April 2025

Bio-polyesters

Fast track commercialization of sustainable resins

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Technip Energies at a glance

Listed on **Euronext Paris** Stock Exchange	Headquartered in **Paris**	**65+** Years of operations
€6.9bn Full year 2024 adjusted revenue	**A global technology & engineering powerhouse** leading in energy & decarbonization infrastructure	**~€20bn** Backlog at end 2024
17,000+ Employees in 34 countries	**60+** Leading proprietary technologies	**500+** Projects under execution

Our solutions to accelerate the energy transition

Our services and capabilities

- **Consulting**
- **Engineering, Procurement & Construction** (EPC)
- **Project Management Consultancy** (PMC)
- **Modularization**
- **Technology scale-up**
- **Products**

Our markets

- **Natural gas**
- **Hydrogen**
- **Downstream**
- **Sustainable Fuels**
- **Carbon Capture, Utilization & Storage** (CCUS)
- **Circularity**
- **Zero-carbon energies**
- **Industries**
- **Loading Systems**

TECHNIP ENERGIES

Polyester value chains

PET in everyday life

Market size:

- 110 MM tpa, 4.5% growth p.a.

Market applications:

- Fibers, textiles : 67%
- Bottles, dishes : 26%
- Films, packaging material : 7%

The challenges to our industry:

- Reduction of the contribution to global warming due to fossil-based feedstocks
- End-of-life plastic pollution
- Micro-plastic pollution

