



CARBIOS

Enzymes powering the Circular Economy

INVESTOR DAY 2022

31st May 2022



Agenda of the plenary session

- Strategic vision & ambition 2022/2025
 -  *Speaker: Emmanuel Ladent, CEO*
- Carbios at the edge of the enzymatic innovations
 -  *Speaker: Alain Marty, CSO*
 -  *Speaker: Lise Lucchesi, Intellectual Property Director*
- Industrialisation focus on Carbios technology
 -  *Speaker: Lionel Arras, Industrial Development Director*
- Carbios' partners testimony
 -  *Speaker: Martin Stephan, Deputy CEO*
Novozymes, L'Oréal, Suntory Beverage & Food Europe
- Conclusion + Q&A
 -  *Speaker: Philippe Pouletty, Chairman*
 - Carbios' management team



Strategic vision & ambition 2022/2025

Emmanuel Ladent, Chief Executive Officer



How do we fix this?



350 million tons⁽¹⁾
of plastic produced every
year and only 14% is
recycled globally⁽²⁾



9 million tons ⁽³⁾
of plastic enter oceans
every year

Let's take action together!

It is time to rethink the way we handle the end of life of
plastics and textiles

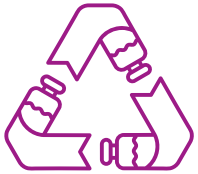
Carbios is best positioned to deliver concrete and sustainable solution to tackle this emergency.



Mission

Lead the transition towards sustainable plastics economy by developing technologies for the end-of-life of plastics

CARBIOS AMBITION



Become the world leader in PET recycling by 2035 and increase our pipeline of eco-friendly technologies



Provide the most sustainable and most circular solutions for the end-of-life of plastics and textiles



Become the best employer of its category
—
The best place to work



Carbios: a team of talents committed to innovate for the planet

The first and only company to have developed biological technologies for the end-of-life of plastics and textiles

84
employees

49%
of women
51%
of men

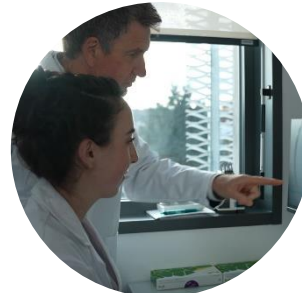
65%
of staff
dedicated to
RDI

+29
new hires
planned

4
sites



■
Clermont-Ferrand
area



■
Toulouse

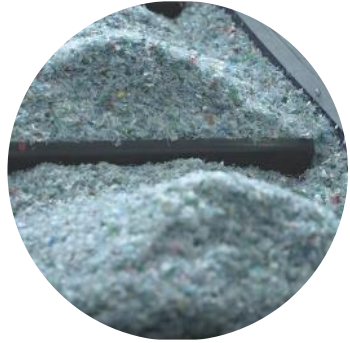


■
Longlaville



Carbios' disruptive solutions: Industrial processes for the recycling and the biodegradation of multiple kinds of plastics

Two disruptive solutions in industrial and commercial scale-up:



■ Biorecycling
PET



■ Biodegradation
PLA

Continue to innovate and offer other polymers an environmentally friendly end-of-life



■ INNOVATION
on other polymers

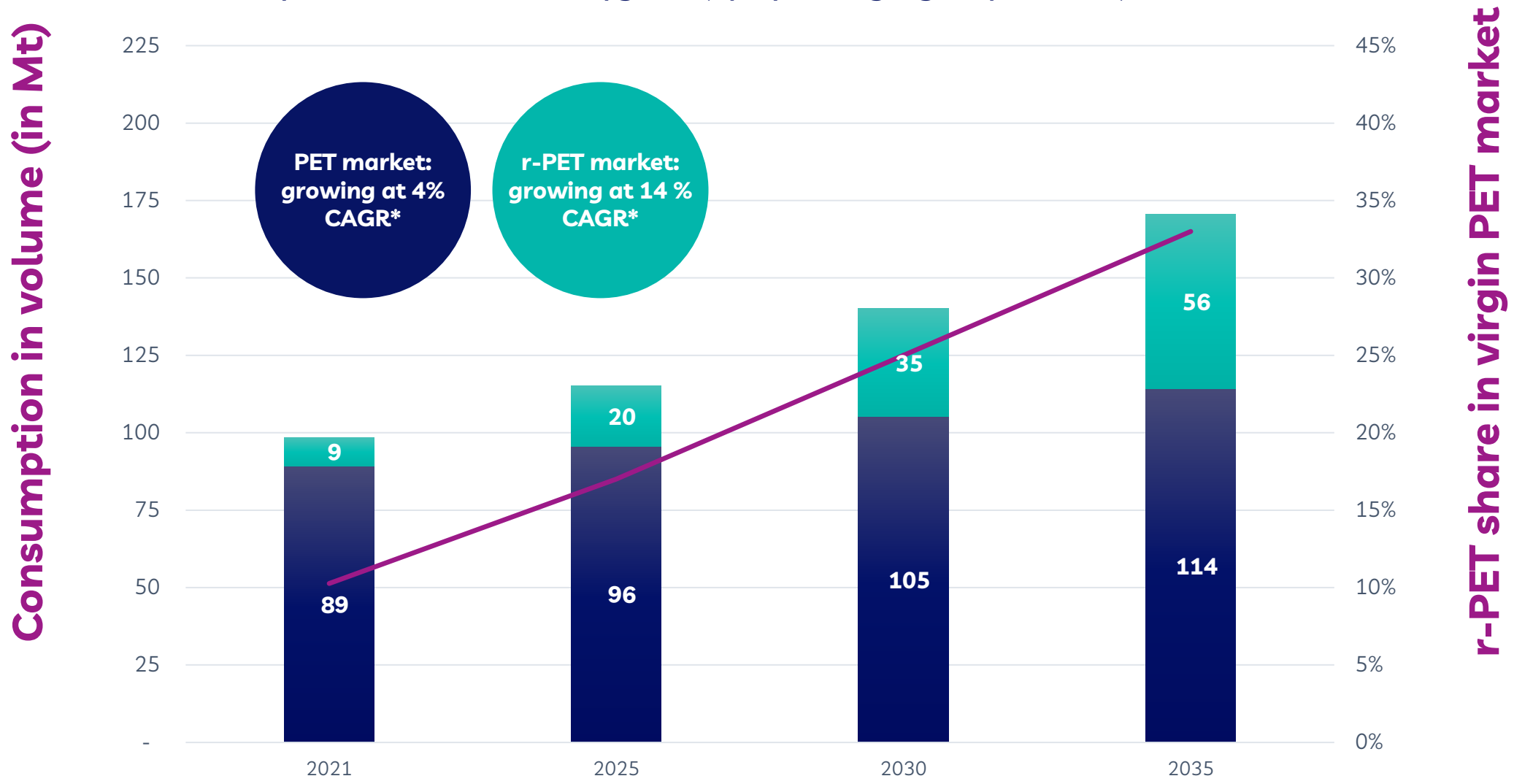


**A booming market for
recycled PET with a strong
unbalanced Supply / Demand**



Recycled PET: a booming market...

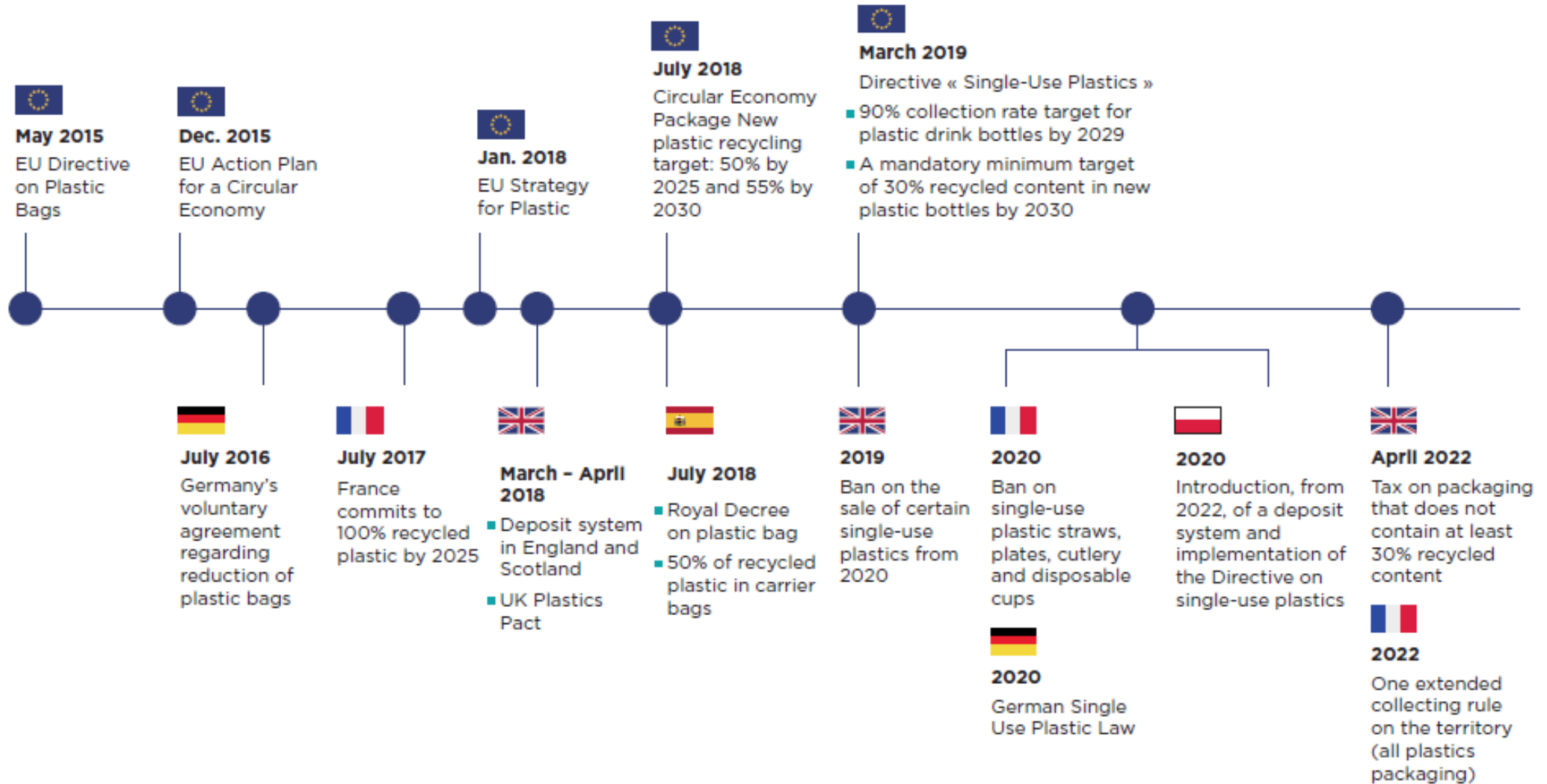
Worldwide consumption of PET ~ 90 Mt/year (1/3 packaging - 2/3 fibers)





