

Compostable Plastics - Market trend and research opportunities to unlock potentials

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March 31, 2023

Nano-enable sustainable materials for green-economy



Circular Economy

- ❖ Established by Ellen MacArthur Foundation, Circular Economy is the system that replaces the end-of-life concept, with reducing, alternatively using, recycling and recovering materials in production/distribution and consumption processes.
- ❖ In collaboration with the UN Environment Programme, Ellen MacArthur Foundation leads a program called “*the Global Commitment*” and “*Plastics Pact Network*” to
 - i. Eliminate unnecessary and problematic plastic packaging through redesign and innovation
 - ii. Move from single-use to reuse
 - iii. Ensure all plastic packaging is reusable, recyclable, or **compostable**
 - iv. Increase the reuse, collection, and recycling or **composting** of plastic packaging
 - v. Increase recycled content in plastic packaging.
- ❖ Businesses and governments over 1,000 signatures including companies representing 20% of all plastic packaging produced globally
 - Well-known consumer businesses (L’Oréal; MARS; Nestlé; PepsiCo; The Coca-Cola Company; and Unilever)
 - World’s largest retailer – Walmart
 - Major packaging producers (Amcor and Berry Global)
- ❖ Brand owners are developing packaging with mono-material (PE, PP) to enable recyclability. Compostable plastics is a part of circular economy, but not as focused as recycling



Bioplastics: Helping waste management 'close the loop'

Biodegradable material contributes to organic recycling loop and this loop is started in each region.

Bio-waste management in EU is consolidated over 4,500 composting facilities in each region EU and highest in Bio-waste recycling is Germany, UK, Italy, France and Netherland.

On the other hand, composting facility in US gradually built up but limited compared with EU region. US market is studying other solution. And other region, compost facilities are limited, and waste management is incineration mainly.

Composting facilities in USA increased from 108 (2021) to 123 (2022).

European Bio-Waste Management

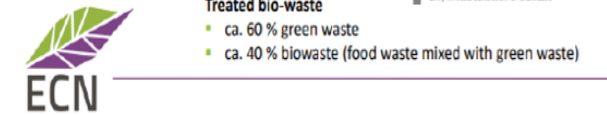
Biological treatment of municipal biowaste	Plants	Input [Mio t/a]
Composting	3.849	30.55
AD and combined AD & composting	705	14.38
Total	4.554	44.93



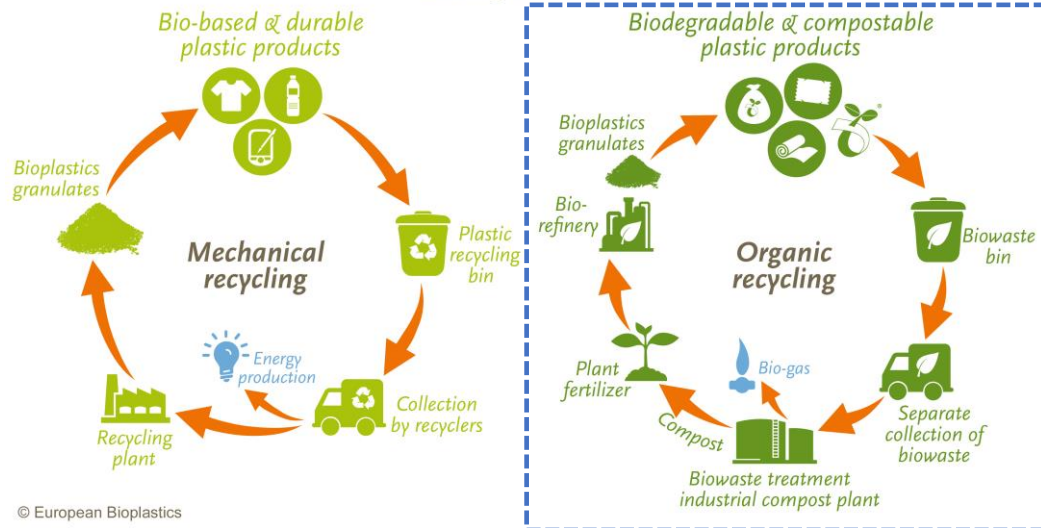
Source: ECN/ISWA Survey 2017 (results from 19 European Countries*)

* AT, BE, CH, DE, EE, FI, FR, HU, IE, IT, LT, NL, NO, PL, PT, SE, SI, ES, UK

- Separate collection and composting of biowaste
- Separate collection of biowaste in preparation/implementation
- Only limited collection of biowaste