PET: PolyEthylene Terephthalate

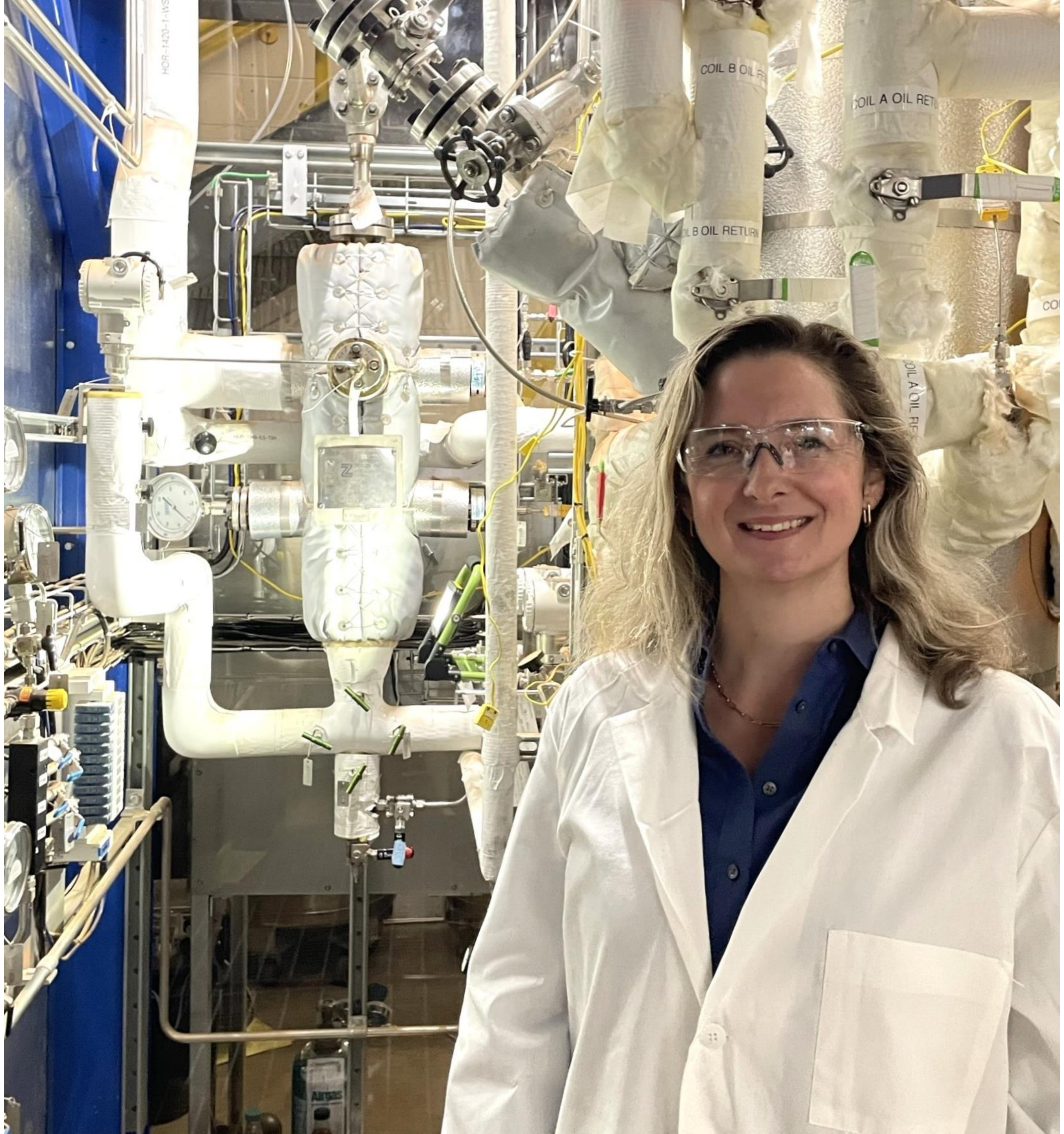
Bio-polyesters

Strategies for enabling sustainable but affordable features

Sustainable drop-in monomers Replacement of fossil feedstocks with bio-based sources to reduce the carbon footprint	**New sustainable polymers** Creation of new polymers with better properties
Recyclability End-of-life resins used as feedstock to reduce carbon footprint	**Bio-degradability** For single-use and specific resin applications: decomposition end-of-life to reduce micro-plastic pollution

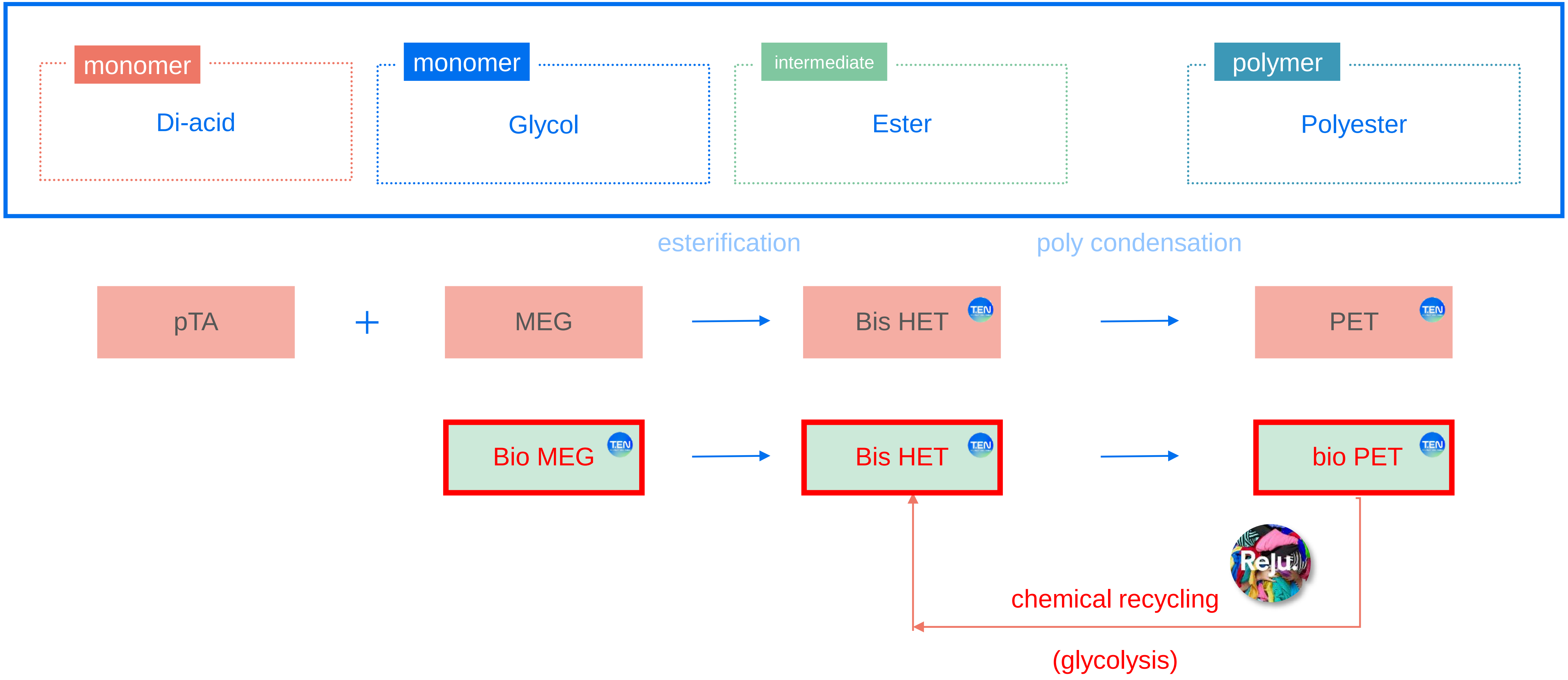
Case study 01

Reduction of carbon footprint



TECHNIP ENERGIES

Polyesters: carbon footprint reduction



PTA: Purified Terephthalate Acid, MEG: Mono Ethylene Glycol,
bis-HET: Bis (2-HydroxyEthyl) Terephthalate; PET: PolyEthylene Terephthalate
ReJu is a textile-to-textile rejuvenation company wholly owned by T.EN