... Supported by more severe regulations

› IN FRANCE AND EUROPE



Source: OECD Environment Directorate in 2018



... but mainly pulled by Brands' commitments

Major brands are committed to propose 100% sustainable plastic packaging

Addressable
markets

30 Mt

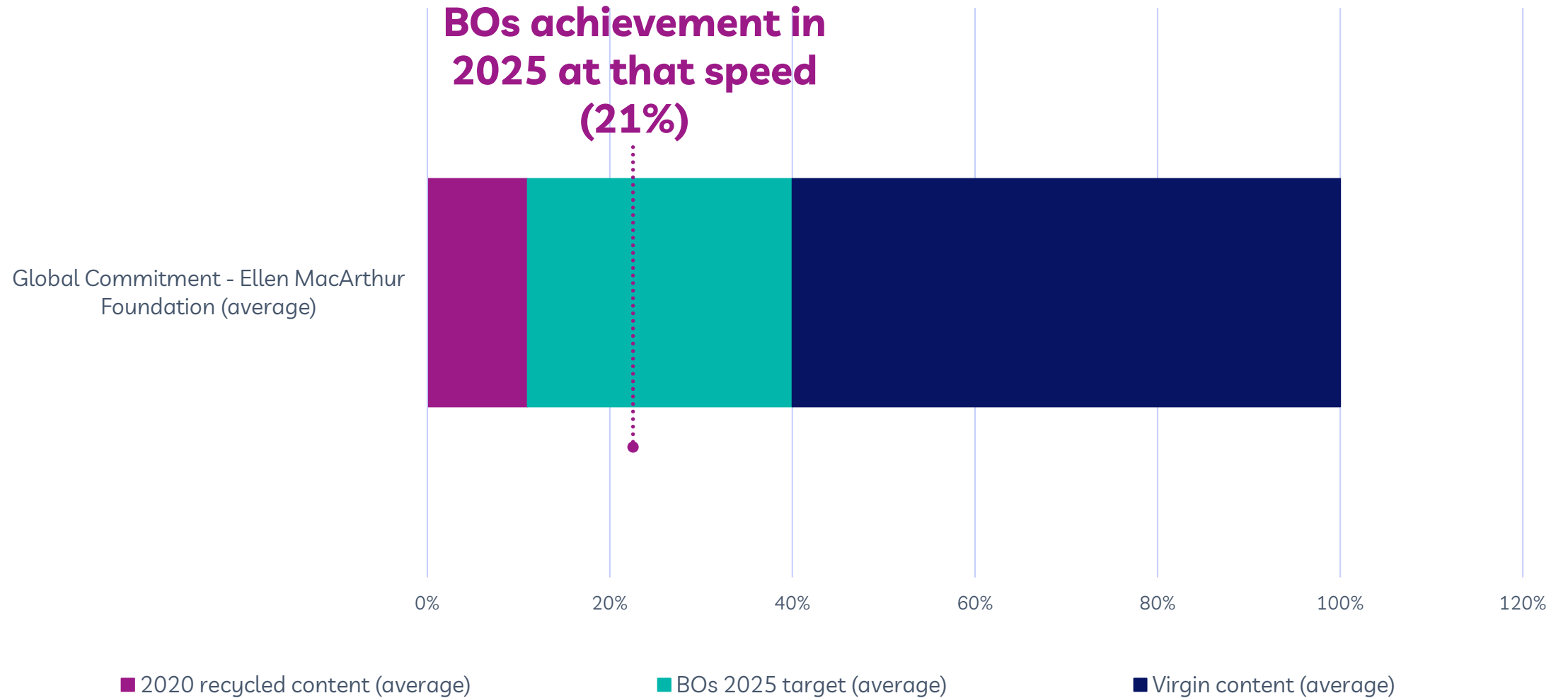
60 Mt

■ PET Plastics ■ PET polyester fibers



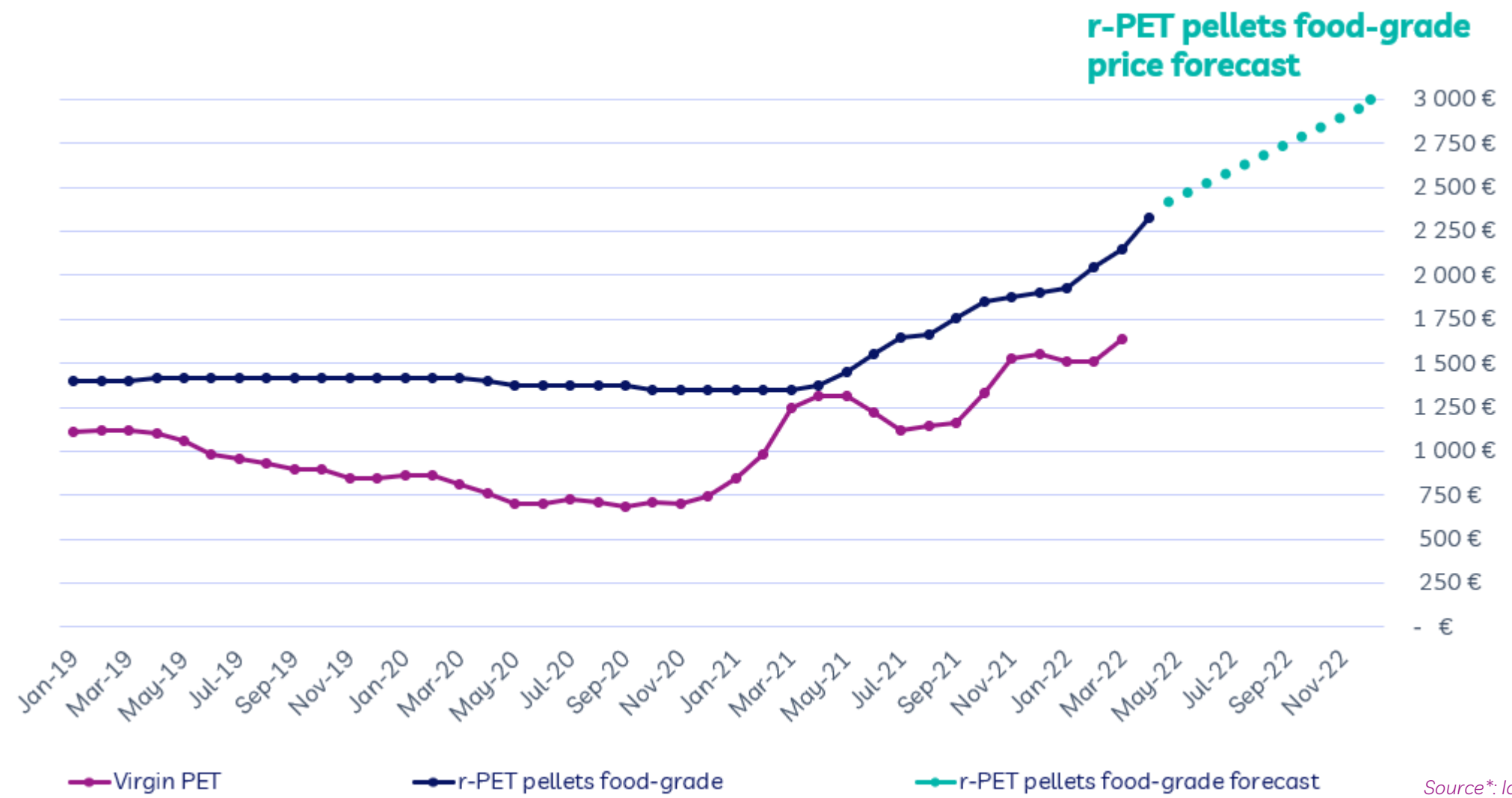


... And main Brands need to accelerate sharply to meet their ambitious commitments



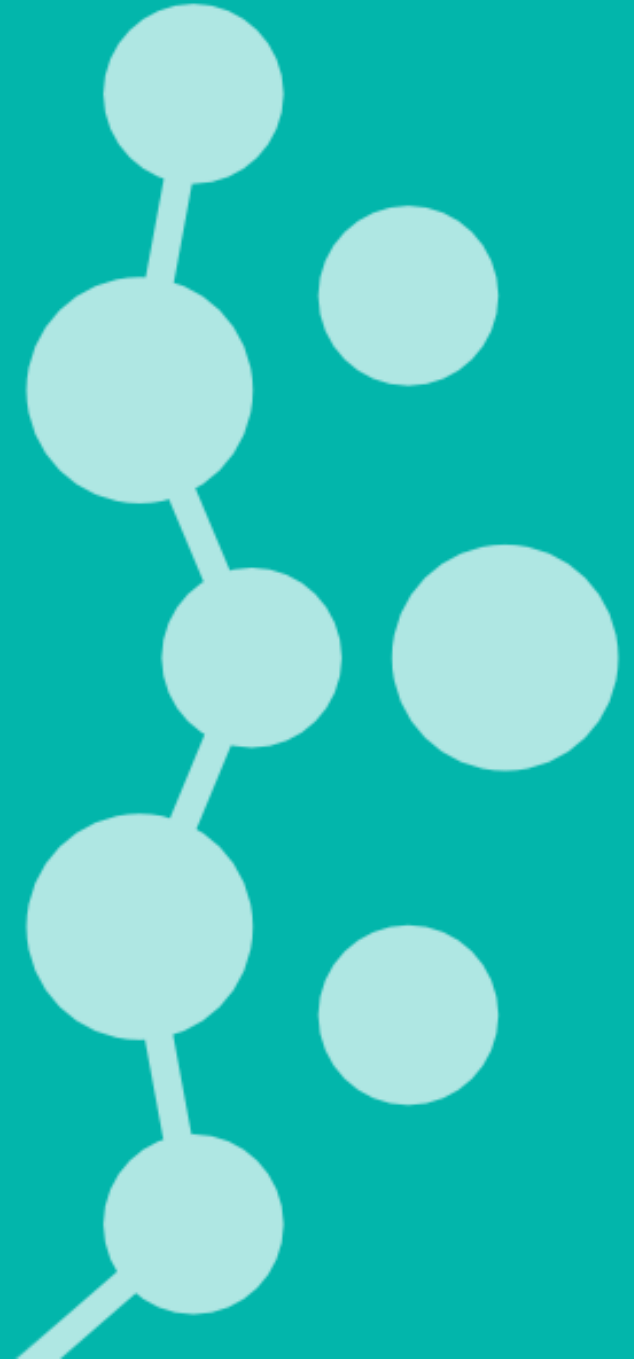


Booming demand for r-PET creates an unprecedented price increase trend ... that we expect to continue





**The most innovative solution
for a worldwide leadership in
the recycling industry**





The rise of a worldwide leader!

Carbios aims to offer the most circular process for the recycling of PET by enabling:



**The treatment of
any kind of PET
waste**



upcycling low-value
feedstocks



**Creating value from
waste which is not
recycled today**



avoiding incineration
and landfill



**Lowering
CO₂
emissions**



low energy
consumption and
proximity sourcing

Circular Economy is becoming a reality!

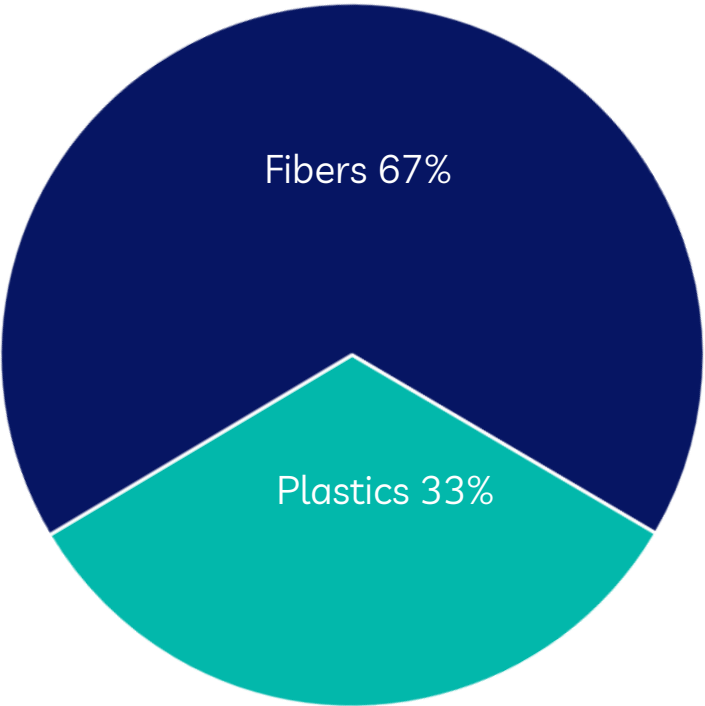


Carbios' technology can process any kind of PET waste



100% PET waste

PET applications



Raw
material
flexibility

22% PET waste



Other rigid
applications 11%



... which give us a strong competitive advantage on the feedstock price

Types of waste		Price estimation
	Clear bottles	~ 1900 €/t ⁽¹⁾
	Colored bottles	~ 1000 €/t ⁽²⁾
	Food trays	~ 250 - 500 €/t ⁽³⁾
	Waste not processable by Mechanical recyclers	~50-300 €/t ⁽⁴⁾
	Textiles	~50 to 500 € ⁽⁵⁾

Sources:

(1) Price of flakes, in WE, delivered. Source ICIS April 2022. +6% versus March 2022.

(2) Price of flakes, in WE, delivered. Source ICIS April 2022. +9% versus March 2022.

(3) Price of flakes, in WE, delivered. Source: Carbios estimate.

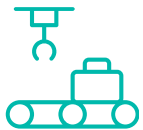
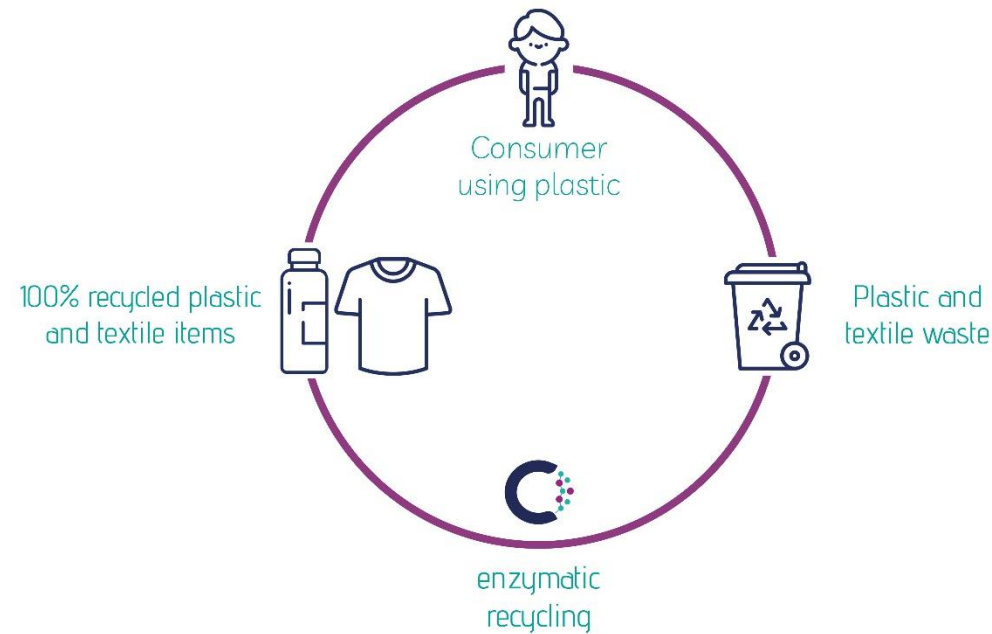
(4) Source: Carbios estimate.

(5) Spot prices for limited volumes. Collected, sorted and shredded. Source: Carbios estimate.



Carbios' technology: building a fully circular process for PET plastics

CLOSING THE LOOP OF RECYCLING



> 90%
yield of
production at
the demo
plant (already
achieved)



Over 97%
achievable
under certain
conditions*

VERSUS CONVENTIONAL RECYCLING





Carbios aims to develop a highly sustainable process for PET life-cycle



46% CO₂ potential savings



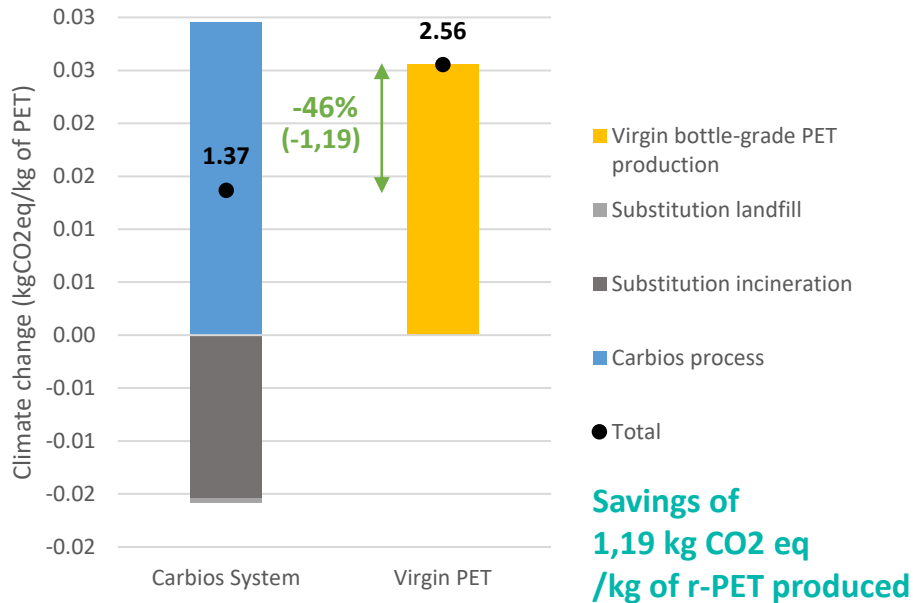
Low temperature,
no pressure



No solvents



LIFE CYCLE ASSESMENT



- 50kt processing capacity plant ⇔ 45kt of CO₂ eq. would be potentially saved annually

-> Compared to virgin PET production, taking into account diversion of PET waste from a conventional end-of-life



Carbios: an attractive partner for PET producers



- Specificity of Carbios process:
 - We get back to the most used monomers in the PET industry :
-> **PTA and MEG** = 97% of the monomers commonly used in the PET industry.