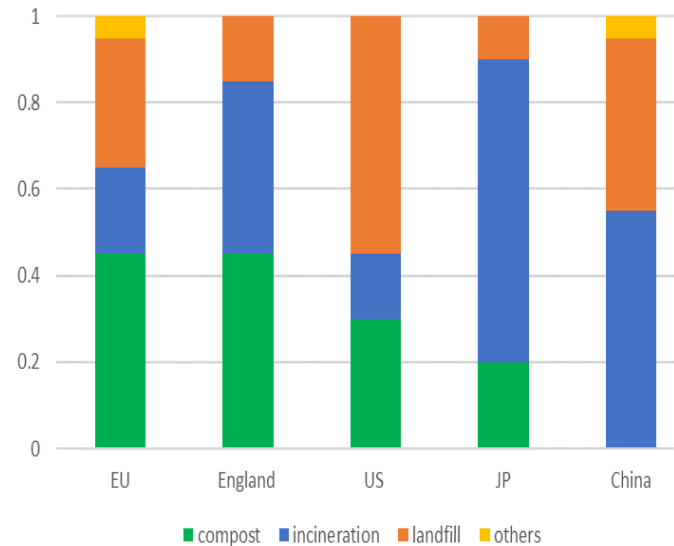


End-of-life options for **BIOPLASTICS** – Closing the loop –

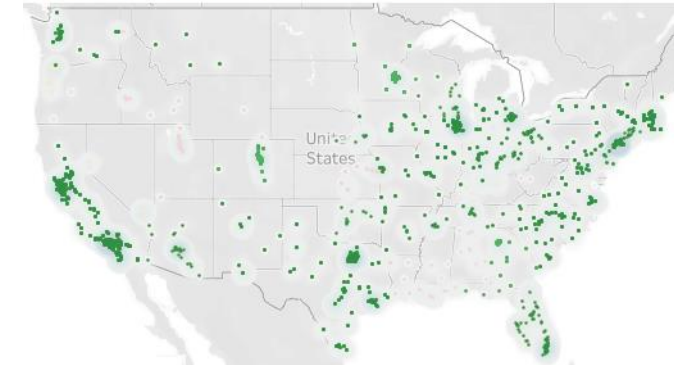


© European Bioplastics

Disposal process of waste in each region



Composting Locations in USA (123 facilities)





There are 21 products under this Directive

1. Balloon sticks
2. Beverage containers made of EPS with caps and lids
3. Beverage stirrers
4. Cotton bud sticks
5. Cups for beverages made of EPS with covers and lids
6. Cutlery (forks, knives, spoons, chopsticks)
7. Food containers made of EPS
8. Plates
9. Straw
10. Products made from oxo-degradable plastic
11. Balloons
12. Beverage containers up to 3L with caps and lids
13. Beverage bottles up to 3L with caps and lids
14. Cups for beverages with cover and lids
15. Food containers
16. Lightweight plastic carrier bags
17. Packets and wrappers
18. Sanitary towels (pads), tampons, tampon applicators
19. Tobacco products with filters and filters
20. Wet wipes
21. Fishing gear

Red = ban

EU Single Use Plastics Directive



Single-Use Plastic Products	Consumption Reduction	Product Requirement	Marking Requirements	EPR	Separate Collection	Awareness Raising
Balloon				✓		✓
Beverage bottles ≤ 3L including caps and lids		✓			✓	
Beverage containers ≤ 3L including caps and lids		✓		✓		✓
Cups for beverage (Paper cup)			✓			
Cups for beverage including covers and lids	✓			✓		✓
Food containers	✓			✓		✓
Lightweight plastic carrier bags	✓			✓		✓
Packets and wrappers				✓		✓
Sanitary towels (pads), tampons, tampon applicators			✓			✓
Tobacco products with filters and filters marketed for use in combination with tobacco products			✓	✓		✓
Wet wipes			✓	✓		✓
Fishing gear <ul style="list-style-type: none"> ○ ensure rules on EPR for fishing gear containing plastic are in place ○ monitor and assess plastic fishing gear with a view to establishing EU-wide collection targets. 				✓		

What is Compostable Plastics

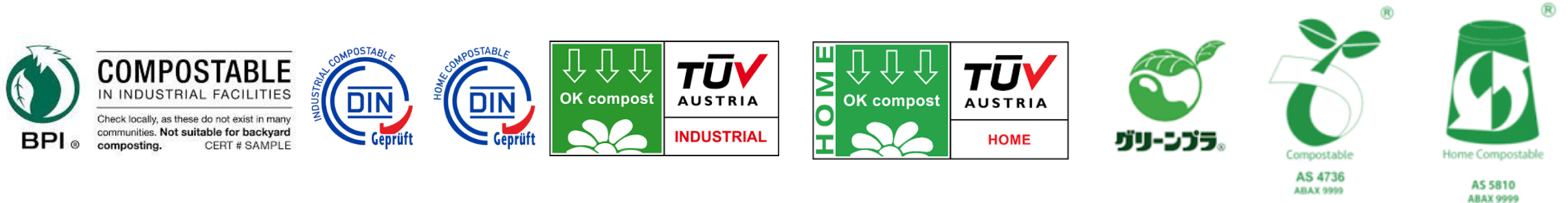
Bio-based Plastics = made of or contain renewable resources