Bio2Glycols™

Bio MEG

Fast track de-risked development of our bioMEG* technology

Technology

A competitive, catalytic sugar to chemicals drop-in process solution**

- Reactor, catalyst IP purchased from Iowa Corn in 2022
- Downstream processing and IP purchased from Shell in 2024

Project description

- Successful parametric testing in lab scale reactor
  - -optimization for good conversion, high selectivity, low excess hydrogen
  - -qualification of commercial catalysts with T.EN formulation
- Pilot size reactor and MEG purification scale-up trials successful
- Polymer resin test packs in T.EN Zimmer

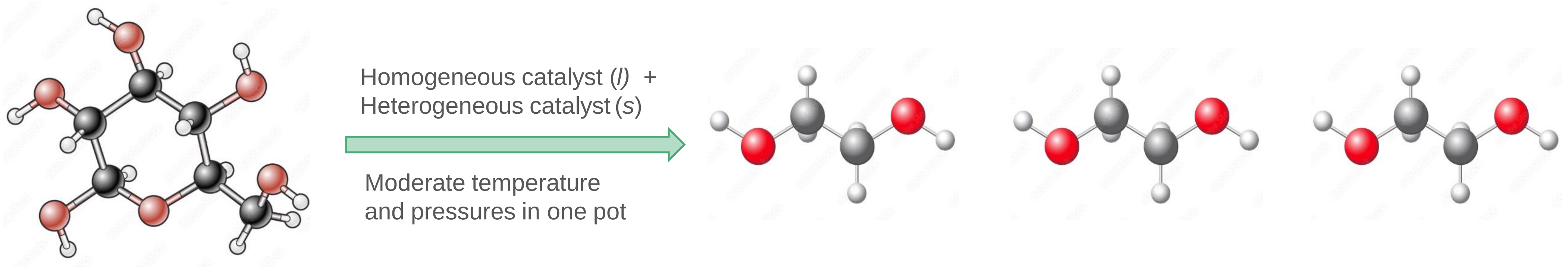
Commercialization

Status

- Competitive Cost of Production (CAPEX / OPEX)
- Commercial scale plant design ongoing
- Discussions ongoing for full scale commercial plant with first adopter