INDORAMA
VENTURES

- Over the next several years, PET producers committed to invest billions in advanced recycling technologies
 - **Indorama Ventures** is going to spend **\$ 8 billion** over the next eight years to help scale up advanced recycling and bio-based plastics
 - “Mechanical recycling will continue, but the big game changer will be a new chapter of advanced recycling and bio-renewable feedstock,” **said Alope Lohia, Chairman of Indorama.** “For bio-based and advanced recycling, the scale is just not there yet. I take this as my personal challenge to deliver on this, and we are prepared to invest \$8 billion from now to 2030.”




A very appealing solution for consumers


Consumer insight



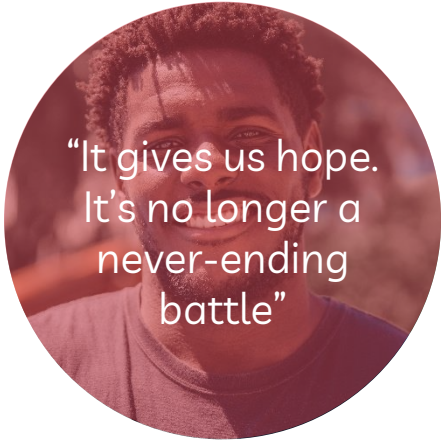
"The fact that it could be done biologically, that's a big, big point"




"It's more than recycling. It's regenerating"




"We need something that is 100% renewable and recyclable because this is what most people have assumed that we have been doing"



"It gives us hope. It's no longer a never-ending battle"



"The forever bottle. Made once, lasts forever"



"It's great that it can be reborn as something new. Maybe a shoe, maybe a bottle... it's not wasted"



Carbios' business model: three streams of revenues





Strong partnerships with Brand owners to promote Carbios Inside solution



Contribute to secure their needs



Carbios' Brand incorporation in the final products



Become the most recognized brand in Circular Economy for plastics and textiles



Carbios
Inside
Solution



Carbios enters its industrial phase in a strong financial position

Cash position of 92M€ as of end of March 2022
excluding an additional 30M€ from EIB to be drawn by end of June 2022



May 2021:

Record breaking capital increase of €114 million with French and International investors confirmed the attractiveness of Carbios investment case



December 2021:

€30 million loan from the European Investment Bank (EIB)



February 2022:

First-of-a-kind plant strongly supported by the French Government and the Grand-Est Region with significant non-dilutive financing*

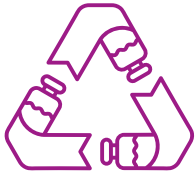


First revenues expected in 2023 from licensing

More significant revenues expected in 2025-2026



Carbios' ambition



Become the world leader in PET recycling by 2035 and increase our pipeline of eco-friendly technologies



Provide the most sustainable and most circular solutions for the end-of-life of plastics and textiles



Become the best employer of its category –
The place to work

Sustainability report to be published by the end of 2022 with strong ESG commitments

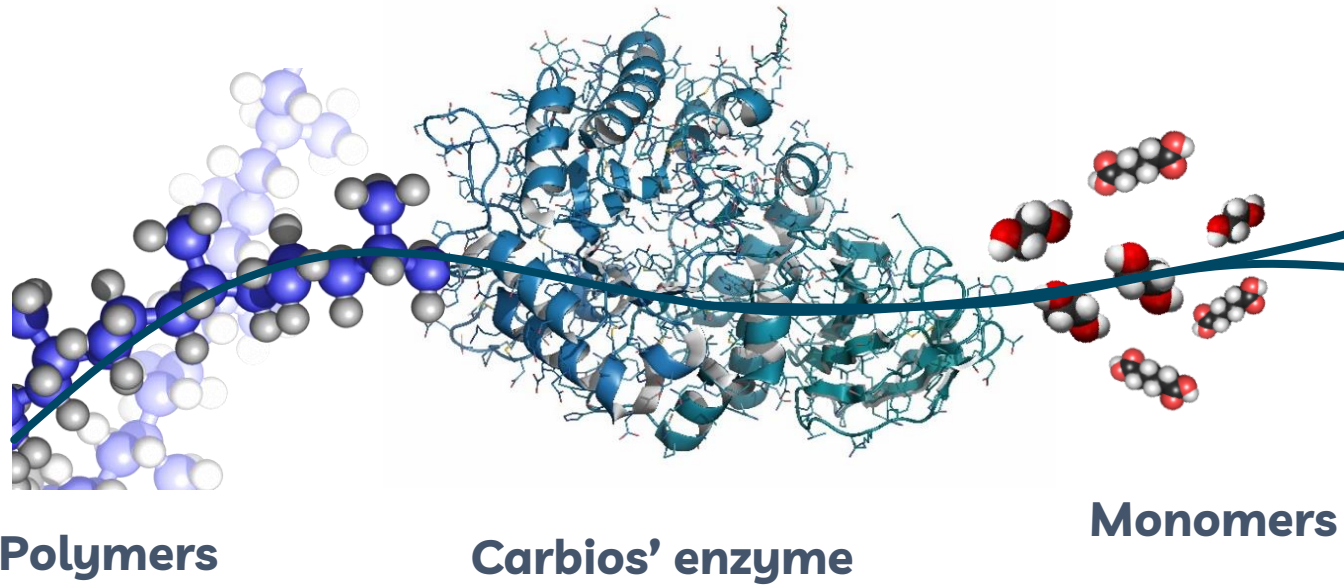


Carbios at the edge of enzymatic innovations

Prof. Alain Marty, Chief Scientific Officer



Enzymes to breakdown plastics: 10 years of innovation!



Polymers

Carbios' enzyme

Monomers

(plastic and fibers)



BIODEGRADATION

POTENTIAL RECOVERIES

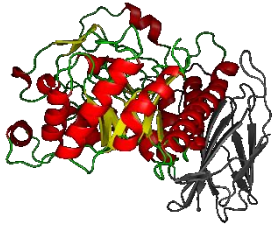


ENZYMATIC RECYCLING

A revolutionary process for infinite recycling and biodegradation of plastics and fibers



What is an enzyme?



Enzyme = Protein
Polymer made from a set
of 20 amino acids



Starch



glucose



Invented by nature to
accelerate reactions



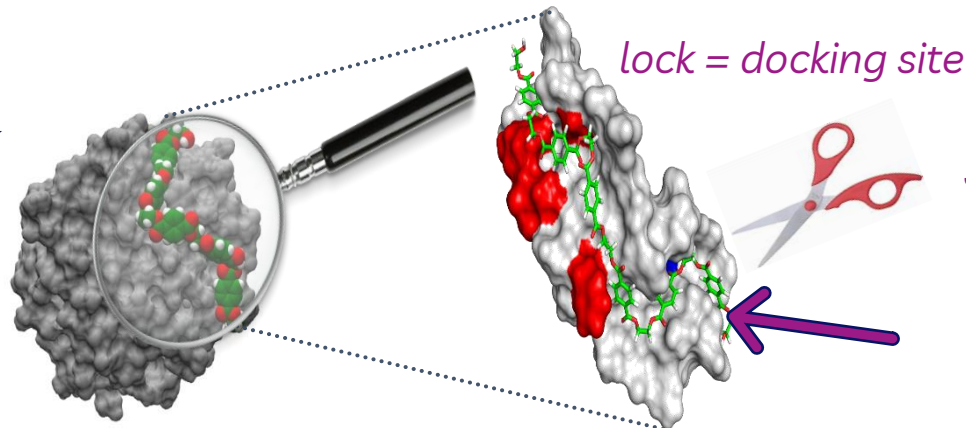
In saliva and stomach: amylase
digests starch as molecular scissors

In a century, Nature has not invented enzymes able to degrade plastics

Meanwhile, some natural enzymes present a limited activity

Our role is to accelerate their evolution

Enzyme contains a lock
Substrate = key



lock = docking site

Scissor = catalysis

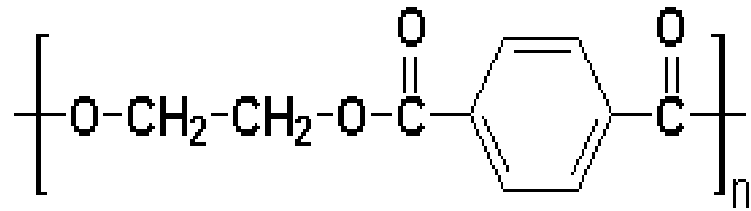
key = substrate



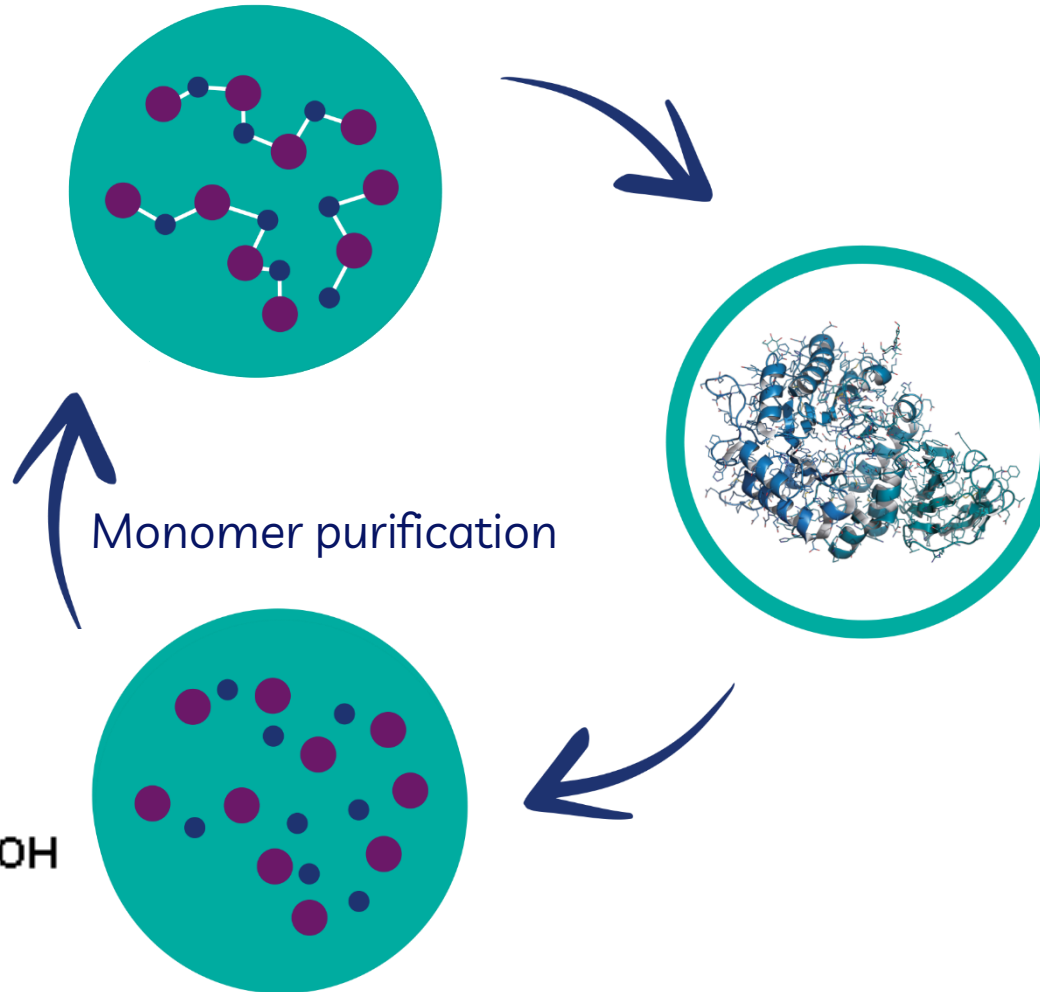
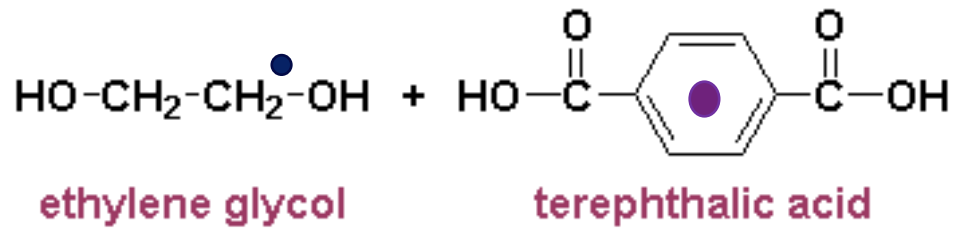
Enzymes for infinite PET recycling!



PET polymer (plastics and textiles)



Polymerist



Depolymerase enzyme





Enzymes for infinite PET recycling!

