Introduction to bioplastics and biocomposites

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Bio2AN – Rotorua - Scion – 14.02.2019


Source: China Hopson

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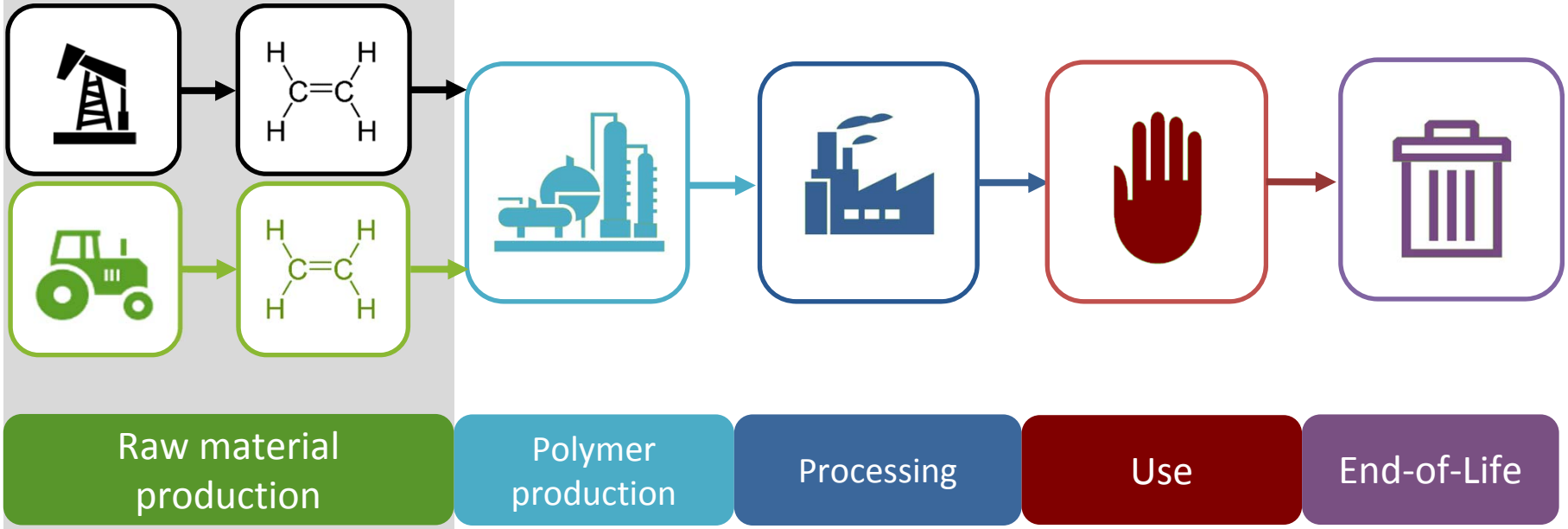
Introducing bioplastics



Agenda

1. Defining bioplastics
2. Bioplastics market data
3. Land use for bioplastics
4. Pros and cons of bioplastics

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What are Bioplastics?

„White“
Biotechnology?

Natural fiber
reinforced plastics?

Polymers from
renewable resources?

Opposite of
conventional plastics?

Degradable?

Bioplastics?

Sustainable?

Bio-degradable?

Renewable?

Compostable?

Biogenic
macromolecules?

Oxodegradable?

Bio-compatible?

Water soluble?

The evolution of bioplastics

Generations of technical bioplastics

Focus on bio-based residues, longevity, drop-ins

4th Bioplastics generation

Residue utilization, bioeconomy

Focus on bio-based, longevity, drop-ins

3rd Bioplastics generation

Bio-PA, Bio-PE, Bio-PET, PTT, Bio-PP

Focus on biodegradation (optimized properties)

2nd Bioplastics generation

Starch blends PLA PBAT PBS

Focus on biodegradation (bad properties)

