Unlocking the Potential of Bioplastics
Provide an honest product. And think beyond.

Our Bio & Beyond strategy is aligned with Trinseo’s commitment to sustainability and corporate social responsibility. The focus on environmental and social responsibility is intrinsic to who we are as an organization.

As we help our customers meet their most complex materials challenges, we create sustainable solutions designed to enhance and improve people’s lives around the world.

Our commitment to sustainability does not stop with us. It is carried out into the world through the tangible benefits of our materials, which power ideas and innovation.

Learn more about the benefits that our approach and products can provide.
Trinseo Fast Facts

A strong track record – a bold direction

Trinseo (NYSE: TSE) is a global materials solutions provider and manufacturer of plastics, latex binders, and synthetic rubber.

We are focused on delivering innovative and sustainable solutions to help our customers create products that touch lives every day — products that are intrinsic to how we live our lives — across a wide range of end-markets, including automotive, consumer electronics, appliances, medical devices, lighting, electrical, carpet, paper and board, building and construction, and tires.

Global resources

Trinseo delivers an unmatched combination of global reach, operational excellence, expertise, leading intellectual property, world-scale assets, and global R&D presence.

$4.6 B
REVENUE IN 2018

2,500
EMPLOYEES IN 25 COUNTRIES

11
R&D FACILITIES GLOBALLY

16
MANUFACTURING SITES GLOBALLY
Bioplastics: Differentiation is Key

Bioplastics can be divided into bio-based and/or biodegradable plastics.
Specific benefits for many applications

We are aware of the specific requirements that our customers’ products have to meet.

Bio-based Plastics

Bio-based means "from nature to plastic." Plastic is derived from petroleum or natural gas while bio-based traditional plastics are to a varying degree derived from renewable biomass sources, such as cornstarch, sugarcane, sugar beet, cellulose, or vegetable oils.

Our bio-based thermoplastic product families APILO™ S2 BIO and APILO™ BIO can be found in a wide range of applications and can contribute to a reduction in CO₂ and other greenhouse gas emissions compared to fossil-based plastics.

Biodegradable Plastics

Biodegradability stands for the potential degradation of a plastic by the action of microorganisms (such as bacteria, fungi, algae) to carbon dioxide (and/or methane), water, mineral salts and biomass.

In a composting environment, biodegradable bioplastic will degrade into CO₂ and water – caused by bacteria or other biological means. The European standards consider a material to be biodegradable if it degrades by at least 90 percent within six months.

Aerobic and anaerobic biodegradation

Calculation of the bio-based mass content

\[
m_B = \frac{\sum_{i=1}^{n} W_i \cdot m_{B,i}}{W}
\]

- \(m_B\) is the bio-based mass content of the product, expressed as a percentage of the total mass of the product
- \(m_{B,i}\) is the bio-based mass content of the constituent (i), expressed as a percentage of the mass of the constituent (i)
- \(W_i\) is the mass of the constituent (i), expressed in grams
- \(W\) is the total mass of the sample, expressed in grams
- \(n\) is the number of constituents of the product

Bio-based or partly bio-based non-biodegradable polymers

Biodegradable and bio-based plastics

Biodegradable fossil-based plastics

Calculation:  \( m_B = \frac{\sum_{i=1}^{n} W_i \cdot m_{B,i}}{W} \)

1. Bio-based or partly bio-based non-biodegradable polymers
2. Biodegradable and bio-based plastics
3. Biodegradable fossil-based plastics

Source: Material coordinate system of bioplastics, Prof. Dr. Ing. H.-J. Endres, FIFA University of Applied Arts
Life Cycle Assessment (LCA)

A measurement for the advantages of bioplastics partly or fully made of renewable resources

Being committed to save fossil resources for future generations and reduce greenhouse gas emissions, we strive to increase the amount of raw materials partly or totally derived from renewable resources. In addition to the reduced use of fossil-based materials, this facilitates the recycling of materials that cannot be reused.

For the optimization of our bio-based products regarding their entire life cycle, we apply the Life Cycle Assessment (LCA) methodology. This methodology allows for evaluating all the environmental impacts associated with a product.

The LCA considers a product’s entire life cycle from the extraction of raw materials to its final disposal or end-of-life waste management (cradle-to-grave). LCA is an internationally standardized method under ISO 14040 and ISO 14044.

Bio-based plastics can provide environmental advantages

For example, bio-based plastic can reduce the consumption of non-renewable primary energy like oil, coal and natural gas.

Also, bio-based plastic can regulate the global warming potential (GWP 100), a measure of the greenhouse effect, which is calculated over 100 years. It is also known as “carbon footprint”.

The water footprint, which will show in Water Scarcity Index (WSI), is the relationship between total water use (“water footprint”) and water availability. Bio-based plastics can reduce the water footprint, too.