Plastic and textile waste



Specific enzyme for PET and water

Advantages of the enzymatic recycling process

Selectivity



no need of sophisticated sorting
recycling of complex plastics (PET/PE; PET/PA)

Low temperature,
atmospheric pressure,
no solvent

Ends to the same
monomers used by
97% of worldwide PET
production plants



2015: PET depolymerization

An inaccessible dream

Sourcing

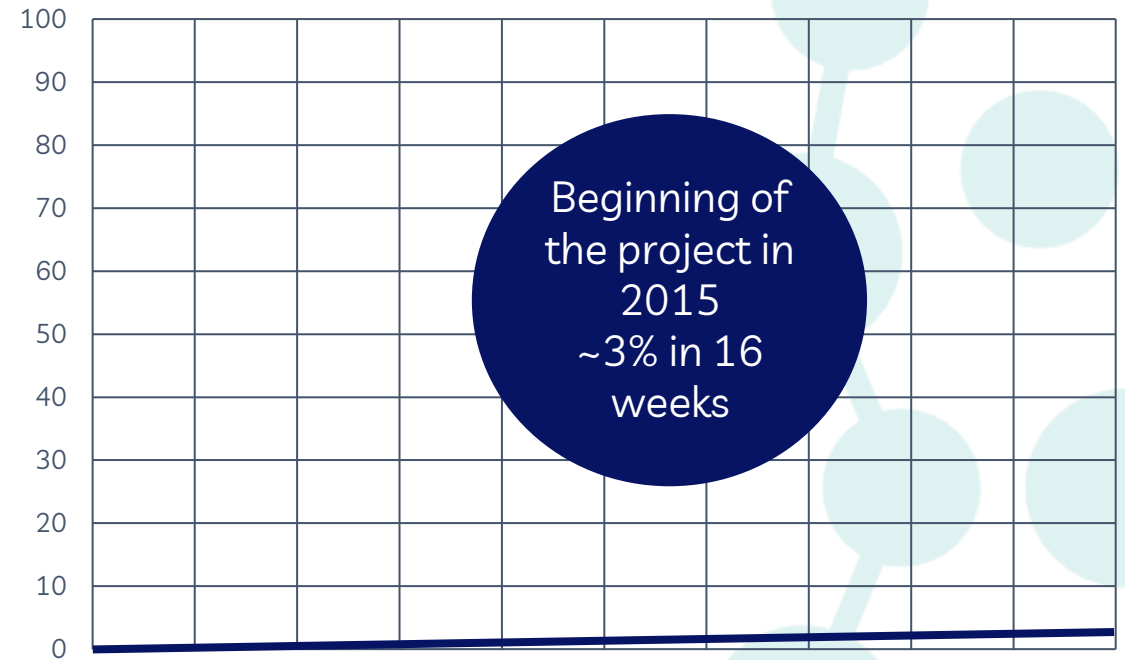


- Commercial 100% PET film



- Reactor 0.5L - PET: 10 g/L
- 60°C, pH8
- Enzyme: 1 % g/g PET

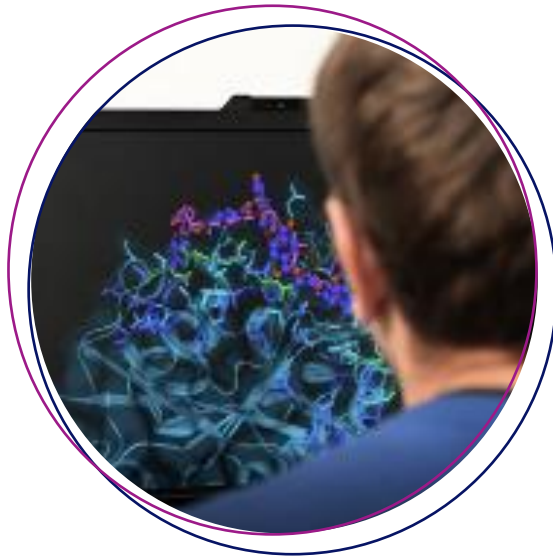
Depolymerization %





PoPLaB: our collaborative Lab in Toulouse

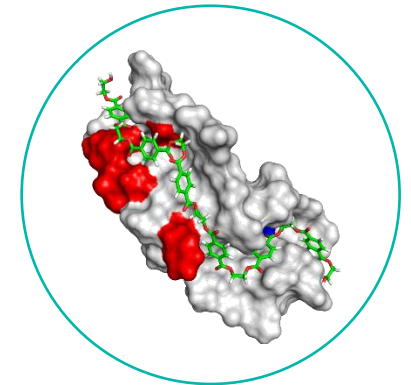
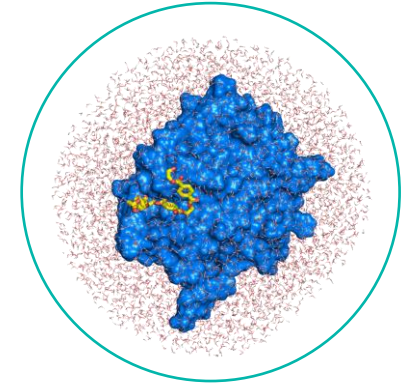
Dedicated to Enzyme discovery & engineering



Staff

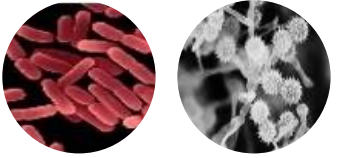
14 PhD

7 engineers & technicians



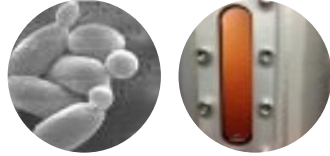


PoPLaB's expertise

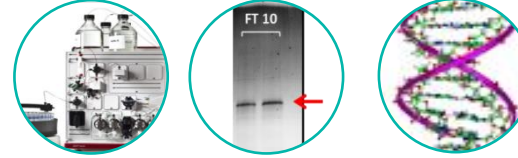


Screening of biodiversity

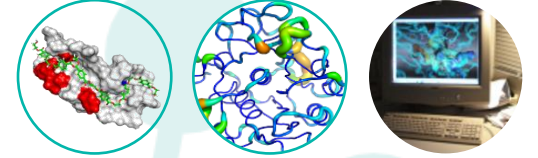
Database analysis
metagenomic



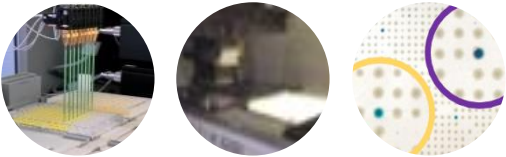
Enzyme production by fermentation



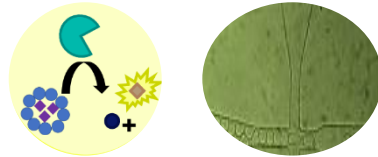
Biochemistry and molecular biology



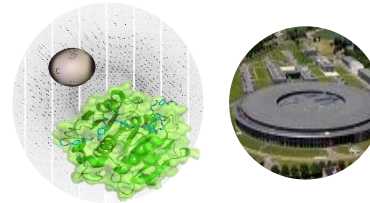
Molecular modeling



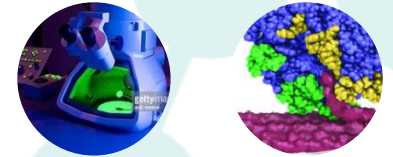
Robotic platform for enzyme screening



Microfluidic screening



Biophysic analysis



Cryogenic electron microscopy



The development center in Clermont-Ferrand

Scale-up of the heart of our process, the reactor

In Toulouse, from 20pL, 200μL to 50 mL

To...



■ 0.5L



■ 5L



■ 1 m³
100 kg PET



■ 20 m³

2tons PET
100.000 bottles
20.000 t-shirts



Staff
1 PhD
9 engineers & technicians

In Clermont-Ferrand

2019: the dream has come true

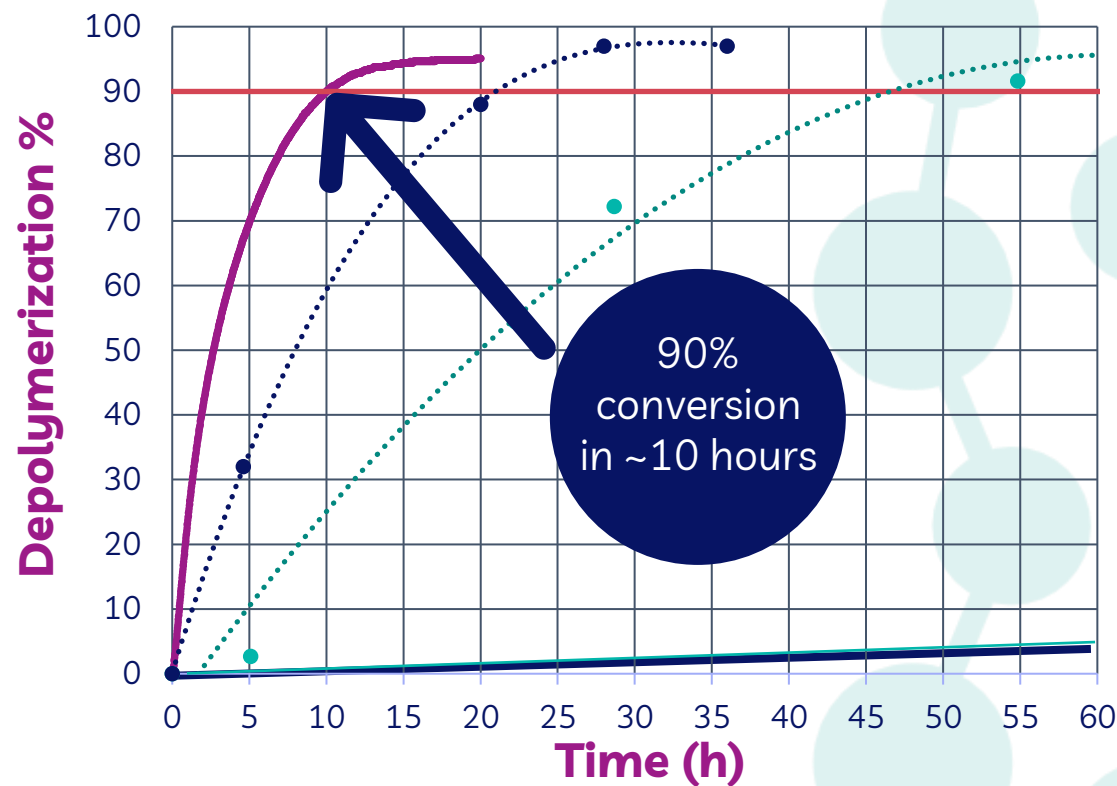
Sourcing



- Post-consumer Flakes or fibers
- (95-98 % PET)



- Reactor 1 m³ -
- PET : 200-400 g/L
- 68-72°C, pH8
- Enzyme: 0.1 % g/g PET



MEAN PRODUCTIVITY

15 g_{TA}.L⁻¹.h⁻¹

Starch 5 g.L⁻¹.h⁻¹, Cellulose 0.5 g.L⁻¹.h⁻¹



Carbios leads worldwide research on PET degrading enzymes

The IsPETase from *Ideonella sakaiensis*



Discovered in 2016 by a Japanese group: Yoshida *et al.*, Science.

	IsPETase	Carbios' enzyme
Relative activity	1	10.000
Thermostability Tm °C	46	84

More than 10 research groups all around the world optimized this enzyme

The best result obtained by Lu *et al.* , Nature, April 2022



	Optimized IsPETase	Optimized Carbios' enzyme
Tm	67	94
PET (g/L)	45	200
Conversion %	83	97
Duration	14days*	16h

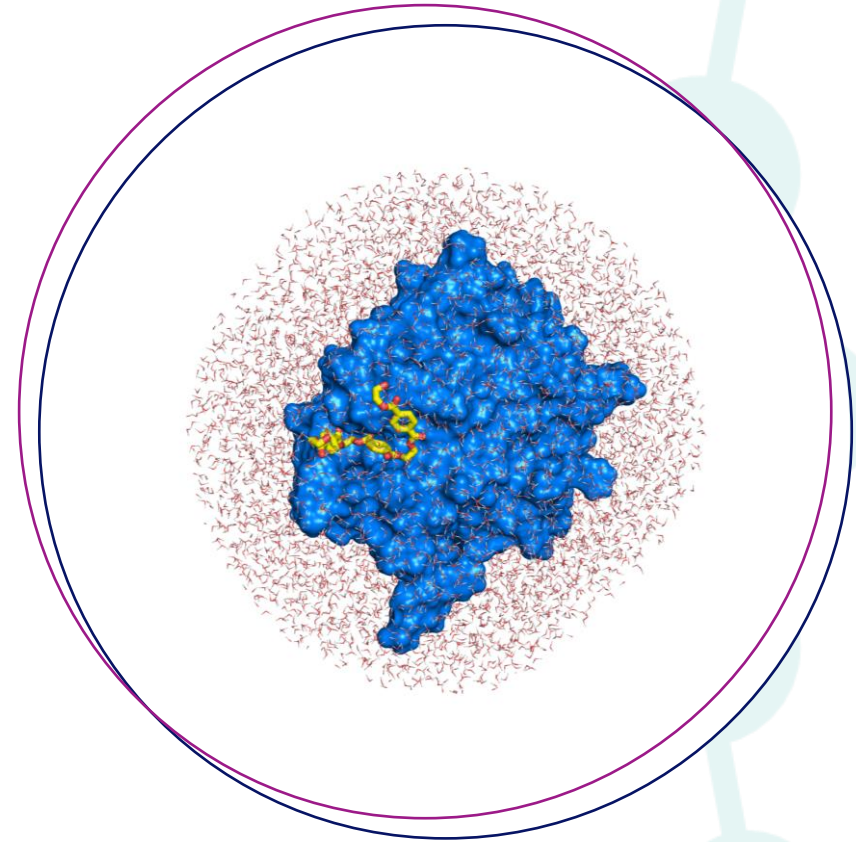
* changing the enzyme every day

Carbios developed strong IP on IsPETase and on the main enzymes described as PETase



The key to success

A successful alliance between polymer science and enzymology





PET crystallinity

A crucial parameter

Colored washed flakes
(95% PET)



High crystallinity
~ 35%

Enzymes prefer
amorphous PET

Extrusion
and fast cooling



Amorphous
PET pellets





Improved thermostability

Enzyme stable during the reaction process

Enzyme working at glass transition T° ($\sim 75^{\circ}\text{C}$)
to take advantage of PET chain mobility

