that the uptake and storage of CO2 in our oceans may be negatively affected by microplastics.[13]
The study suggests salp faecal pellets[14] will remain at the sea surface for longer when they contain microplastics and while there, they may get broken down causing the CO2 to be re-released back into the ocean and atmosphere.

This means microplastics have the potential to lower the efficiency of one of the most important natural processes occurring within our oceans – the biologically-driven transport of CO2 to the seafloor.[13]

12_Phytoplankton is responsible for 50% of the amount of oxygen created on Earth. The other 50% comes from plants and trees.
13_Environmental Science & Technology 2019, 53, 9, 5387-5395

14_Discharge from barrel-shaped planktonic grazers. They are of importance to the ocean's carbon cycle as their fecal pellets are fast sinking and contribute to carrying carbon to the ocean's floor.

How does PHA take on climate change?

Use greenhouse gases and renewable carbon-rich substances as feedstock

CO2 and methane can be used as feedstocks to produce PHA, helping reduce greenhouse gases in the atmosphere.
Composted carbon-rich feedstock diverted from landfills, means CO2 and methane are not being emitted.

Renewable feedstocks that produce PHAs

Many types of bacteria produce PHAs in nature by consuming different types of carbon-rich feedstocks. These bacteria can be paired with different feedstocks using distinct growing conditions that result in endless material possibilities.

The main feedstock sources for natural PHAs are:

- Plant-based and renewable feedstocks:
  Corn, sugarcane, and vegetable oils.
- Waste streams:
  Used cooking oils, wastewater streams, organic waste, plastic waste.
- Greenhouse gases:
  CO2 and methane.

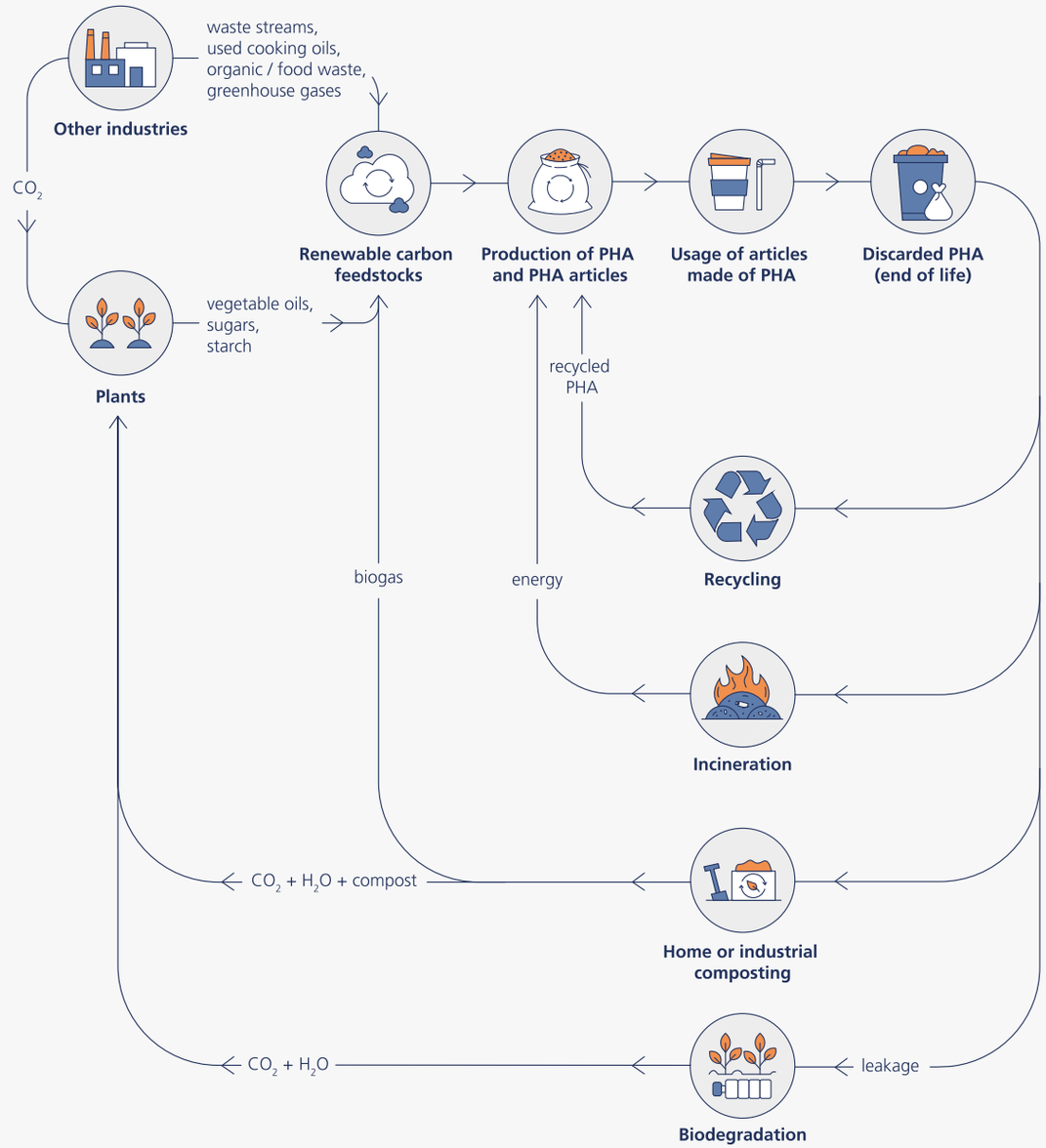
Today, almost any carbon-rich feedstock can help produce PHA biopolymers, providing a unique opportunity to reduce greenhouse gas emissions and close the loop for organic and synthetic virgin and recycled feedstocks.