The benefits of having bio-based materials can be:

→ Strategic repositioning of the product
→ Communicate environmental information that can be used to enhance the product reputation
→ Get eco-labeling (e.g. EU Ecolabel, Carbon Footprint)
→ Release Environmental Product Declarations (EPD)
Bioplastics Market

The increasing consumer demand for sustainable products supports the continuous growth of the bioplastics market.
Global Production Capacities of Bioplastics

It is expected that global bioplastics production capacity is set to increase from around 2.05 million tonnes in 2017 to approximately 2.44 million tonnes in 2022.

Global production capacities of bioplastics by market segment (in 2017)

- Packaging (flexible & rigid)
- Consumer goods
- Automotive & Transport
- Building & Construction
- Textiles
- Agriculture & Horticulture
- Electrics & Electronics
- Others

Global production capacities of bioplastics (2017–2022)

<table>
<thead>
<tr>
<th>Year</th>
<th>Bio-based/non-biodegradable</th>
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<td>880</td>
<td>931</td>
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<td>911</td>
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Land use estimation for bioplastics 2017 and 2022

In the course of the next few years, there will be no competition between renewable feedstock for food, feed and bioplastic.

Global land area

- 15 billion ha = 10.0% (Pasture)
- 1.4 billion ha = 29% (Food & Feed)
- 1.24 billion ha = 25% (Agriculture & Horticulture)

Global agricultural area

- 4.9 billion ha = 38% (Pasture)
- 1.5 billion ha = 29% (Food & Feed)
- 1.25 billion ha = 25% (Agriculture & Horticulture)

Including bioplastics

- 2017: 0.82 Mio ha = 0.016%
- 2022: 1.08 Mio ha = 0.021%

* In relation to global agricultural area
** Including approx. 1% fallow land

Source:
- European Bioplastics (2017), FAQ Stats (2014), nova-Institut GmbH (2017), and Institute for Bioplastics and Biocomposites (2016)
Bio & Beyond

Unlocking the Potential of Bioplastics

We embraced the Bio & Beyond strategy when we developed our first biodegradable compound APINAT™ BIO. Our aim was and still is to reproduce our current products in a bio-based and biodegradable version.

Reproduction of current fossil-based plastic applications in bio-based and biodegradable versions can offer environmental benefits:

- Saving of global fossil resources
- Reduction of Global Warming Potential
- Reduction of water consumption
- Sustainable waste management
Over the last few years, we have introduced bioplastics in a growing number of new applications. Our bioplastics portfolio includes advanced biodegradable and bio-based polymers and compounds:

**Bio-based and biodegradable TPE solutions**

**Bio-based**

- non-biodegradable plastics
- **APILON**™ 52 BIO
  - Bio-based TPU Polymers and Compounds
- **APIGO**™ BIO
  - Bio-based TPO Compounds

**Biodegradable**

- and bio-based plastics
- **APINAT**™ BIO
  - Biodegradable TPC Compounds
- **APINAT**™ F BIO
  - Biodegradable TPC Compounds

**Biodegradable**

- fossil-based plastics
**APIOLON™ 52 BIO**

**Main features**

- High bio-based content with environmental benefits
- Recyclability
- Transparent, translucent
- Soft-touch haptic surface
- Resistant to oil, grease, chemicals
- Resistant to low temperatures
- Good abrasion resistance
- Good processability
- Colorability

**Proactive Product Innovation: APIOLON™ 52 BIO for footwear and fashion applications**

The broad range of APIOLON™ 52 BIO grades allows it to use these polymers and compounds in a huge variety of applications, both in footwear and in leather goods.

We developed APIOLON™ 52 BIO facing the increasing importance of ethical principles in the world of fashion. It is part of an evolution towards an eco-sustainable economy bringing social, economic, and environmental advantages.

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**APIIGO™ BIO**

**Main features**

- High environmental benefits
- Soft and hard products
- Special grades: food contact approved (EU 10/2017, FDA)
- Medical grades (biocompatibility in accordance with USP VI and ISO 10993)
- Resistance to low temperature
- UV stability
- Good processability
- Colorability
- Recyclable

**Proactive Product Innovation: Tampon applicator made with APIIGO™ BIO**

Nearly all the tampon applicators on the market are made of polyethylene or polypropylene.

Women are increasingly interested in hygiene products made from natural or sustainable materials.
### BIODEGRADABLE SOLUTIONS

#### APINAT™ BIO

Biodegradable TPC

### Main features

- OK compost certification (EN 13432)
- Food contact approved (EU 10/2011, FDA)
- Highly bio-based
- Resistance to low temperature
- Transformation technology: film blowing
- Recyclable
- Colorability

#### Proactive Product Innovation: Biodegradable and compostable coffee capsules

- Biodegradable and compostable
- Highly bio-based
- Food contact approved
- Easy processability
- High oxygen barrier properties
- High thermal stability

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**Oxygen transmission rate (cm³/m²/day) - ASTM F 1927 (thickness 800µm)**

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<th></th>
<th>PP HOMO 40</th>
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**Total biodegradation of APINAT™ BIO**

- Before degradation
- During degradation
- Compost at the end
- Back to Nature

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