Technology monetization

- License, basic engineering, proprietary equipment, catalyst



, **glucose DE95

* MEG: mono ethylene glycol

TECHNIP ENERGIES

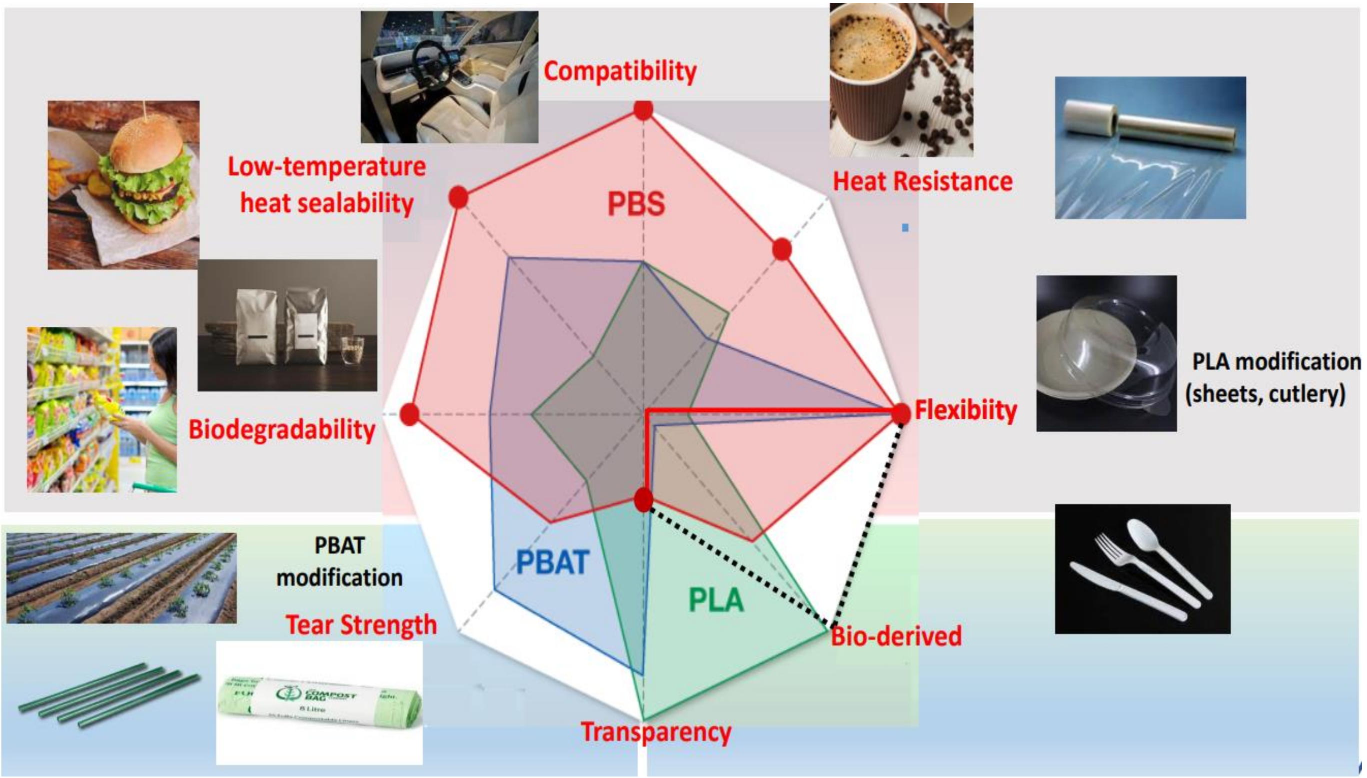
Case study 02

A step-wise approach to a new polyester of choice

TECHNIP ENERGIES

PBS: a new polyester of choice

Properties of competing bio-polyesters



- PBS present a well-balanced mix of properties
- PBS can be mixed with other cheap polyesters to enhance their performance
- PBAT / PBS can be made on the same swing polymerization plant

PBS: polybutylene succinate, PBAT: polybutylene adipate-terephthalate, PLA: poly lactic acid