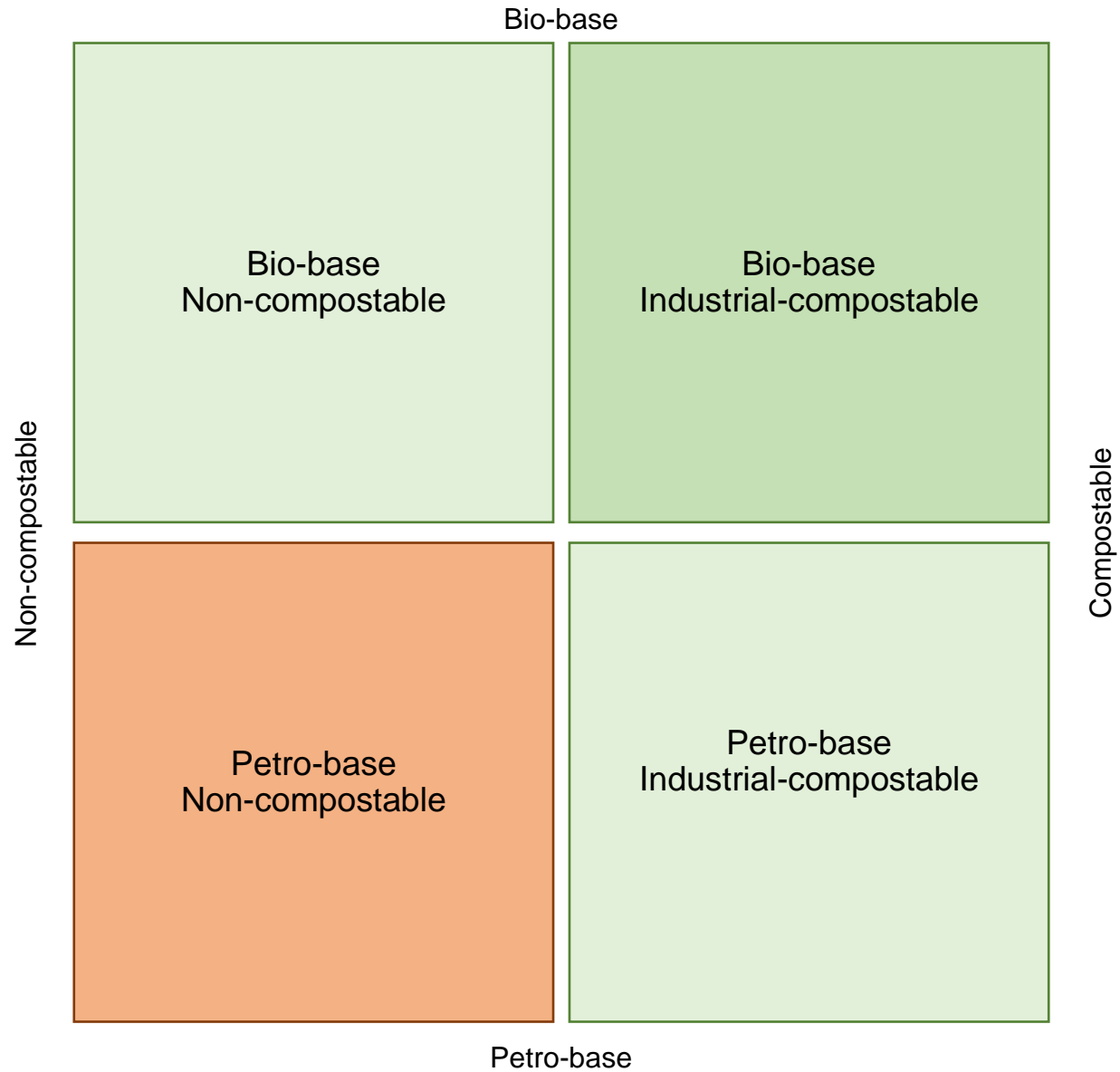
Compostable Plastics: EN13432, EN14995, ASTM D6400, ISO17088, AS4736, TIS17088

Controlled condition: 60°C

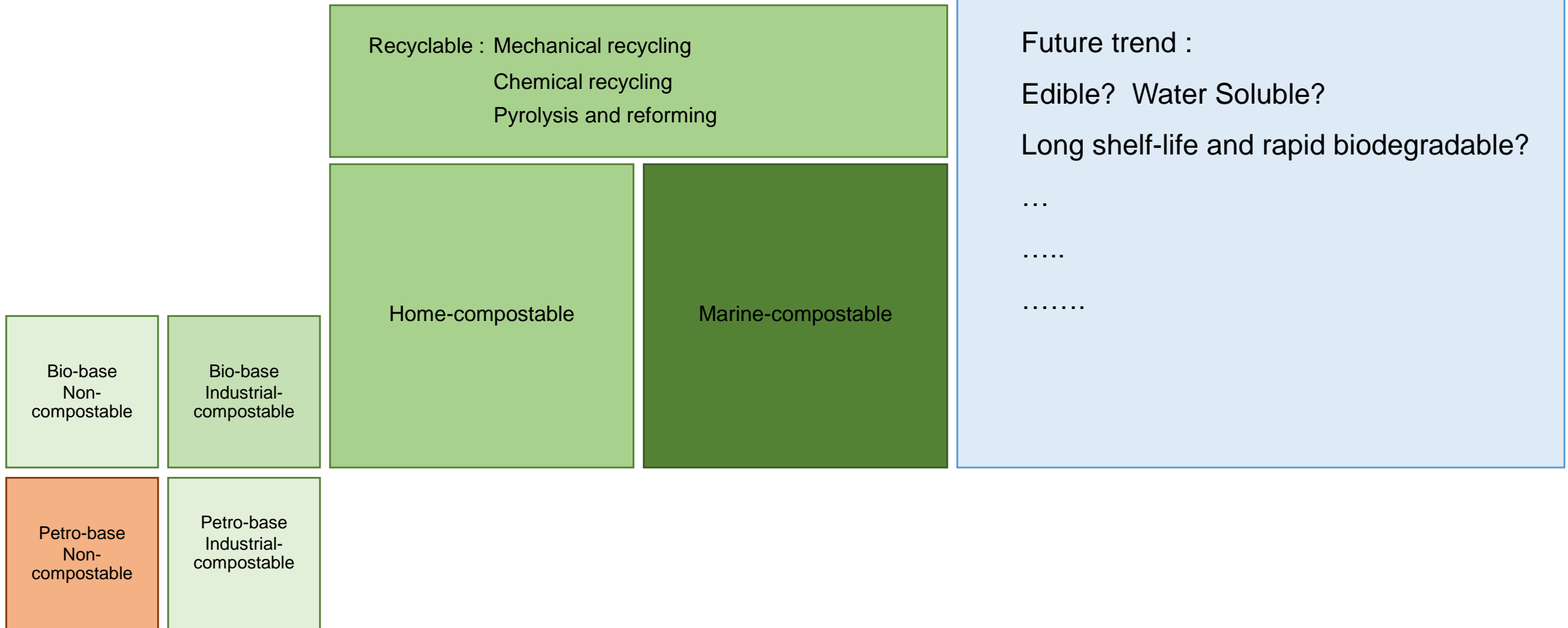
- Disintegration: decomposed into tiny pieces (2x2 mm) in 12 weeks
- Biodegradation: ≥90% broken down by biological action into CO₂, water, and mineral within 6 months.
- Ecotoxicity
- Chemical Composition: volatile matter, heavy metals (Cu, Zn, Ni, Cd, Pb, Hg, Cr, Mo, Se, As) and fluorine