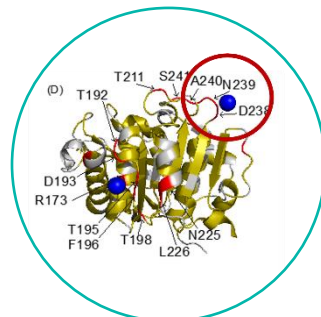
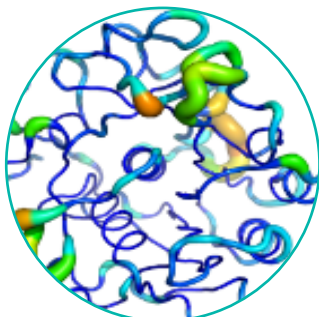
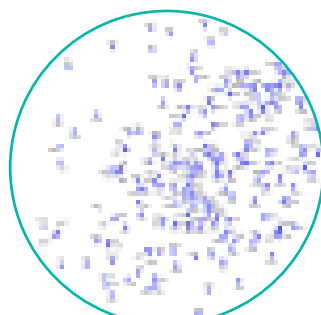
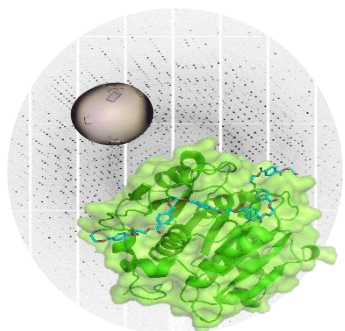


Improved activity

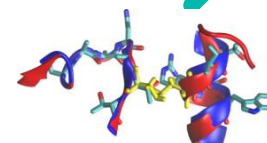
to minimize

- need in enzyme
- reaction duration
- CAPEX and OPEX

Molecular modeling and Nuclear Magnetic Resonance spectroscopy (NMR)



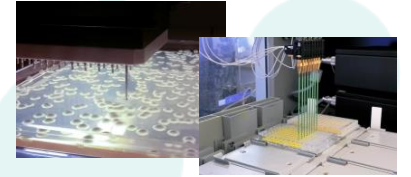
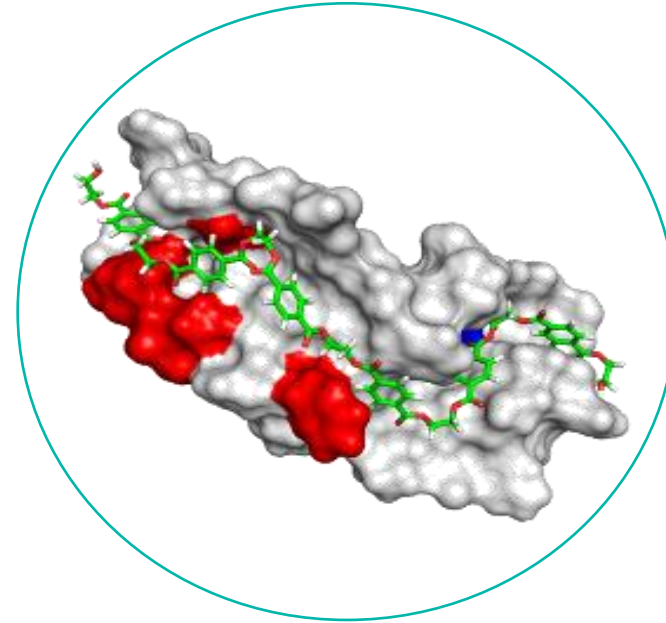
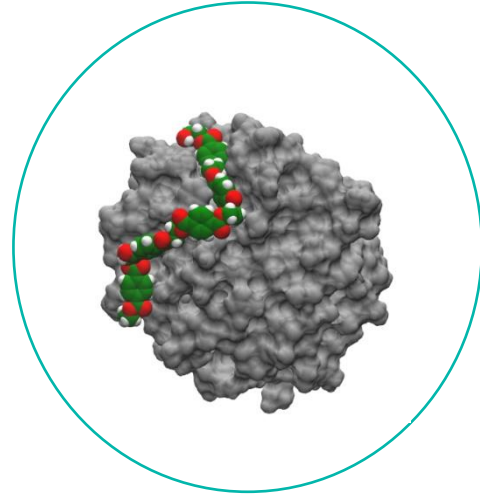
Identification of
weaknesses at high T°



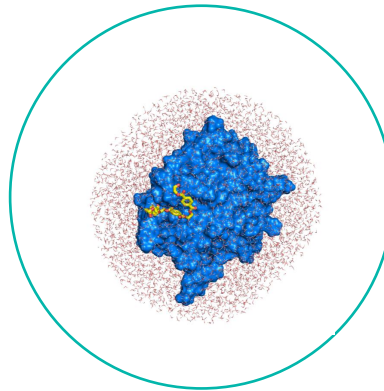
PETase_thermo
T_m ~104 °C



Activity improvement



Identification and fully redesign of the active site



PETase_opt





World's first enzymatic technology to recycle and reuse PET-based plastics & fibers



We made the cover of Nature! In April 2020



Real success for the scientists from Carbios and TBI



Article

An engineered PET depolymerase to break down and recycle plastic bottles

<https://doi.org/10.1038/s41586-020-2149-4>

Received: 27 June 2019

Accepted: 19 February 2020

Published online: 8 April 2020

Check for updates

V. Tournier^{1,2}, C. M. Topham^{1,2}, A. Gillet¹, B. David¹, C. Folgoas¹, E. Moya-Leclaire¹, E. Kamionka¹, M.-L. Desrousseaux¹, H. Teyssie¹, S. Devadas¹, M. Cori¹, E. Guinand¹, M. Dalbey¹, J. Nommé¹, G. Cloot¹, S. Berbe¹, M. Chateau¹, I. André^{1,3}, S. Duquenois^{1,3} & A. Marty^{1,3*}

Present estimates suggest that of the 359 million tons of plastics produced annually worldwide¹, 150–200 million tons accumulate in landfill or in the natural environment². Poly(ethylene terephthalate) (PET) is the most abundant polyester plastic, with almost 70 million tons manufactured annually worldwide for use in textiles and packaging³. The main recycling process for PET, via thermomechanical means, results in a loss of mechanical properties⁴. Consequently, de novo synthesis is preferred and PET waste continues to accumulate. With a high ratio of aromatic terephthalate units – which reduce chain mobility – PET is a polyester that is extremely difficult to hydrolyse⁵. Several PET hydrolase enzymes have been reported, but show limited productivity^{6,7}. Here we describe an improved PET hydrolase that ultimately achieves, over 10 hours, a minimum of 90 per cent PET depolymerization into monomers, with a productivity of 16.7 grams of terephthalate per litre per hour (200 grams per kilogram of PET suspension, with an enzyme concentration of 3 milligrams per gram of PET). This highly efficient, optimized enzyme outperforms all PET hydrolases reported so far, including an enzyme^{8,9} from the bacterium *Aeromonas caviae* strain 201-F6 (even assisted by a secondary enzyme¹⁰) and related improved variants^{11–14} that have attracted recent interest. We also show that biologically recycled PET exhibiting the same properties as petrochemical PET can be produced from enzymatically depolymerized PET waste, before being processed into bottles, thereby contributing towards the concept of a circular PET economy.

Over the past 2 years the enzyme has been improved
Enzyme engineering always in progress



Enzyme production



The world leader as partner for the production and supply of Carbios' proprietary enzyme



They developed an efficient production micro-organism



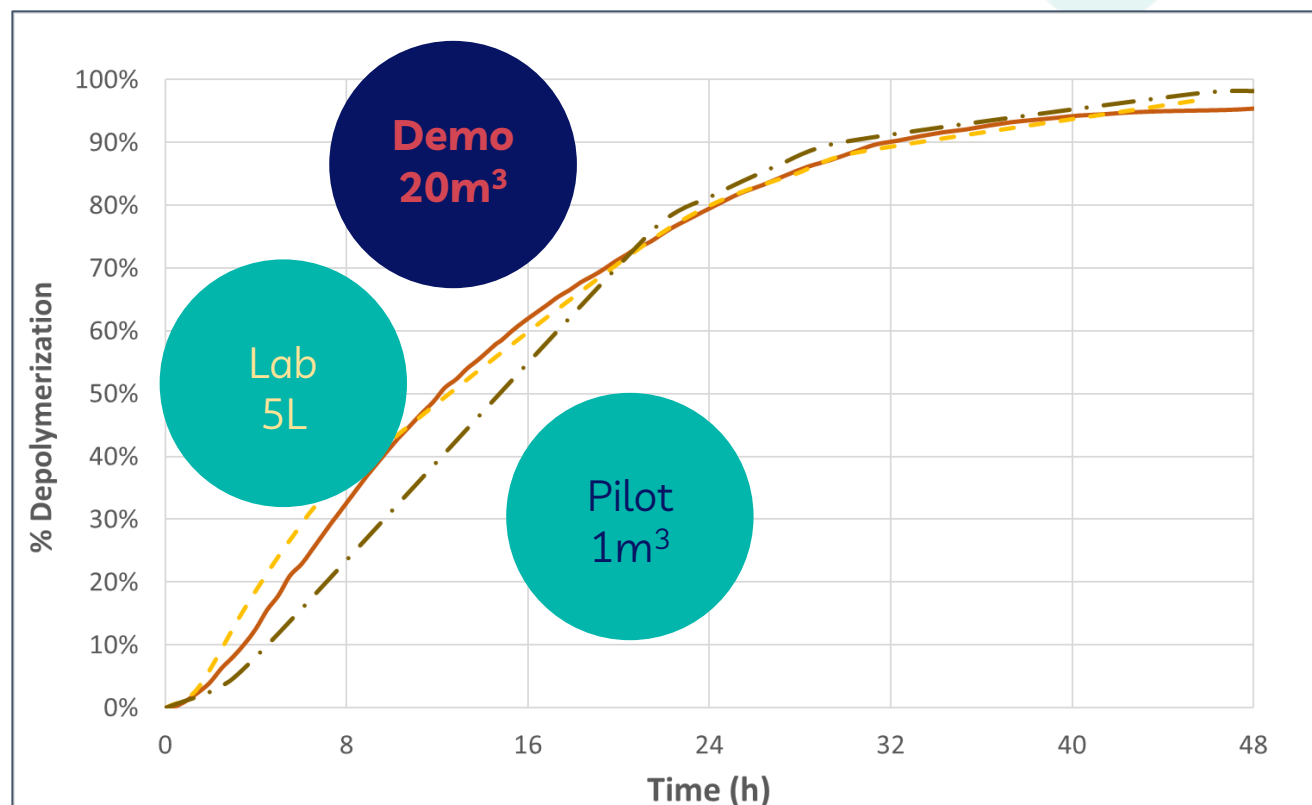
The enzyme formulation is very stable at room T°

Scale up in line with the target

- 20 m³ reactor
- 2 mt of waste
(~100.000 bottles or 20.000 tee-shirts)
- In water
- pH 8, 60°C
- Atm. pressure

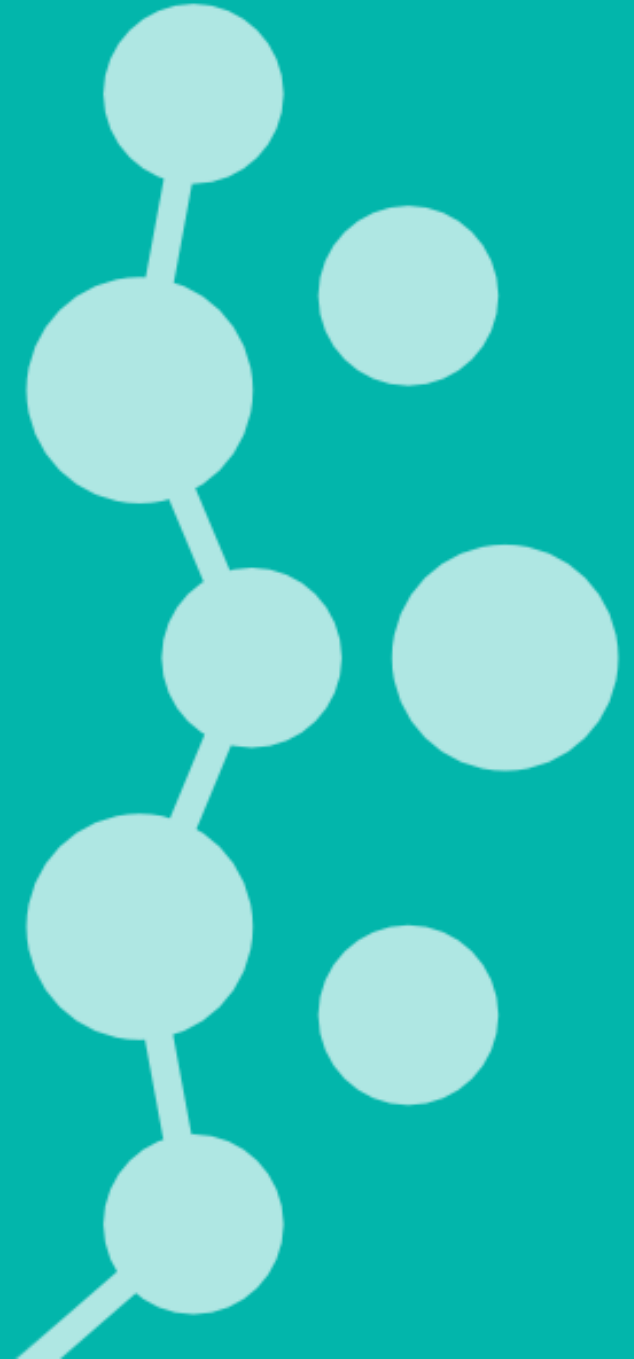


Successful scale-up Lab (5L) > Pilot (1m³) > Demo (20m³)





Carbios PLA enzymatic biodegradation technology





An innovative solution for PLA-based single-use plastics

AN INNOVATIVE ENZYMATIC ADDITIVE TO MAKE PLA COMPOSTABLE IN DOMESTIC CONDITIONS
at ambient temperature