PBAT then PBS

An evolutive approach to follow market take-up of new resins

monomer	monomer	intermediate	polymer
Di-acid	Glycol	Ester	Polyester

Step 1

pTA / AA + BDO → BAcT oligomer → PBAT

Build a PBAT/PBS swing plant, producing initially PBAT

Step 2

Bio SA + BDO → Bio-PBS oligomer → bio-PBS

Build a bio-SA plant, producing bio-PBS

TECHNIP ENERGIES

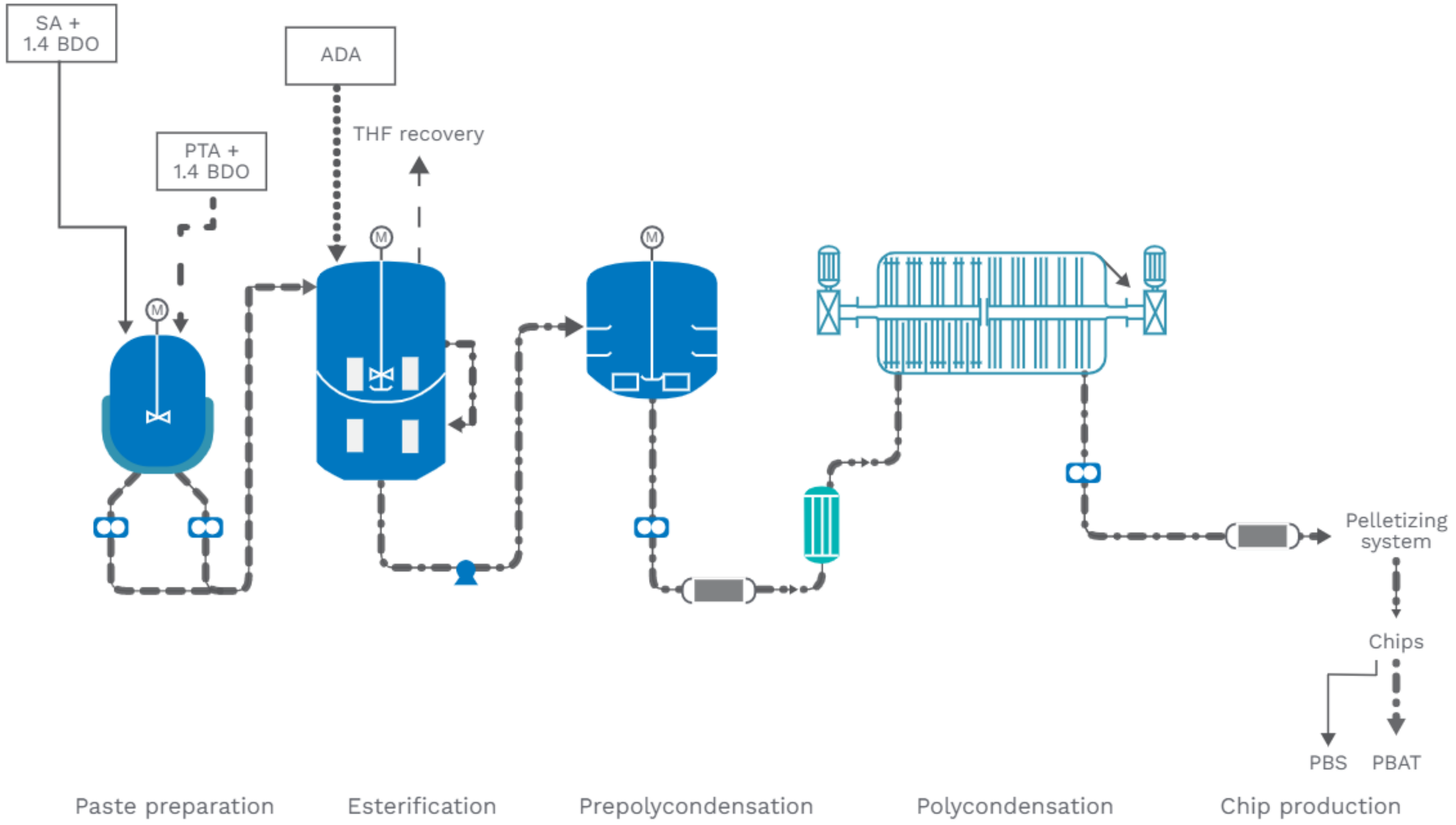
PTA: Purified Terephthalate Acid, AA: Adipic Acid, BDO: 1,4 butanediol
BAcT:Butylene adipate-co-terephthalate, SAc: Succinic acid,
PBAT: polybutylene adipate-terephthalate, PBS: polybutylene succinate,