1st Bioplastics generation

Starch polymers PHA

1980 1990 2000 2010 2020

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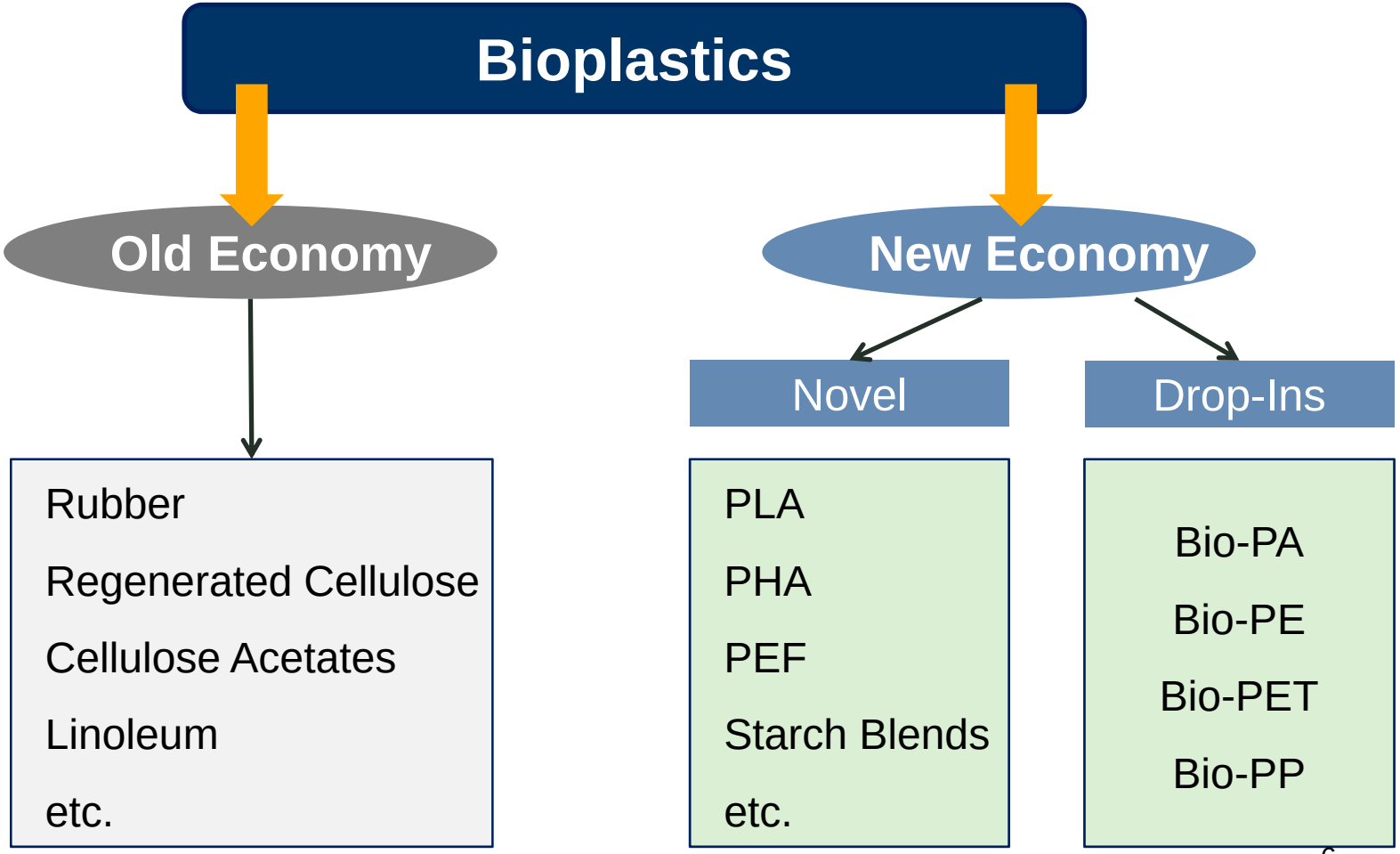
Definition
Old and New Economy Bioplastics



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But still, what are Bioplastics?

No new material group
→ classification in the class and the spectrum of plastics.

Classification into:

- Degradable petro-based bioplastics
- Degradable (predominantly) bio-based bioplastics
- Non-degradable, bio-based bioplastics

!!!