Ease of use

Introduced as an additive on conventional industrial lines

Compostable

100% Home compostable, at room temperature

Circular

The compost is used as a fertilizer or help to produce biogaz

Competitive

Circularity of composting versus incineration / landfill



A sustainable biodegradation technology suitable for a large range of applications



Food packaging



3D printing



e-Commerce
air-cushion



PLA biodegradable & compostable

Challenges



Optimized enzyme able to resist
at extreme T° of extrusion
(170°C)



Enzyme active in the polymer

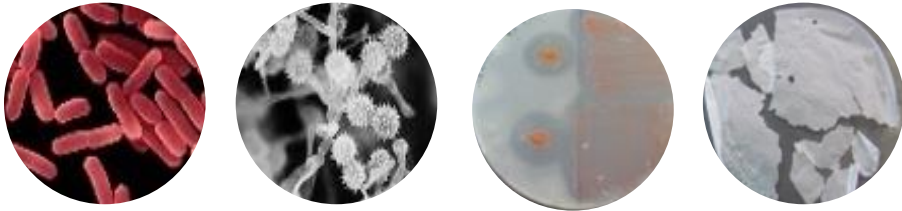


Total degradation to CO₂:
Home compost Label

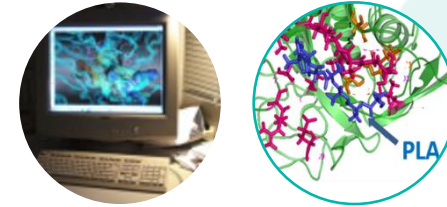


Discovery of PLAase

Challenge: enzyme able to resist at extreme T° of extrusion (170°C)



Thermophilic micro-organisms
were screened for PLA degradation

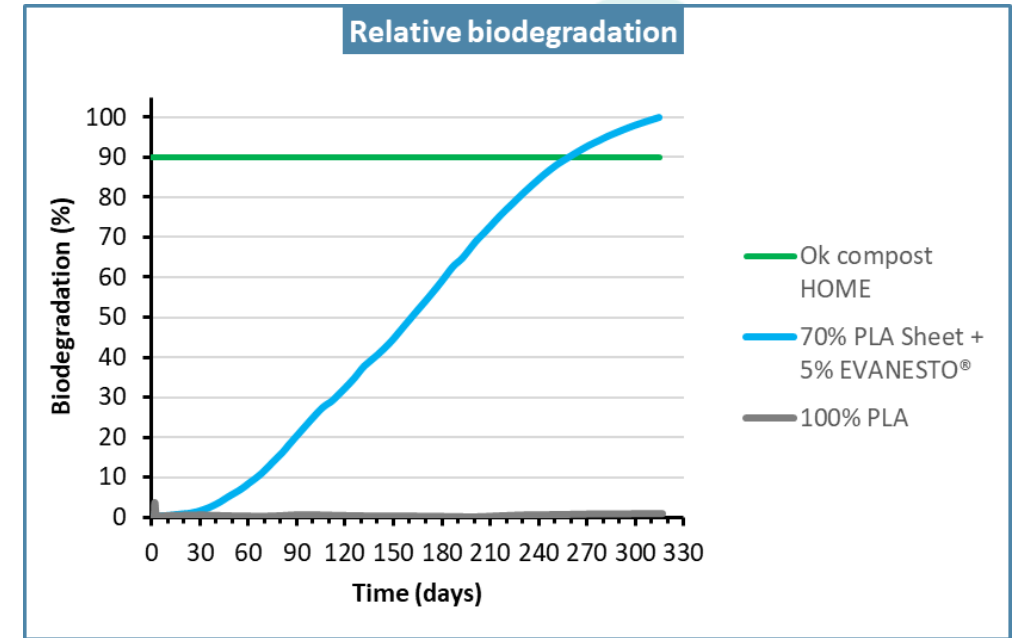
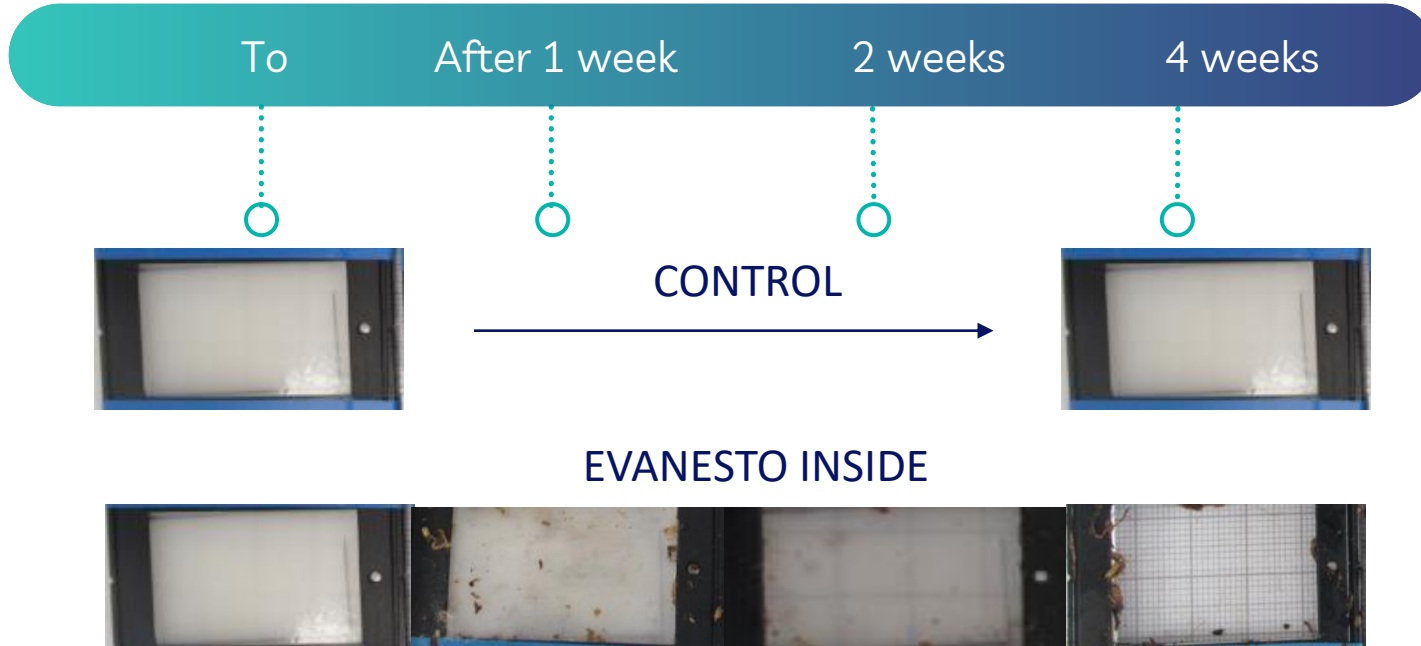


The active site of the enzyme was fully
redesigned

And the activity of PLA degradation
increased 200 times



Evanesto®: a validated performance



Disintegration within 4 weeks



Full biodegradation in CO₂ in 255 days

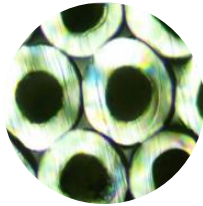
Evanesto®, the first additive that allows plastics with high PLA content to achieve certification **“OK Compost Home”** by TÜV Austria Group



New developments to make fibers & 3D filament



fibers



3D filaments

T0

**1
Week**

**14
Weeks**

Evanesto® inside



Control







New polymers

Collaboration with european Labs of reference



Identification of efficient enzymes

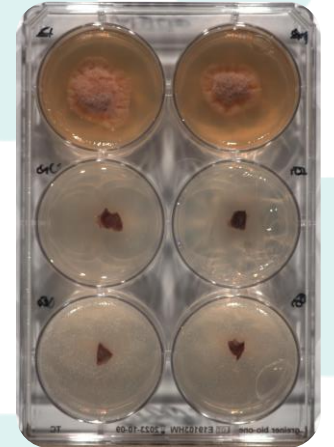


Promising results at Lab scale



Next Step:

Enzyme optimization
Process development at Lab scale





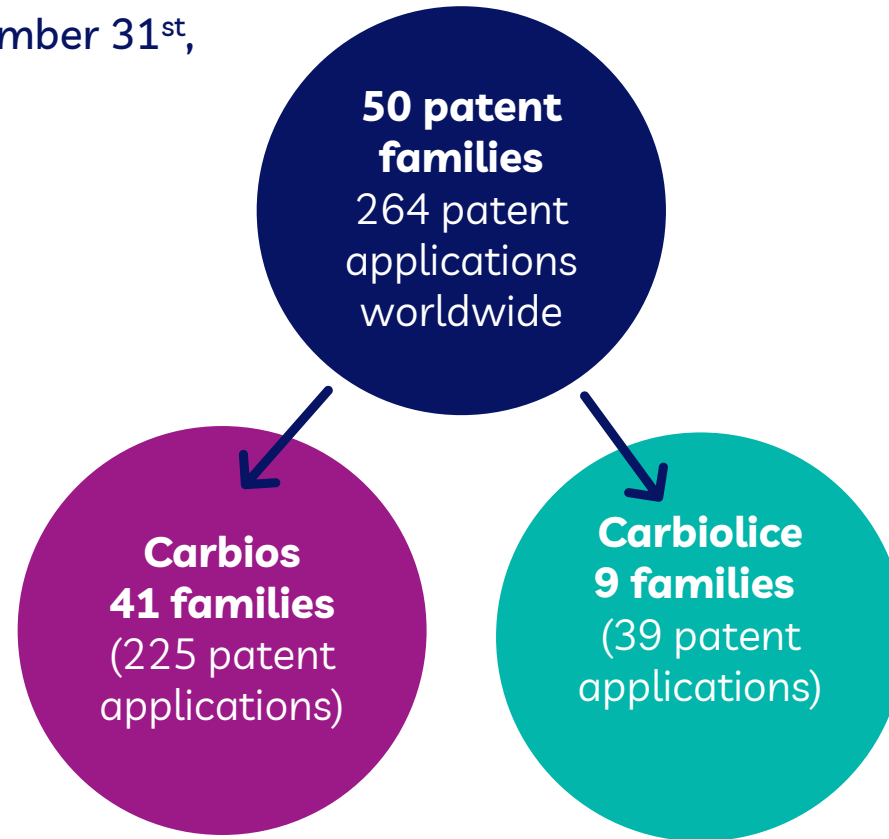
Carbios' Intellectual Property Strategy

Lise Lucchesi, Intellectual Property Director



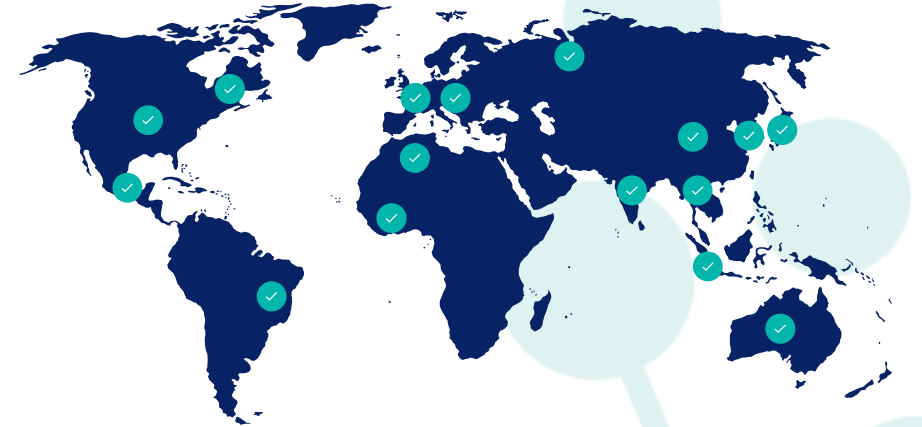
A strong and worldwide intellectual property

As of December 31st,
2021

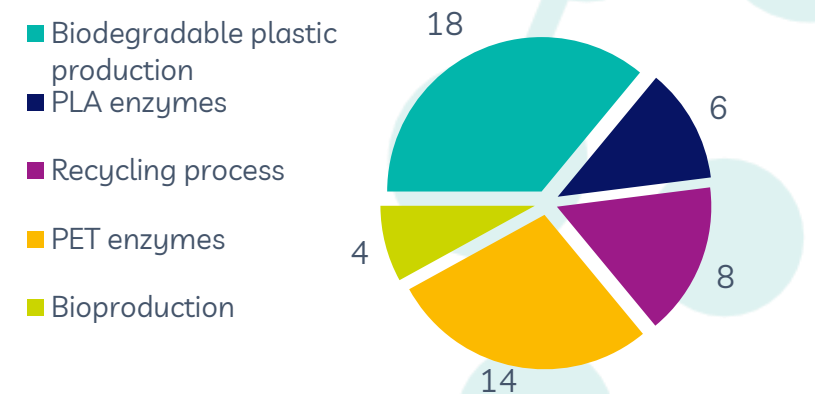


50 granted patents (from 23 different patent families)
In Europe, United-States, Canada, Mexico, China, Japan, Korea, Brazil...