T.EN Zimmer's polyester process

PBAT

bio-PBS

Step 1: Swing technology plant designed for PBAT/PBS, producing PBAT



Attributes:

- Defined ratio of glycols and carboxylic acids in the paste with additives
- Controlled polymer chain growth and final viscosities by
  - Specific reaction degrees
  - Defined temperature and pressure profiles
- Internal recycling & removal/separation of side products
- Chip production or direct spinning/preform/film
- Good combination of physical and biodegradable properties
  - Properties similar to polypropylene
  - Suitable for packaging and film applications
  - Biodegradation according to EN 13432

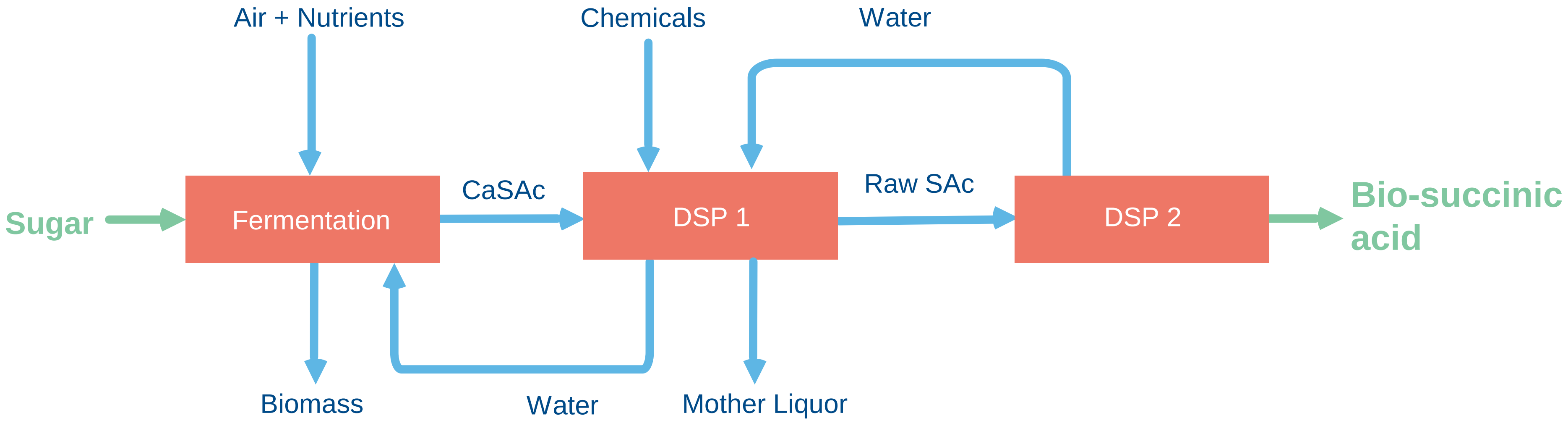
T.EN TECHNIP ENERGIES

Zimmer® Polymer Technologies

T.EN Biosuccinium® technology

Step 2: Bio-SA plant

Bio-SA



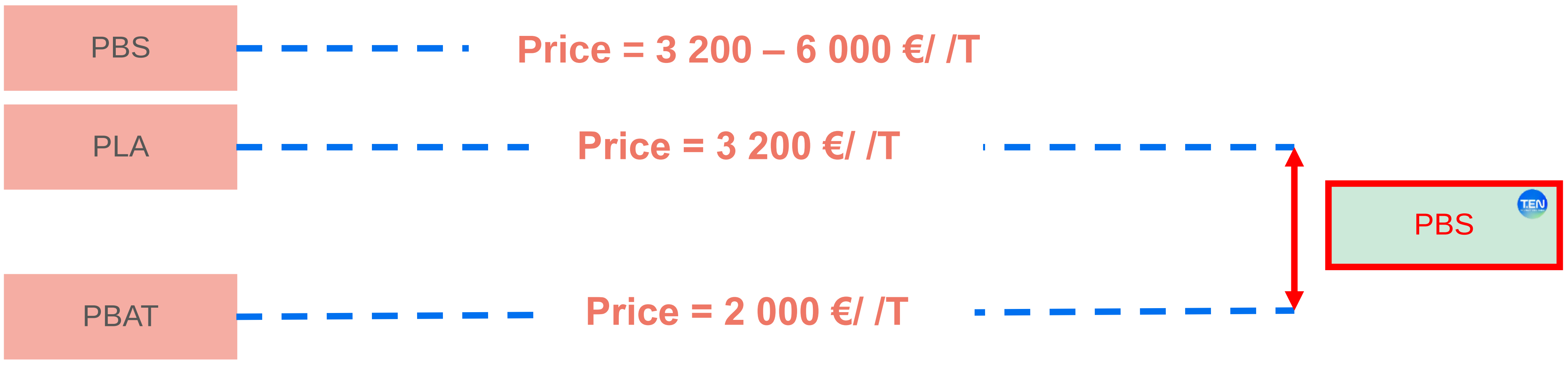
- Yeast based fermentation
  - Proprietary yeast strain
  - High yield / low fermentation by-products
  - Low pH: minimize chemicals consumption, salts in effluent, contamination risk

- Standard downstream processing
  - Readily available equipment
  - No proprietary or uncommon unit operation
  - High recovery yield with proven quality track record

Commercial unit, Roquette, Italy

DSP: Downstream processing

Economics



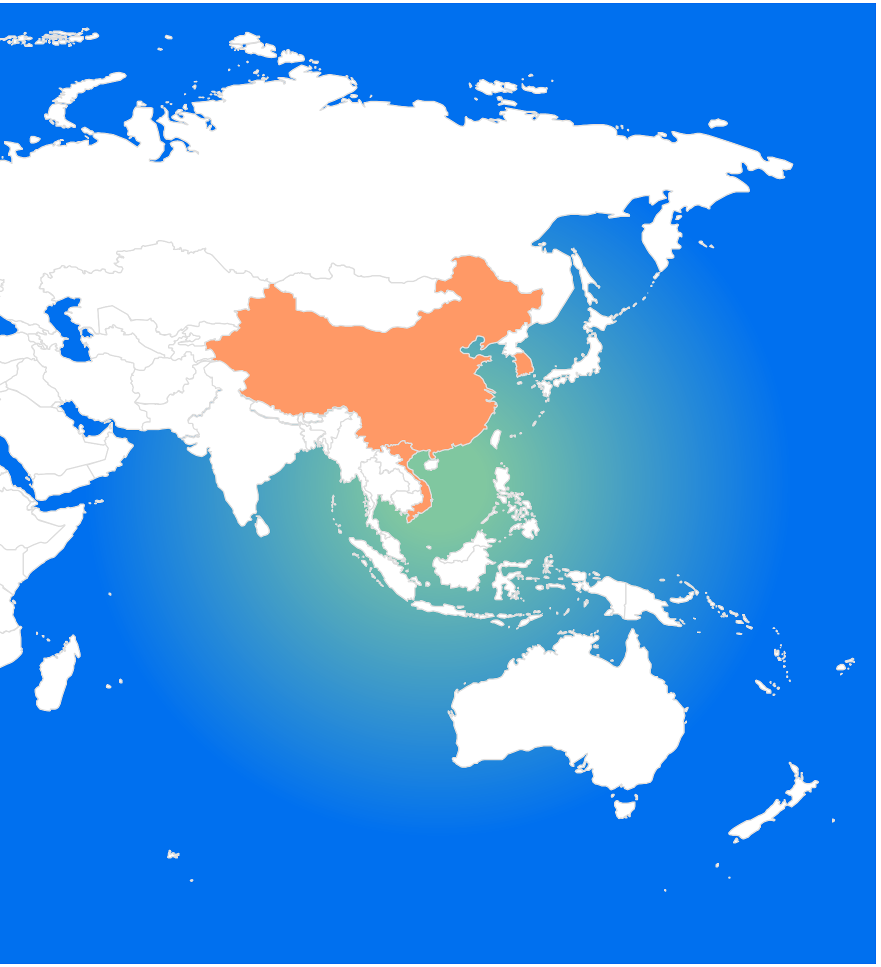
- Historically, PBS commands a premium against PLA / PBAT
- For widespread market acceptance, PBS must be produced at a cost between that of PBAT and PLA