Facts about **bio-based** plastics:

- Renewable raw material base
- Raw material production for bio-based plastics requires less energy
- Novel material properties (except drop-ins)
- Various disposal options (material recycling, composting, climate-neutral energy recovery)

!!!

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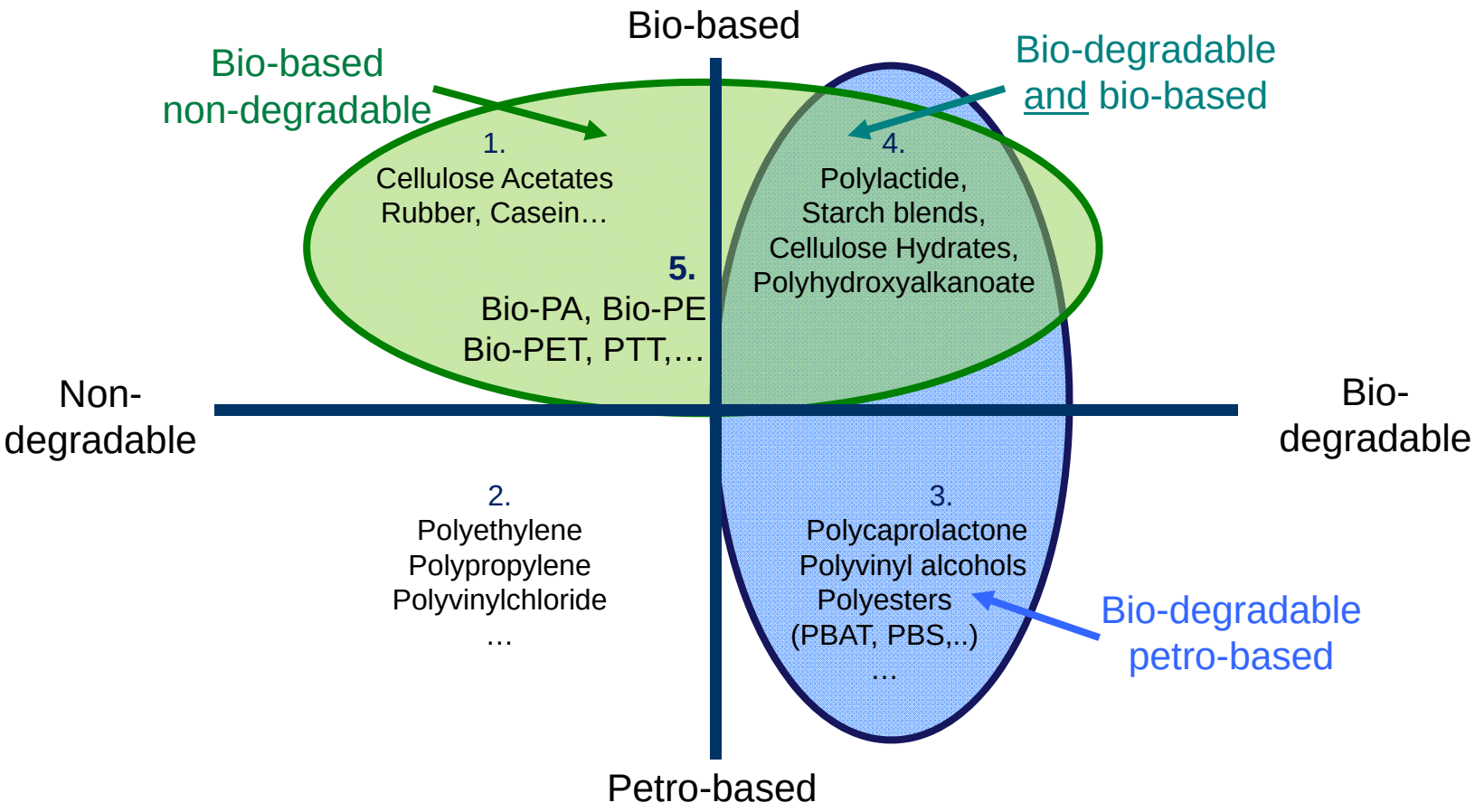
Definition of Bioplastics
“The bioplastics cross"