Sustainability Trend

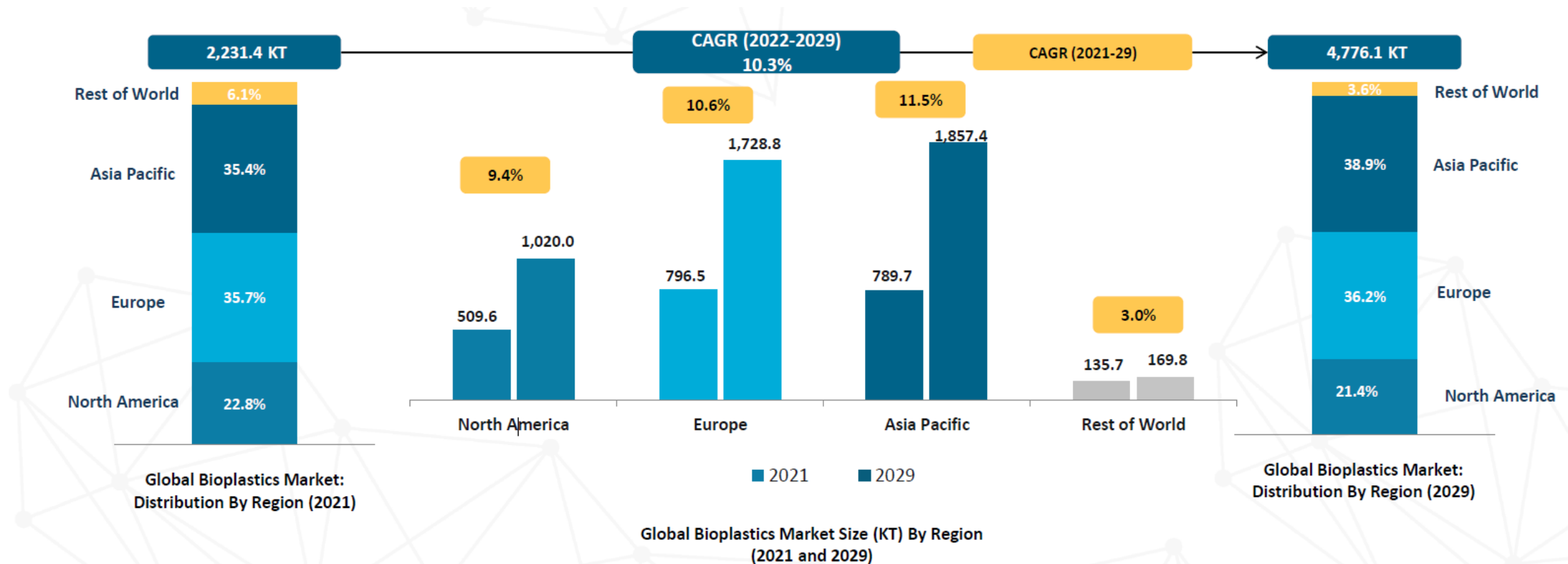


Sustainability Trend



Market trend of bioplastics

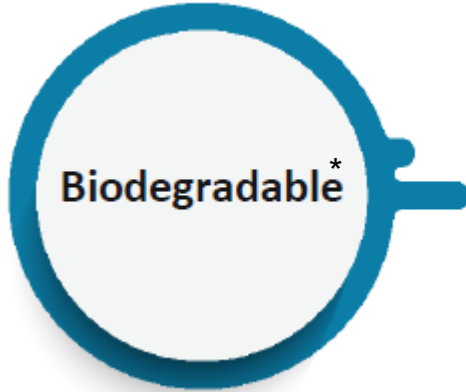
Global Bioplastics Market Volume Breakdown (KT, %) by Region, 2021 & 2029 (Include biodegrade& non-biodegradable)