Worldwide pending applications



Patent family distribution by project





IP, an underlying asset for business success



Active policy of securing and strengthening our innovations

- Protection of our results from the upstream lab phase to the final industrial phase
 - Covering enzymes, processes, products and applications
- When necessary, acquisition of know-how and rights from third parties



Keeping a watch on competitors, technology and patents

- Identify existing prior art before applying for patents
- Identify emerging work, expertise and patents in relevant fields, to ensure the use of our processes and products without restrictions



Ensuring our freedom to operate

- When collaborating with third parties (academics and/or private companies):
 - Full ownership of the collaboration results or co-ownership and exclusive worldwide exploitation rights for the results within the company's fields of activity
- Action against third party's patent application



Example of PET Recycling

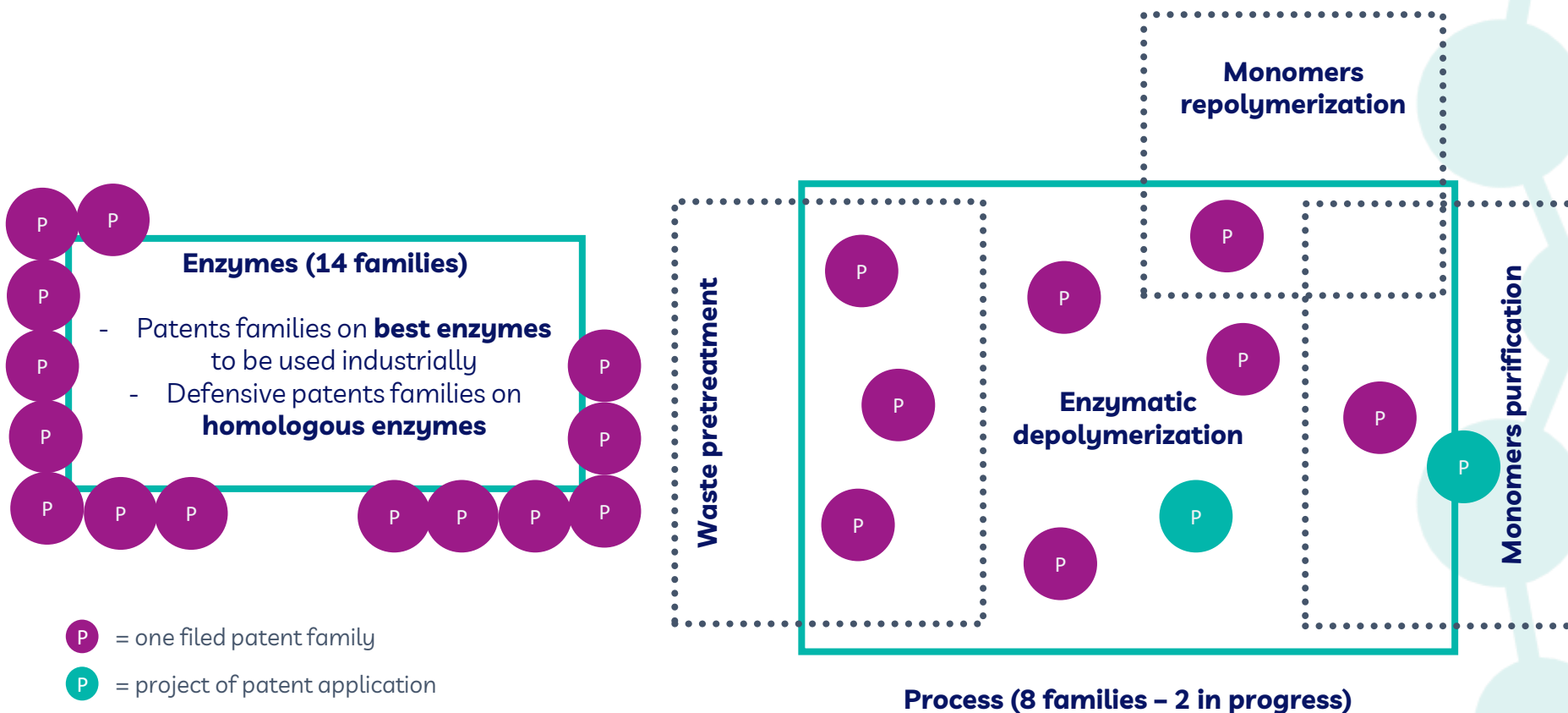
A strong intellectual property covering



Proprietary and optimized enzymes

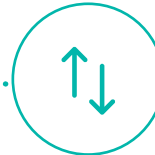
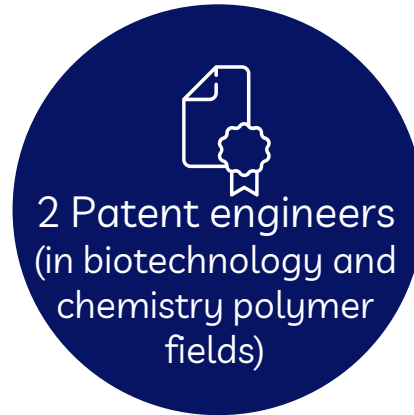


All the steps of our recycling process





Our IP team



2 IP consultancy firms
with

3 European patent attorneys
(each with 15-30 years of
experience)

**Intellectual Property
Committee**

reporting to the Board of
Directors



Industrialisation focus on Carbios PET recycling technology

Lionel Arras, Industrial Development
Director



Carbios reinforces its industrial organization

Carbios Industrial Development Director

Lionel Arras



DEMONSTRATION
plant



15

Carbios employees,
growing

TECHNOLOGY and
LICENSING



8

consultants driven
by Carbios

PROJECT
1st commercial plant



50

people involved in
Carbios industrial
development



The best experts to support Carbios' first commercial plant project



Lionnel Perrin, Project Director

Before this role:

Project manager of the Carbios demo plant project and start up

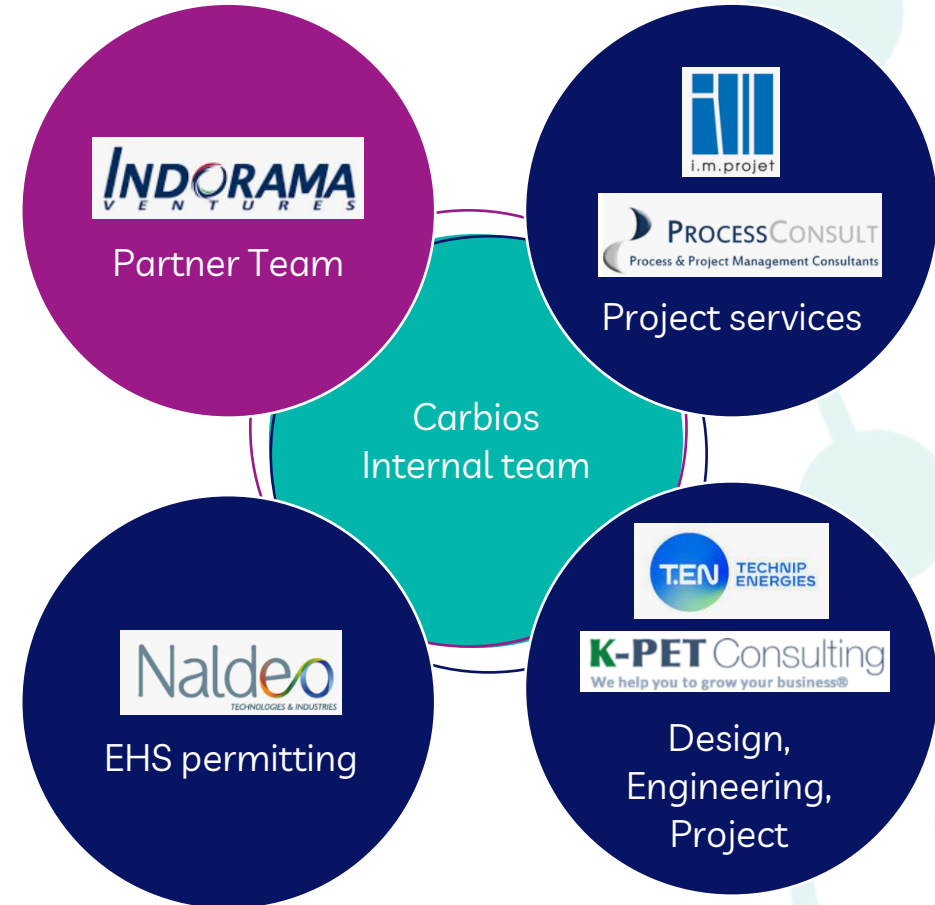
Before joining Carbios:

More than 15 years experience in projects with Arkema, Hexcel

Skills:

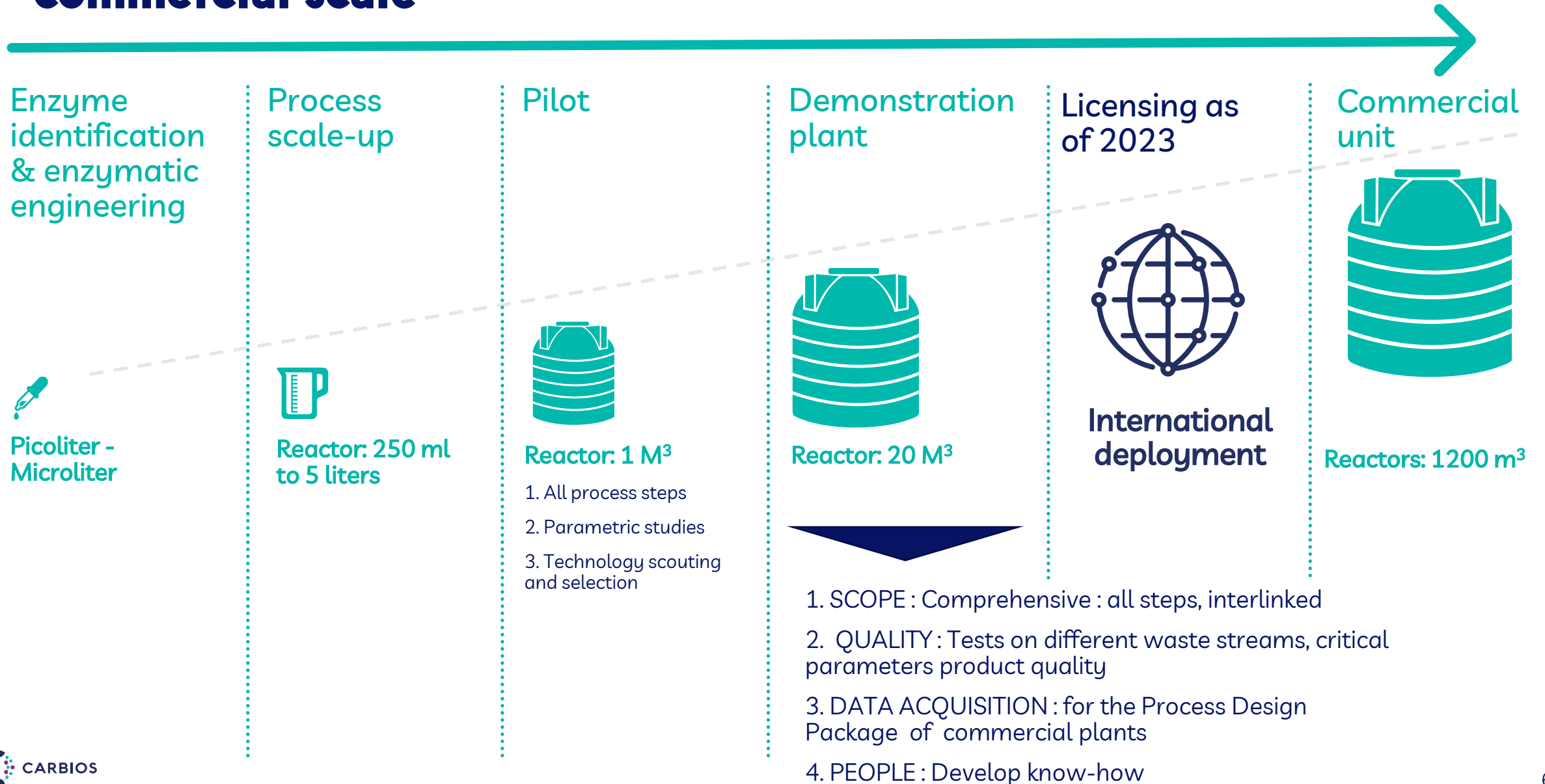
Extensive project management experience

Drive and Leadership





The demonstration plant: the last step before commercial scale





The demo plant confirms scale-up performance and robustness



Enzymatic reaction kinetics and PET conversion: no impact of scale



Low sensitivity to process conditions: Robust!

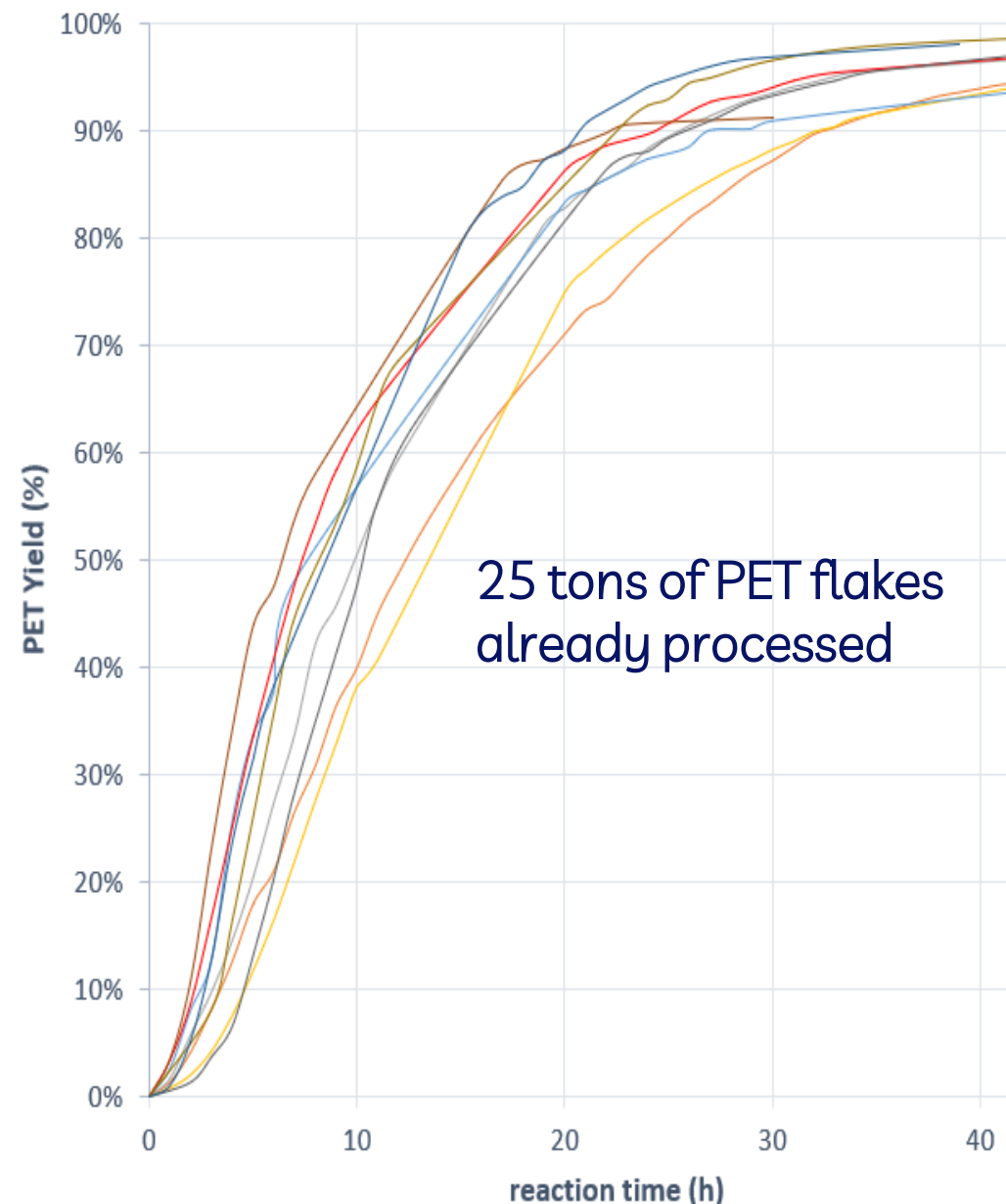


Monomer quality: Good!