Source: H.-J. Endres, A. Siebert-Raths; Engineering Biopolymers, Carl Hanser-Verlag, 2011

Bioplastics applications

www.alibaba.com

Bio-based

www.greenject.de

https://de.dreamstime.com

www.bakerross.de

www.innovativeindustry.net

https://www.asdreports.com

Non-degradable

Bio-degradable

Conventional plastics

www.pressreleasefinder.com

https://http://www.pbat.info/en.html

joyforce-chem.com

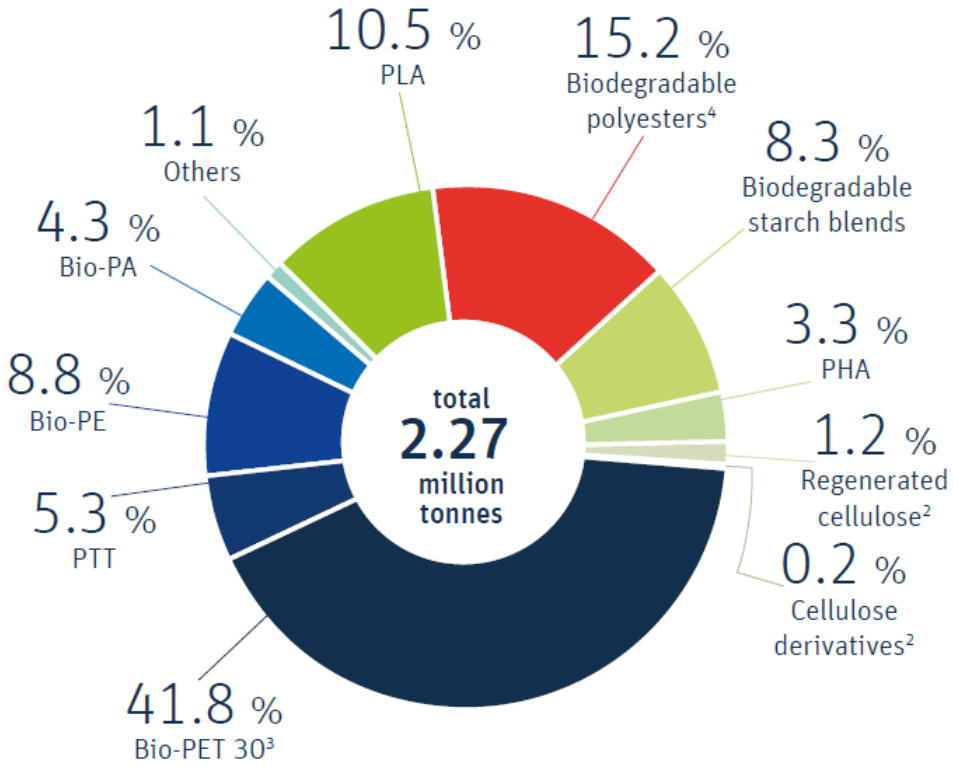
Petro-based

Market figures for bioplastics

New economy bioplastics production capacities 2017

61.3%
bio-based/non-biodegradable

38.7 %
biodegradable



[1] Biodegradable cellulose esters
[2] Compostable hydrated cellulose foils
[3] Bio-based content amounts 30%
[4] Contains PBAT, PBS, PCL