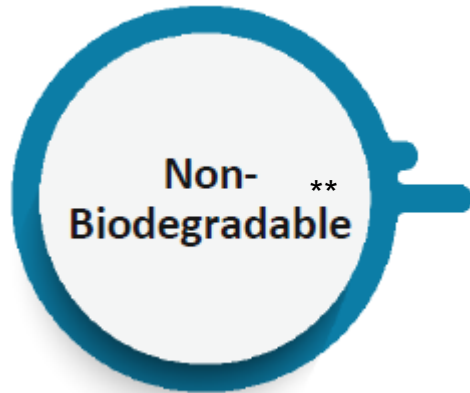
Biodegradable demand growth : APAC > EU > NA

- Due to swiftly increasing demand of bioplastics to reduce the impact of plastic waste on the environment, biodegradable grades of bioplastics are expected to gain market share during the forecast period.
- The market for biodegradable segment accounted for a volume of 1,241 KT in 2021 and is expected to reach the volume of 2,749 KT in 2029 growing at a volume based CAGR of 10.8%.

Bioplastics Market

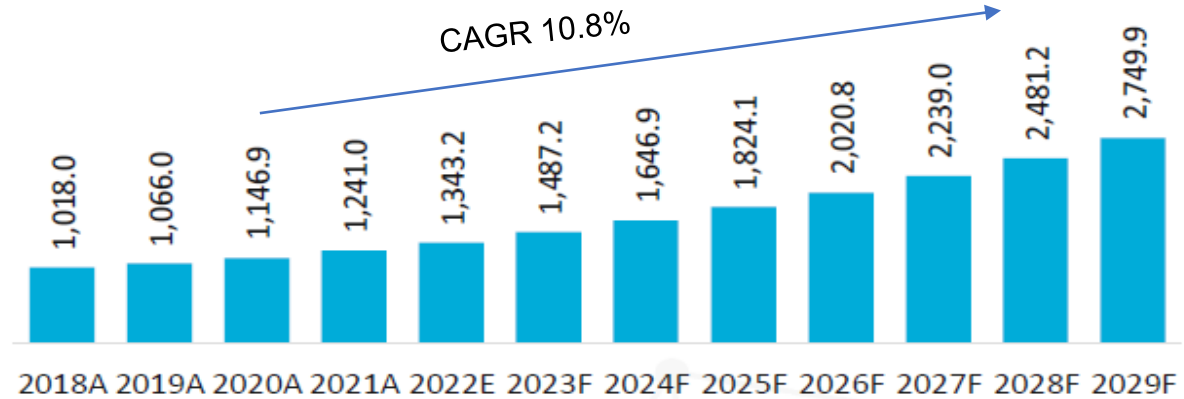


*All bioplastics that has compostable property - PLA, PBAT, PBS, PHA, starch blend

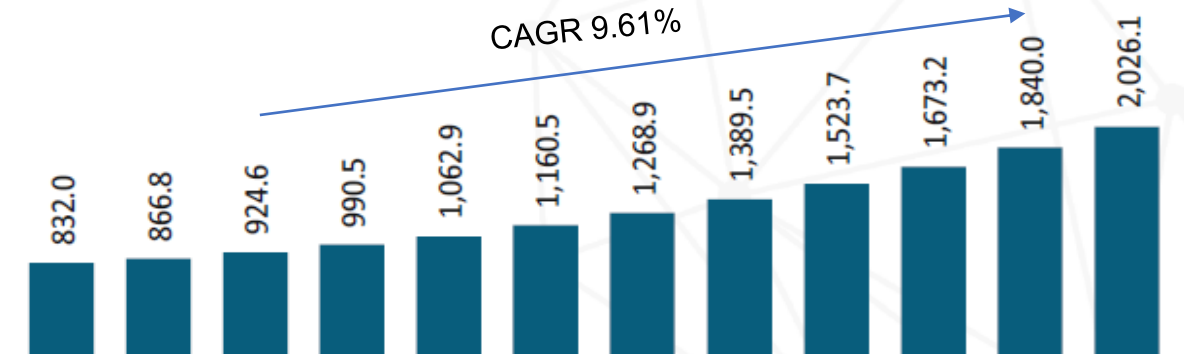


**All bioplastics that has biobased property, but not compostable-Bio-PET, Bio-PA, BioPE, BioPP, BioPTT

Global Bioplastics Market Forecast (kT), by Biodegradable, 2018-2029



Global Bioplastics Market Forecast (kT), by Non-Biodegradable, 2018-2029



Demand growth of biodegradable plastic will outpace non-biodegradable due to swiftly expanding demand of bioplastics to reduce the impact of plastic waste on the environment.