Eliminating microplastics

As PHAs are 100% biodegradable, PHA materials won't turn into microplastics which lower the uptake and storage of CO2 in our oceans.

Closing the loop.

Fig. 2 Here's how PHAs close the loop



TARGET MARKETS AND **APPLICATIONS.**

How can PHA be used?

The PHA family accommodates a wide range of market applications, due to their biocompatibility, biodegradability, and performance versatility. PHA can replace about half of any fossil plastic on the market today.

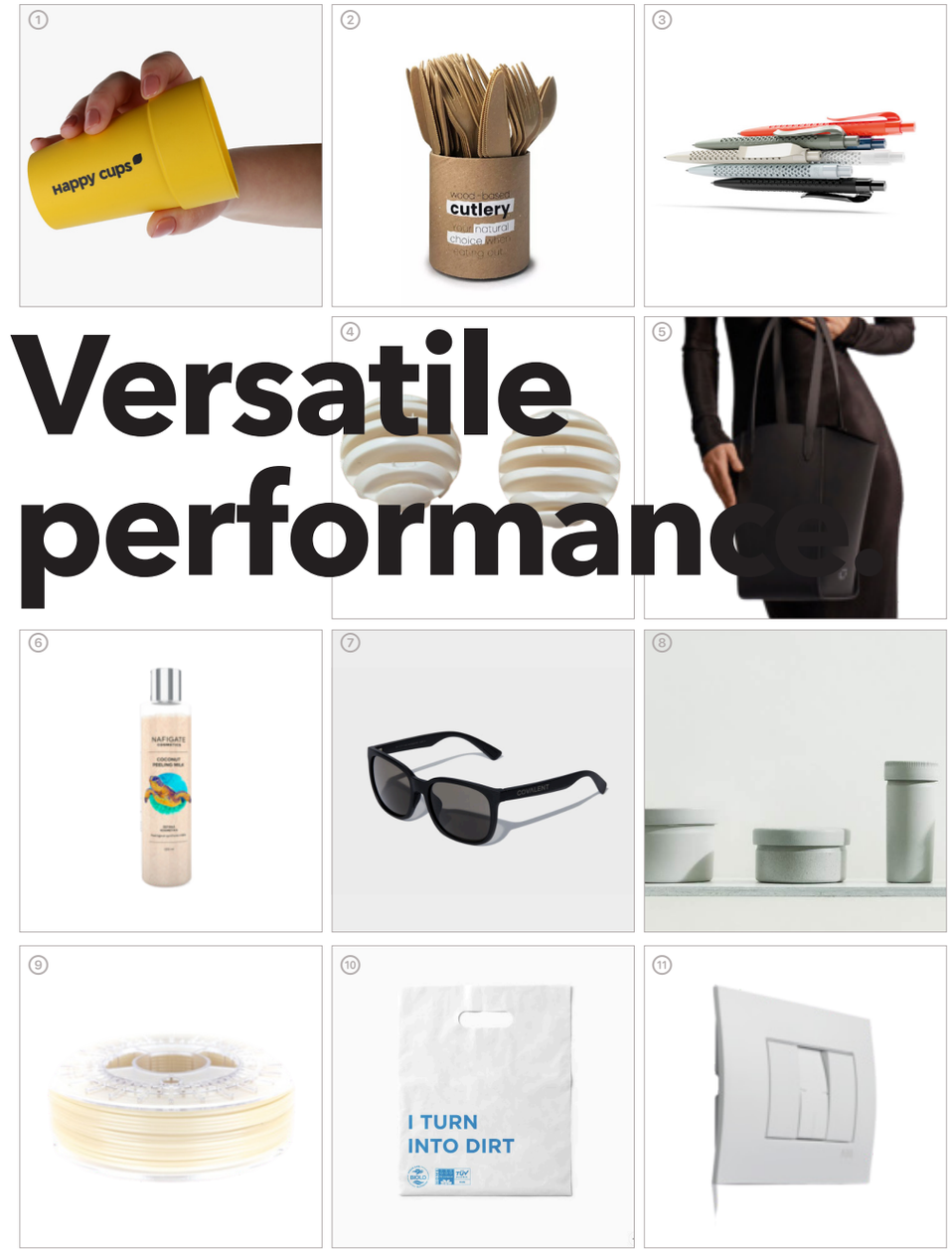
Depending on type and grade, PHAs can be used for injection moulding, extrusion, thermoforming, foam, woven (textiles) & non-woven applications, fibers, 3D printing, paper coating, and fertiliser coating, glues, adhesives, in lubrication systems, as an additive for reinforcement or plasticisation or as a building block for thermosets in paints and foams.