www.ifbb-hannover.de/de/facts-and-statistics.html

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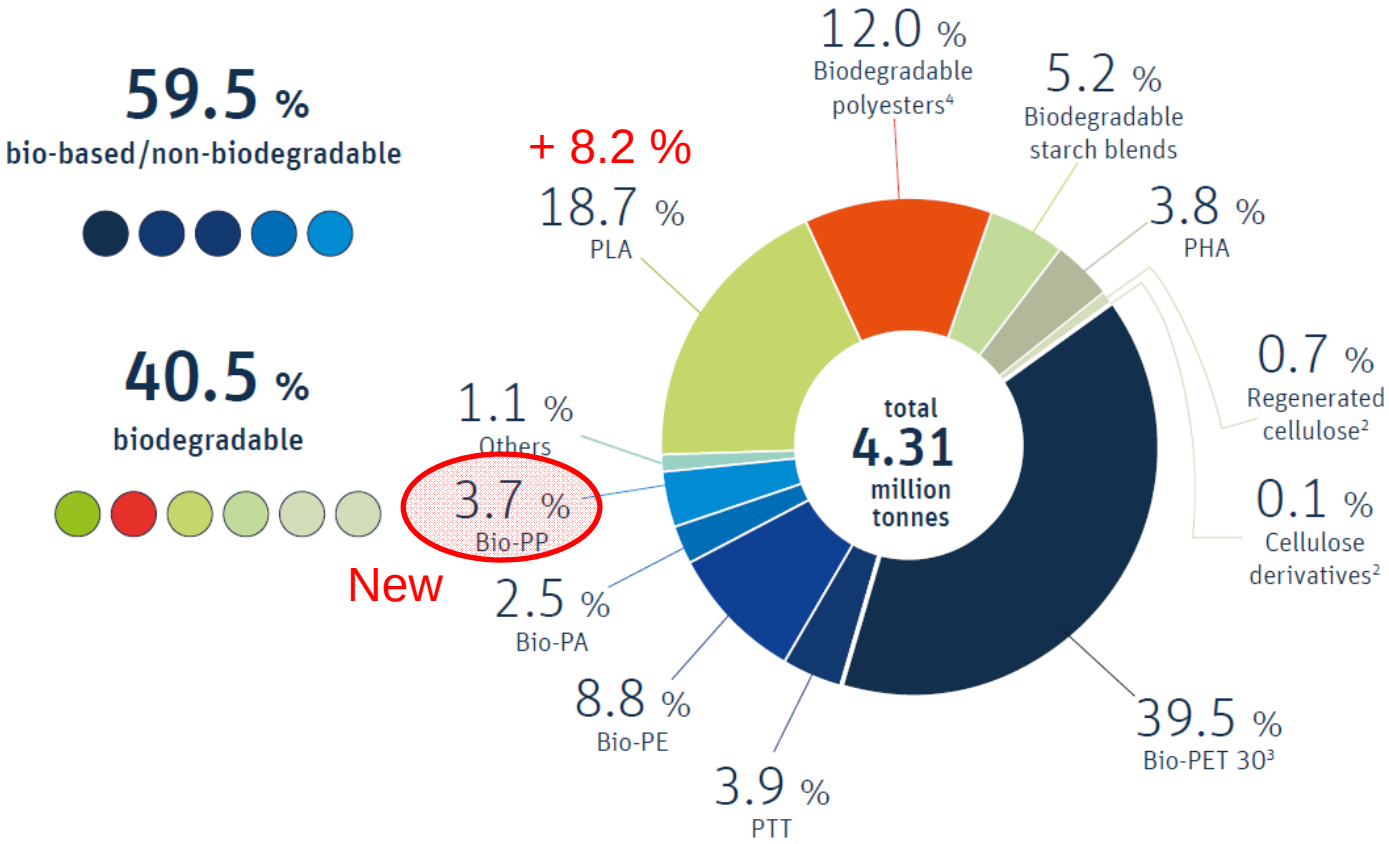
Market figures for bioplastics