Market driver (+)

Bioplastics growth

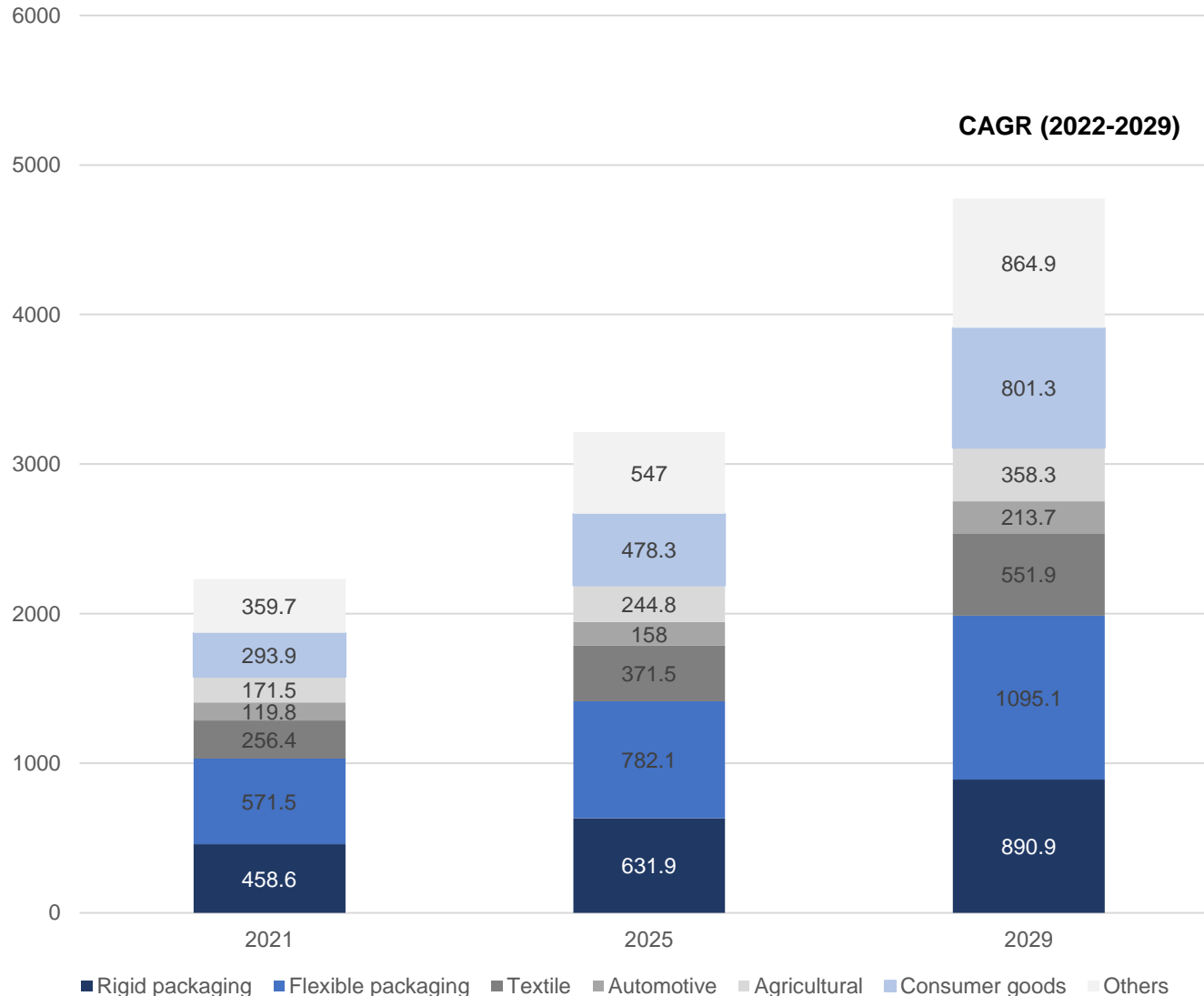
Market restraint (-)

- The increasing demand of plastics for packaging generates plastics wastes at the same time. Industry is looking for sustainable solution to tackle the waste issue.
- The increase of government mandates has moved their focus on usage of more sustainable solutions including recycled plastics and bioplastics
- Usage of plastic not only cause damage to the environment, but also affects the growth of crops by restricting the access of roots to water and nutrients present in soil. Newly developed bioplastics film can help improve soil quality without removing. These factors led to increasing demand for biodegradable plastics from agriculture and horticulture sectors
- **Russian Ukraine Conflict:** The increasing global prices of oil and gas due to the decrease from Russia's oil and gas exports to the world. This results in price increase of ethylene, PE ,and ultimately shift the consumer towards sustainable alternatives such as bioplastics
- **The cost inflation** is impacting the packaging industry due to increase in costs of energy transportation, and labor. This impact of inflation will shift the end users to sustainable and recycled alternatives such as bioplastics and recycled plastics

- Due to duality in meaning of bioplastics (Biobased vs Biodegradable), many consumers get confused about the biodegradability of bioplastics thus creating a hurdle in its adoption
- With governments raising the bar regarding the usage of non biodegradable grades of plastic, consumers are concerned about the quality and sustainability of bioplastics and thus possessing a restraint to the growth of the market
- Due to lack of proper infrastructure & collecting system, result, bioplastics may often end up in landfills
- if bioplastics are not disposed properly, they contaminate the feedstock stream of recycled plastics and harm the recycling infrastructure instead. Thus, increasing the total cost of management.
- Comparatively High Cost of Bioplastics than Conventional Alternatives creates hurdle for easy adoption.