- Yes we can provide PBS with a CoP compatible with the required market price

Average China 2023

Bio-polyesters

References in South-East Asia



- China
  - 2019 Start-up of swing bio-polyester plant: PBAT/PBS (120/100 kta)
  - 2023 Start-up of swing bio-polyester plant: PBAT/PBS (240/200 kta)

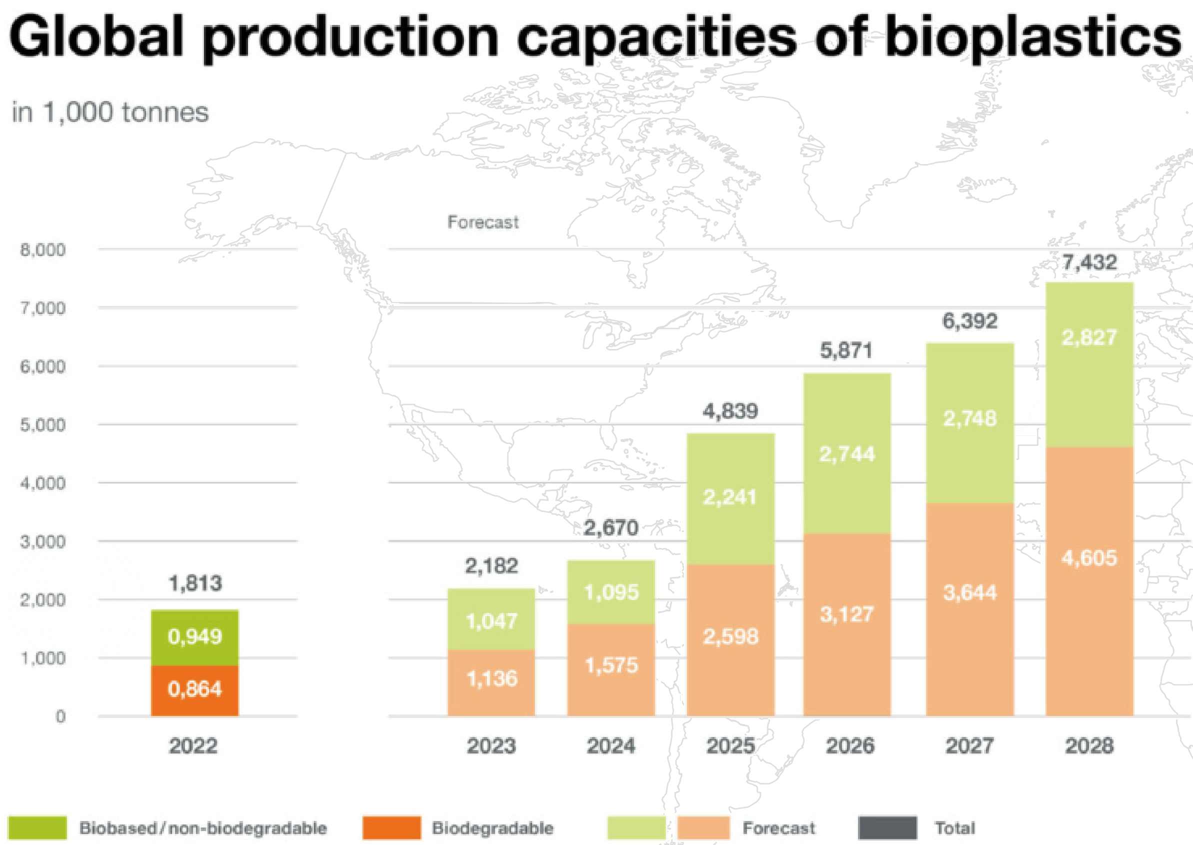
- South Korea
  - 2024 Start-up of bio-polyester plant: PBAT (50 kta)

- Vietnam
  - 2025 Start-up of swing bio-polyester plant: PBAT/PBS (70/60 kta)

Thank you

Market development

Worldwide demand on bioplastics



Market – European Bioplastics e.V. (european-bioplastics.org) (21.08.24)

- References
  - 2019 Start-up of PBAT (120 kta) or PBS (100 kta) in China
  - 2022 Award of PBAT (70 kta) or PBS (60 kta) in Vietnam
  - 2023 Start-up of PBAT (240 kta) or PBS (200 kta) in China
  - 2024 Start-up of PBAT (50 kta) in South Korea