New economy bioplastics production capacities 2022



2017 = 2.27 million tons

2022 = 4.31 million tons

→ + 190 %
Mainly pushed by PLA & Bio-PP

[1] Biodegradable cellulose esters
[2] Compostable hydrated cellulose foils
[3] Bio-based content amounts 30%
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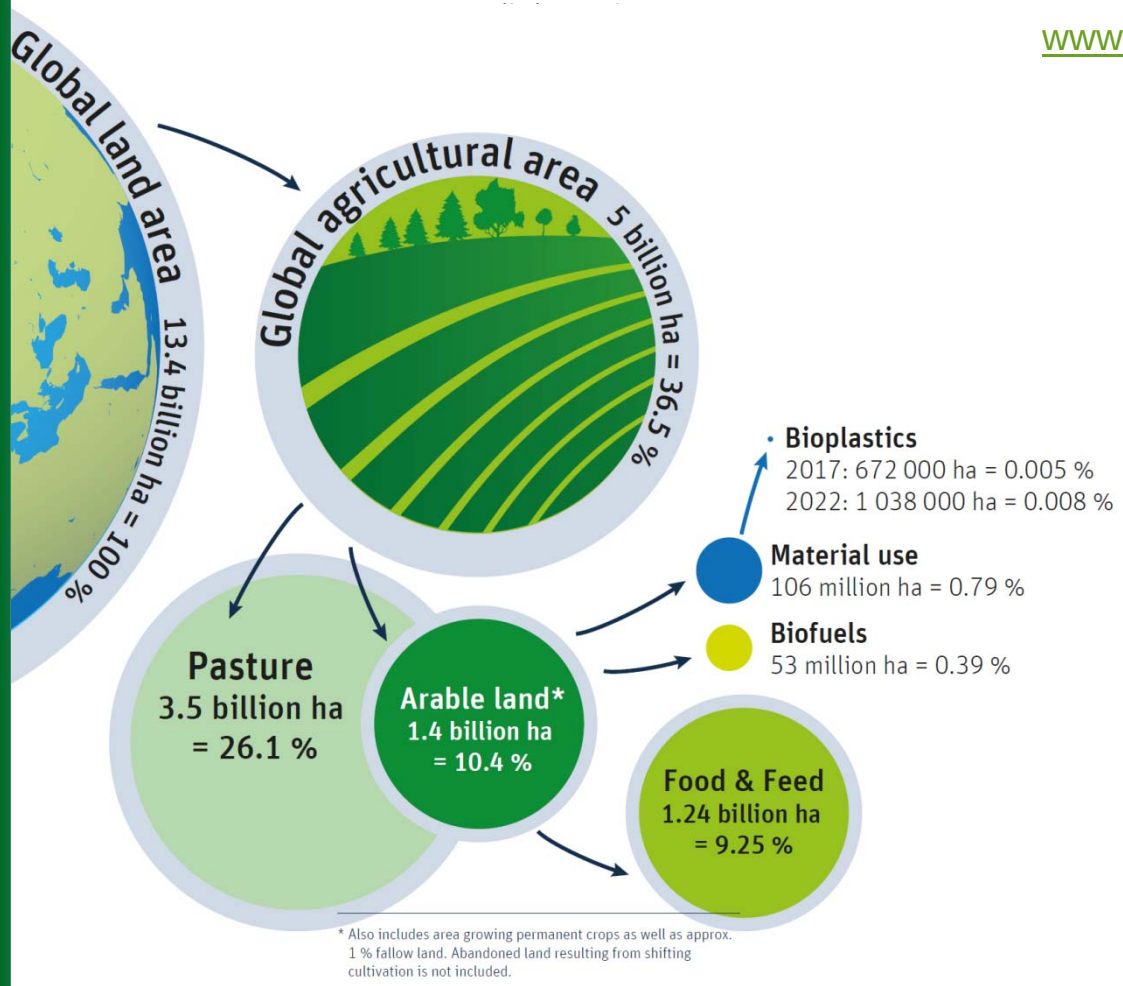
Market figures for bioplastics: Land area usage

www.ifbb-hannover.de/de/facts-and-statistics.html



Global land area = 13.4 billion ha = 100%

Agricultural area = 5 billion ha = 36.5%

Pasture = 3.5 billion ha = 26.1%

Arable land = 1.4 billion ha = 10.4%

Food & Feed = 1.24 billion ha = 9.25%

Biofuel = 53 million ha = 0.39%

Bioplastics 2022 = 1.04 million ha = 0.008%

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Pros and cons of bioplastics

- Performance compared to conventional plastics
  → Same for the Drop-Ins / Others often comparable but some show weaknesses
- Special features
  → Biodegradability / new, special and unique material properties
- Feedstock
  → Independence from oil (for the bio-based) as a finite source of raw material
- Processing and material data basis
  → Is getting better but needs to be improved / Often only little or outdated information's
- Price
  → Competitive for some materials like PLA, but most are still more expensive

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Thank you for your attention