Bioplastics Market:

Global Bioplastics Market Volume (Kton) Forecast by Application



- The largest application of bioplastics is in Flexible Packaging as packaging products like films, pouches and bags are in significant demand for manufacture of food packaging to safeguard them from potent microorganisms and environmental aspects.
- Leading automobile manufacturers are already utilizing bioplastics like Bio-PA and Bio-PP to
 - reduce the product's environmental impact
 - provide additional strength to the components used in automobiles
- Bioplastics is also finding application in home textiles, clothing and footwear industry Poncho, a type of raincoat manufactured by Equilicua, a Spanish company, is an excellent example of bioplastic based protective clothing that is 100% compostable and biodegradable.



Introduction & Methodology

To understand what sustainable food packaging could look like in 2040, UPM Specialty Papers and Smithers harnessed the collective insight of the global packaging community by surveying over 200 senior packaging professionals from across the value chain.

EXECUTIVE SUMMARY

KEY TRENDS FOR SUSTAINABLE PACKAGING IN 2040:

- By 2040 consumers won't tolerate a choice between sustainability and convenience. They will expect both. Brands will need packaging solutions that provide good end-of-life options without compromising convenience and performance.
- By 2040 sustainability will not be a brand choice but a strict government mandate. Materials and pack types that do not reach thresholds for environmental performance will not be available for use.
- By 2040 Fibre-based packaging will be perceived as the most sustainable packaging solution by consumers.
- By 2040 recycling, reuse and composting will all increase significantly but 21% of all food packaging will still find its way to landfill and incineration.

Trend of Sustainability / Consumer view

TREND 1
CONSUMERS
WON'T TOLERATE
A CHOICE BETWEEN
SUSTAINABILITY AND
CONVENIENCE

TODAY

Most food is purchased every few days from local convenience stores, variety is limited to local supply chain capabilities and shelf space limitations

Grocery stores are functional and high cost for retailers and a declining barrier to entry for start up brands. They are necessary and mundane for consumers

Packaging delivers mass marketing with minimal direct interaction or personalisation. Global brand packaging has little or no regional or demographic variations

BY 2040

→ All products will be a few clicks and a few minutes away, omnichannel packaging that enables speed and convenience will be essential

→ Retail environments will become more experiential, orientated to product launches and engagement

→ Packaging will continue to play an important promotional role enabled by highly customised or personalised campaigns and immersive technology

“Smart packaging, functionality, and personalisation will be key growth drivers for packaging for more sustainability, traceability, authentication and protection, and a better consumer experience!”

– Asian Brand Owner –

“Functionality and environmental impact of the packaging will be very influential in the decision buying process.”

– Asian Converter –

“Convenience is given, environmental footprint of product and package will be the key differentiator, enabled by smart packaging.”

– European Converter –

Outlook for Consumers

By 2040 consumers won't tolerate a choice between sustainability and convenience. They will expect both. Brands will need packaging solutions that provide good end-of-life options without compromising convenience and performance.

- By 2040, consumers will make a decision on purchase based on environmental impact of packaging also : recyclable, compostable
- Traceability of how packaging is made of and end-of-life options will be important : original feedstock, recyclable, compostable

TREND 2

SUSTAINABILITY WILL BE A STRICT GOVERNMENT MANDATE

By 2040 sustainability will not be a brand choice but a strict government mandate. Materials and pack types that do not reach thresholds for environmental performance will not be available for use.

Changing Regulatory Requirements, %



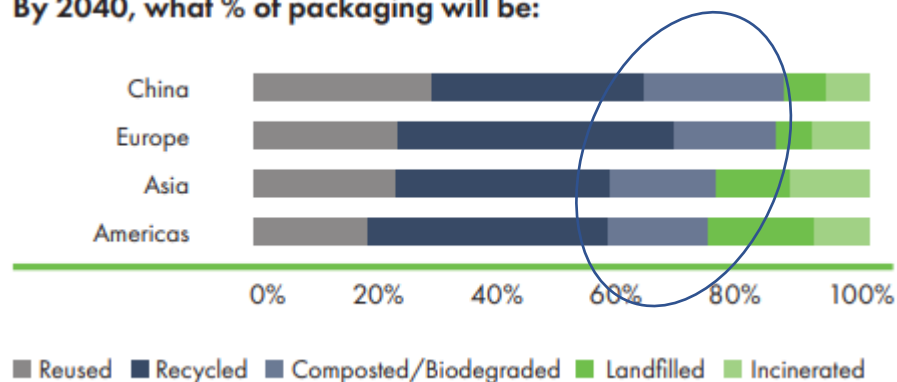
TODAY	BY 2040
Established EPR systems in developed markets, increasing prevalence of climate change regulations impacting packaging materials	→ Many fossil fuel based and non-recyclable packaging materials are now banned and companies face heavy taxes and fines for packaging this is not reused or recycled
Use of Recycled fibre in food contact applications has been hindered due to food safety/migration concerns and lack of clear legal standards	→ Food safe recycled fibres are FDA and EFSA approved, improvements in recycling technology and better supply chain traceability enable safe use of recycled fibre in food applications
Consumers find it hard to make informed packaging choices about the environmental impact and appropriate disposal of the materials they use	→ Smart packaging will enable informed sustainability choices for consumers and better traceability throughout the value chain

- By 2040, fossil-based packaging could be banned due to climate change regulations. Bio-based packaging becomes mandatory.
- Traceability of how packaging is made of and end-of-life options will be important : original feedstock , recyclable , compostable

TREND 3
CHALLENGES IN MEETING TARGETS FOR SUSTAINABLE END-OF-LIFE

By 2040 recycling, reuse and composting will all increase significantly but 21% of all food packaging will still find its way to landfill and incineration, meaning many brands will need to adapt their sustainable packaging targets.