T.EN TECHNIP ENERGIES

Biosuccinium® technology

Value Chain

Zimmer Polymer Technologies

biosuccinium sustainable succinic acid

Sugar → Bio-SA → PBS / Bio BDO

CONSER JM

Bio BDO → PBS

Bio BDO → Bio THF → Bio PTMEG

Bio BDO - - → Bio GBL

PBS → Bio THF

Bio-SA is a substitute for Maleic Anhydride in the fossil route

Elastic Fibers

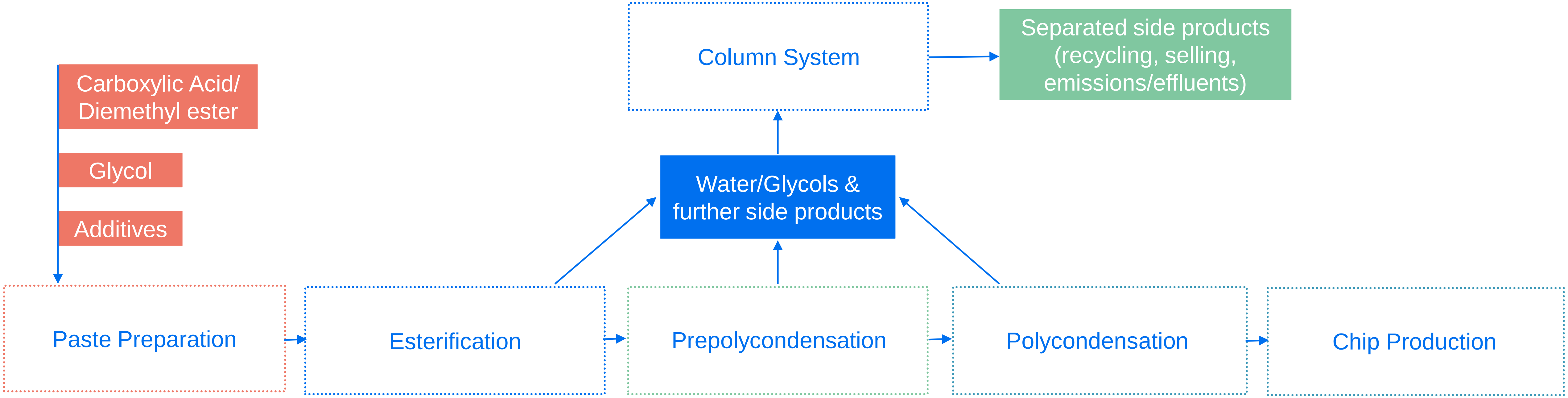
Engineering Plastics

- SA = Succinic Acid
- BDO = 1,4 Butanediol
- PBS = Polybutylenesuccinate

- THF = Tetrahydrofurane
- PTMEG = Polytetramethyleneglycol
- GBL = Gammabutyrolactone
- NMP = N-methylpyrrolidone

T.EN TECHNIP ENERGIES

Polyester Technology by T.EN



T.EN Zimmer's Polyester Process

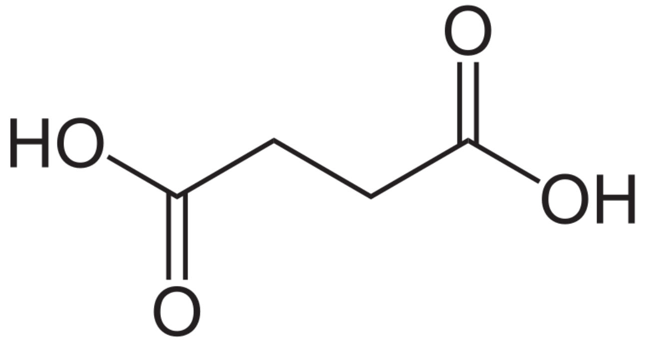
- Defined ratio of glycols and carboxylic acids in the paste with additives
- Controlled polymer chain growth and final viscosities by
  - Specific reaction degrees
  - Defined temperature and pressure profiles
- Removal and separation of side products

Proprietary Equipment

- Disc Ring Reactor (DRR) for high viscosity polymers
- Viscosimeter for final polymer melt
- Vacuum jet and scraper seal system for very high vacuum

Biosuccinium® technology

Succinic Acid specifications



- Succinic Acid specification from Biosuccinium® technology derived from plant operations, from Zimmer technology requirements for Bio-PBS and from trials in collaboration with Conser S.p.A. and JM for the Bio-BDO production
- The final product is **polymer grade**

Product specifications

Parameter	Requirement	Analytic methods	Principle
Appearance	White crystalline powder	MCL 086G*	Visual comparison to control.
Water content	≤0.3 w%	MCL 006A*	Karl Fischer titration.
Purity (dry basis)	≥ 99.5 w%	MCL 1462*	Separation by ion exchange chromatography. Detection by refractometry.
Other (small) organic acids	≤ 0.1 w% each ≤ 0.5 w% total	MCL 1461*	Separation by ion exchange chromatography. Detection by UV at 210 nm.
Iron	≤ 5 ppm	ICP-MS	Inductively-coupled plasma mass spectrometry.
Arsenic	≤ 0.1 mg/kg	ICP-MS	Inductively-coupled plasma mass spectrometry.
Lead	≤ 0.1 mg/kg	ICP-MS	Inductively-coupled plasma mass spectrometry.
Mercury	≤ 0.1 mg/kg	ICP-MS	Inductively-coupled plasma mass spectrometry.