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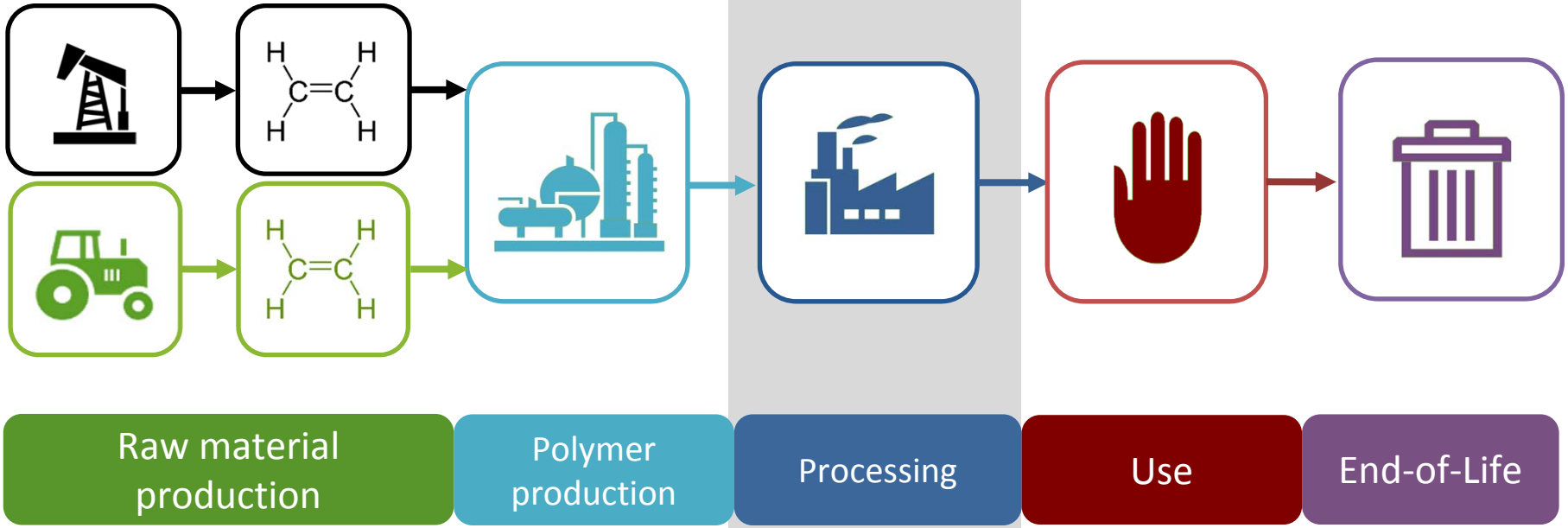
Processing


Raw material production
Polymer production
Processing
Use
End-of-Life

Agenda

1. (Bio)Plastics Overview & market share
2. “The bioplastics processing challenges”
3. Processing bioplastics
4. Bioplastics processing hints & information´s

Plastics Overview & market share

The two categories of plastics

Thermoplastics

are a family of plastics that can be melted when heated and hardened when cooled. These characteristics, which lend the material its name, are reversible. That is, it can be reheated, reshaped and frozen repeatedly.

- Polyethylene (PE)
- Polypropylene (PP)
- Polyvinyl-chloride (PVC)
- Polyethylene Terephthalate (PET)
- Polystyrene (PS)
- Expanded polystyrene (EPS)
- ABS
- SAN
- Polyamides (PA)
- Polycarbonate (PC)
- Poly methyl methacrylate (PMMA)
- Thermoplastic elastomers (TPE)
- Polyarylsulfone (PSU)
- Fluoropolymers
- PEEK
- POM
- PBT
- Etc.

Thermosets

are a family of plastics that undergo a chemical change when heated, creating a three dimensional network. After they are heated and formed these plastics cannot be re-melted and reformed.

- Polyurethane (PUR)
- Unsaturated polyester
- Epoxy resins
- Melamine resin
- Vinyl ester
- Silicone
- Phenol - formaldeyhde
- Urea - formaldeyhde
- Phenolic resins
- Acrylic resins
- Etc.