By 2040, what % of packaging will be:



TODAY	BY 2040
<p>Less than 1% of all food packaging is reused, pilot initiatives like loop are being implemented on a trial basis, volumes are very low.</p>	<p>→ 23% of food packaging could be used through a range of retailer return and collection systems in store and through delivery with consumers incentivised through price to participate</p>
<p>Food packaging is predominantly plastic and recycling rates are relatively low. Fibre-based packaging is widely recycled for non food use</p>	<p>→ Recycling rates for plastic and fibre based food packaging have increased significantly. Fibre-based packaging is approaching circularity as it can be used in food applications</p>
<p>Compostable packaging is a nascent technology with cost barriers and limited disposal options</p>	<p>→ 17% of all food packaging can be easily home composted</p>

TREND 4



FIBRE-BASED PACKAGING WILL DOMINATE

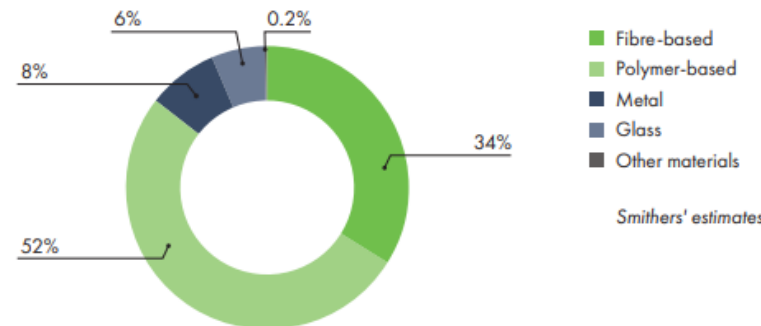
By 2040 fibre-based packaging will be perceived as the most sustainable packaging solution by consumers. Packaging innovations will enable smarter, more interactive and higher performance fibre-based packaging to succeed in new food applications.

“The use of fibre-based packaging is likely to grow even further due to its perceived image by consumers as easily recyclable and more circular. Smart packaging technologies with full traceability (blockchain) will be used to comply with stricter regulations and recycling quota allocation”

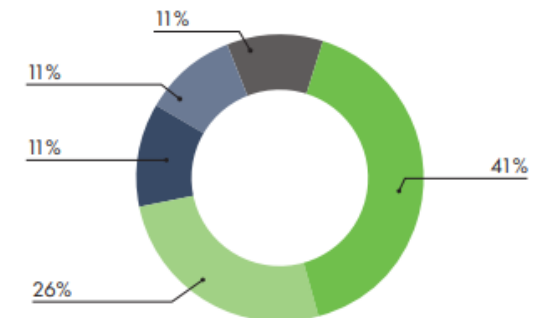
– European Packaging Supplier –

TODAY	BY 2040
Fibre-based packaging can't achieve sufficient moisture and oxygen barrier for some food packaging applications	→ A range of new technologies including micro fibrillated cellulose, novel coatings technologies and nanotechnology has enabled fibre-based packaging to compete in a wide range of markets
Consumer sentiment is starting to turn against plastic	→ Consumers perceive fibre based packaging as the most sustainable packaging solution
Initiatives to track and trace packaging through the supply chain are starting to emerge to enable smarter packaging recycling (e.g. holygrail 2.0*)	→ A range of sophisticated and low-cost digital tagging technologies will enable extremely accurate tracking of materials throughout a circular lifecycle

2021 Food Packaging Market by Material, %



Forecast Future Global Food Packaging Market By Material type (based on survey responses), %



What slows development of bioplastics

Pain Points

1. High Cost
 - Polyester has higher density
 - Smaller economy of scale
2. Poorer processability and machine is designed for polyolefin
3. Short shelf-life
4. Poorer mechanical and barrier properties
5. Limited uses condition (temperature)
6. Limited end-of-life options

What Customers Want

1. Maximum 10% higher cost
2. Similar processability
3. Long shelf-life, but rapidly biodegradable when disposed
4. Sufficient mechanical and barrier properties
5. Microwavable and ovenable
6. Multiple end-of-life options
(home compost + marine biodegradable + recycle)

Nanotechnology to improve compostable plastics

Example : Flexible Packaging

Improve shelf-life
Rapid biodegradable when disposed

Home compostable
Marine biodegradation

Recycle friendly



← Anti-microbial coating

← Improve barrier properties

← Active packaging

← Intelligent packaging

- Compostable plastics market has high potential to grow in both horizontally and vertically.
- There are big technology gap between compostable plastics and conventional plastics.
- Nanotechnology could play important roles to develop compostable plastics such as enhancing mechanical properties, improving barrier properties, accelerating biodegradation, creating antimicrobial properties, extending shelf-life of products, etc.
- Key important for development is to understand the background and trend of compostable market, sustainability, and regulation in main markets.