Several non-traditional plastic applications have been developed as well, such as animal feed, medical care for humans and animals, denitrification agents, artificial turf infill, and cosmetic ingredients.

The main markets where PHAs are already accomplishing major growth initiatives are packaging, food service applications, agriculture, and medical products.

Application examples (right page)

1. Reusable drinking cups by Happy Cups
   Injection molding, PHBV
2. Reusable cutlery set by Refork
   Injection molding, Wood flour with PHBV
3. Pens by Prodir True Biotic
   Injection molding, PHBH
4. NPX Bioballs by Reef Interests
   Injection molding, PHB
5. Handbag by Covalent Fashion
6. Cosmetic ingredients by Nafigate
   Exfoliants, UV-protection and deodorant absorbers, PHB
7. Sunglasses frame by Covalent Fashion
   Injection molding, PHB
8. Rigid packaging by Shellworks
   Injection molding, PHBV
9. 3D printing filament by colorFabb
   PHBV
10. Reusable shopper bag by Biolo
    Cast film, PHBH
11. Light switch by ABB
    Injection molding, PHBH



Help the planet recover.

The one solution

- Globally, principles of circularity and sustainability are taking center stage as investors, legislators (e.g. the European Green Deal) and the general public increasingly focus on combating climate change and plastic pollution.
- Making the switch from fossil-based plastics to 100% natural-based materials is one solution that will have a tremendous impact on combating climate change and plastic pollution.

Meet climate targets

- CO2 and methane can be used as feedstocks to create PHAs, helping the reduction of greenhouse gases in the atmosphere.
- PHA can be produced using renewable and plant-based feedstocks.
- Articles made from natural PHAs won't turn into microplastics which lower the uptake and storage of CO2 in our oceans.

Why is PHA important to you as a change agent or influencer?

Boost the bio-based circular economy

Natural PHAs offer a wide range of end-of-life options including recycling or upcycling, home or industrial composting, and biodegradation in soil and marine conditions.

Natural PHAs are fully compatible with nature and can be absorbed by natural bacteria (closing the loop in the back-end).

Prevent plastic pollution and tackle (food) waste

Waste streams like used cooking oils, organic/food waste, plastic waste, and wastewater are used as feedstock to create PHA.

Products made from natural PHAs will degrade harmlessly into the soil or the ocean without harming wildlife, people or the environment.

A cost-efficient and cost-competitive solution

Natural PHAs are already competing at reasonable levels with their fossil-based equivalents for specific applications.

With increased production capacities and processes, cost-efficiency and cost-competitiveness will improve.

Investing in a natural alternative to fossil-based plastics that tackles so many pressing global issues all at once = saving money in the long run.

FUTURE
DEVELOPMENTS.

How scalable is PHA?

The demand for PHA on the market is heavily increasing. Gradually, multi-national brands and innovative startups are collaborating with producers to innovate traditional fossil-based plastics.

Can PHA handle growing market demand?

The PHA industry has taken ±40 years to develop, pilot, and install about 48 kilotons of different PHA polymer types per annum.
This capacity is expected to increase tenfold in the next five years. It is estimated to reach a production capacity of about 570 kilotons. This increase is the result of rising demand and the advancement of technology.[15]

The PHA industry is surpassing its growth expectations. Several PHA biopolymers have already proven their success in various market applications and are ready to scale, while others are quickly advancing in their development.

The recent expansions and the rapid increase in capacity demonstrate the scalability of the PHA production process. The PHA industry also has the advantage of having a very diverse feedstock intake. Different producers use different renewable and recycled feedstocks making future growth limitless.

15_Nova institute and GO!PHA Industry Landscape Report 2022

2022
48 kilotons
2027
570 kilotons

"We think that natural PHA materials show a larger application versatility than any other existing material platforms can mimic. The reason for this thought is that natural PHA materials are already used in nature for many purposes and for much longer than the existence of mankind."

Jan Ravenstijn and Gui-Qiang Chen

Let's go PHA.

We are here to help you reduce and eliminate plastic pollution.

GO!PHA

The Global Organization for PHA is a member-driven, non-profit initiative to accelerate the growth of the PHA industry.

GO!PHA is a platform for learning, creating, and sharing experiences and knowledge on PHA biopolymers and to facilitate the growth and proliferation of the PHA Industry and its downstream markets.

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