- Sampled with positive feedback from potential end-users



The selected technologies from the Piloting stage are operational.





The demo plant: 2022-2024 roadmap

Q3 2022:

- PET feedstock : test new grades
- first r-PTA and r-MEG volumes produced

2023:

- LIFE project : textile feedstock
- Launch ISO 9001 certification

Q4 2022:

- Licensing documentation
- Final alignment with the reference unit process design

2024:

- Train the operators for the 1st commercial plant



First-of-a-kind commercial plant will generate revenues ... and boost Carbios position for licensing

Strategic value of the 1st commercial plant project:

For Carbios

- Monomers sales from 2025
- Volumes deliveries to Brand Owners
- Initiate Novozyme supply operations

For Carbios future licensees

- 100% proven technology
- Experience of the licensor
- Demonstration of Carbios' technology integration in the r-PET value chain



Project of the first-of-a-kind plant

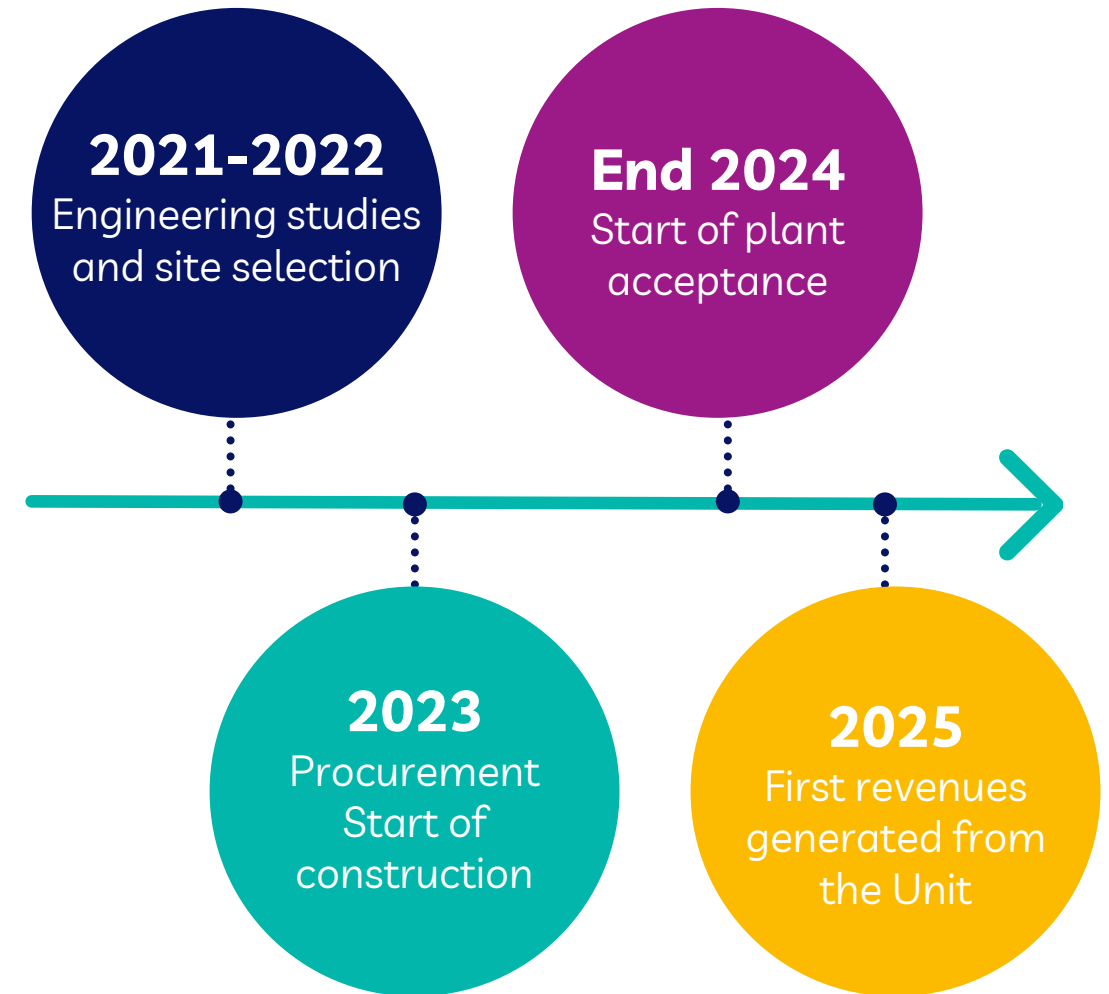
Key figures:

- Operational in Q1 2025
- Processing capacity of 50.000 tons of waste/year
 - ie. to 2 billion PET bottles
- 150 direct and indirect new jobs created

A major partner: **INDORAMA**
V E N T U R E S

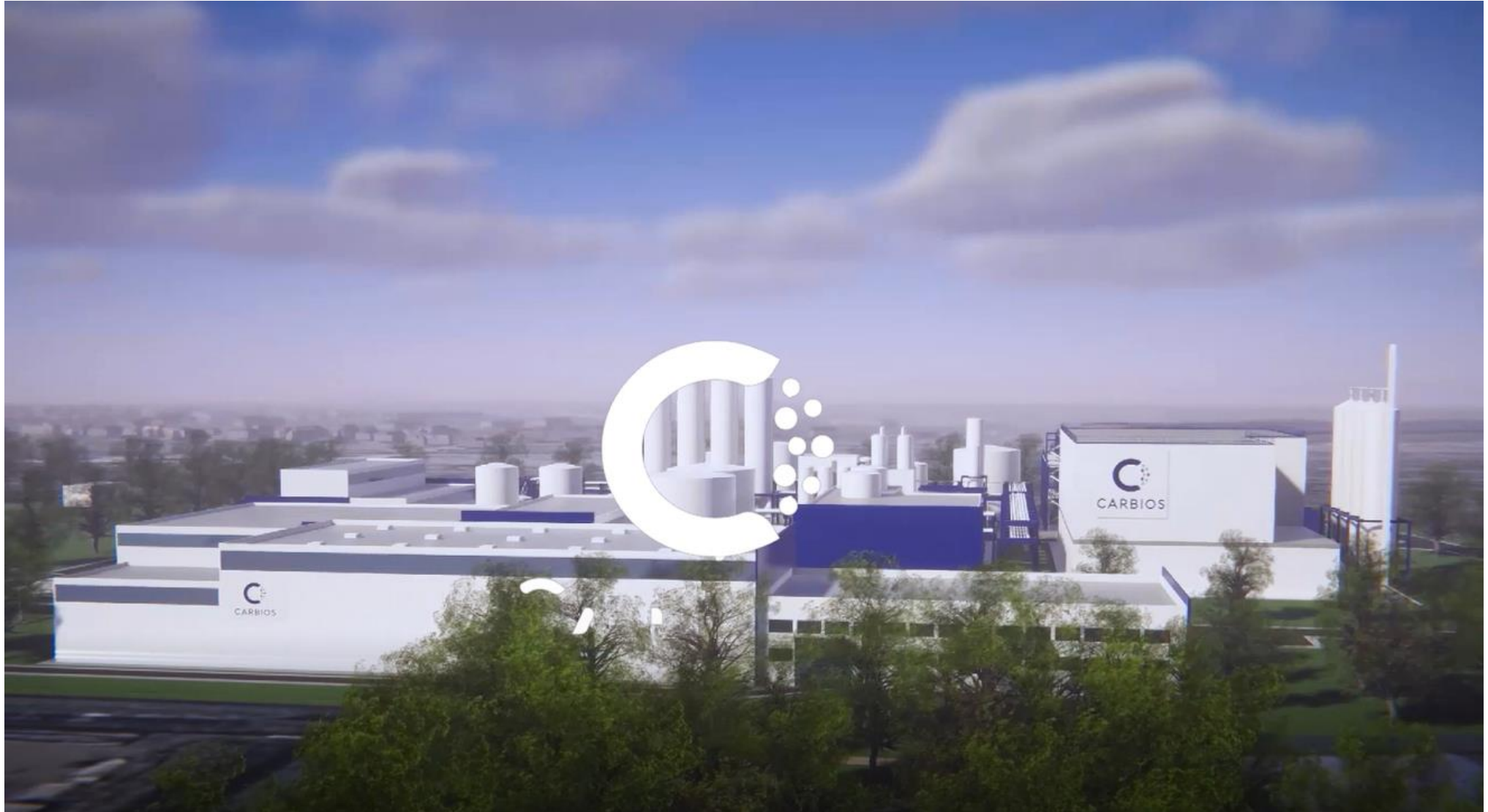
- One of the world-leading PET manufacturer
- Operates 19 PET production plants on four continents in 11 countries
- May co-invest in this project
- Consider expanding Carbios' technology at other PET sites for future developments

Key timetable for the building of the Unit





3D model – preliminary plot and layout





A site designed and located to favor local waste sourcing

Carbios & Indorama Industrial plant (50kT): a strategic location with a nearby accessible PET waste due to the border countries (Germany, Luxembourg, Belgium)



+ optimize the carbon footprint and Life Cycle Analysis of the entire process



Parallel and synchronized activities preparing for licensing...

supported with the development of the industrial team

First of a kind plant



Demoplant design and operations



Worldwide technology licensing





Key industrial takeaways



A team, supported by leading partners in the field



A demonstration plant that confirms the main technology choices



Industrial Unit:
A project fully on track for the operational launch by 2025



A licensing offer that will ready by 2023



Carbios' partners testimony

Martin Stephan, Deputy Chief Executive Officer



Our key partners

Our PET Consortium

L'ORÉAL



Our industrial partners



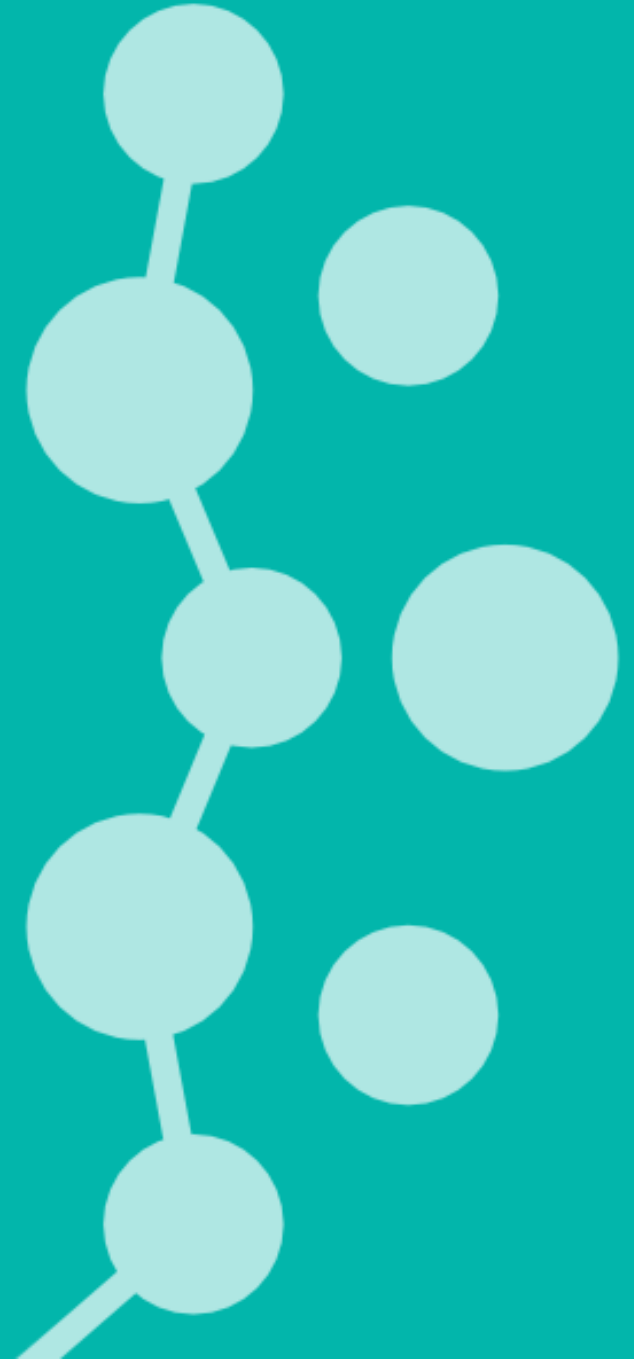
Our strategic shareholders

L'ORÉAL





Conclusion & Q&A session





Carbios highlights



Carbios disrupt the entire plastic industry with breakthrough technologies



Huge market opportunities and growth potential



Major milestones ahead including reaching licensing stage early 2023



Ambition to build the most circular and sustainable solutions for the plastic industry



A highly attractive proposal for the entire value chain



A strong competitive advantage on waste sourcing



A highly experienced management team supported by renown shareholders and partners



CARBIOS

Enzymes powering the Circular Economy

THANK YOU!

INVESTOR DAY 2022

31st May 2022