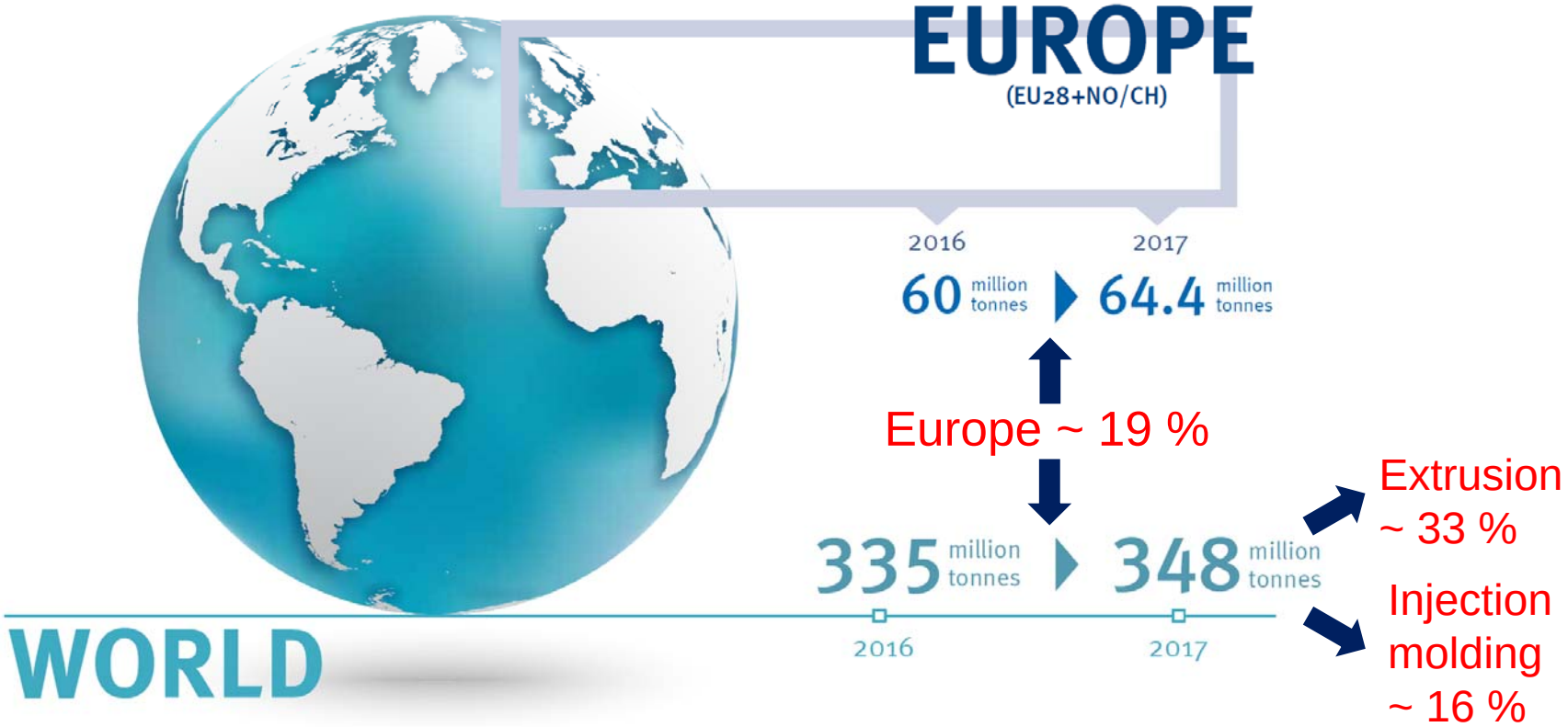
Source: www.plasticseurope.org

Plastics Overview & market share

World and EU plastics production data

The world plastic* production almost reached 350 million tonnes in 2017.

Source: PlasticsEurope Market Research Group (PEMRG) / Conversio Market & Strategy GmbH



Includes thermoplastics, polyurethanes, thermosets, elastomers, adhesives, coatings and sealants and PP-fibers.
Not included PET-, PA- and polyacryl-fibers.

Source: www.plasticseurope.org

Source: Ceresan study

Biolastics Overview & market share

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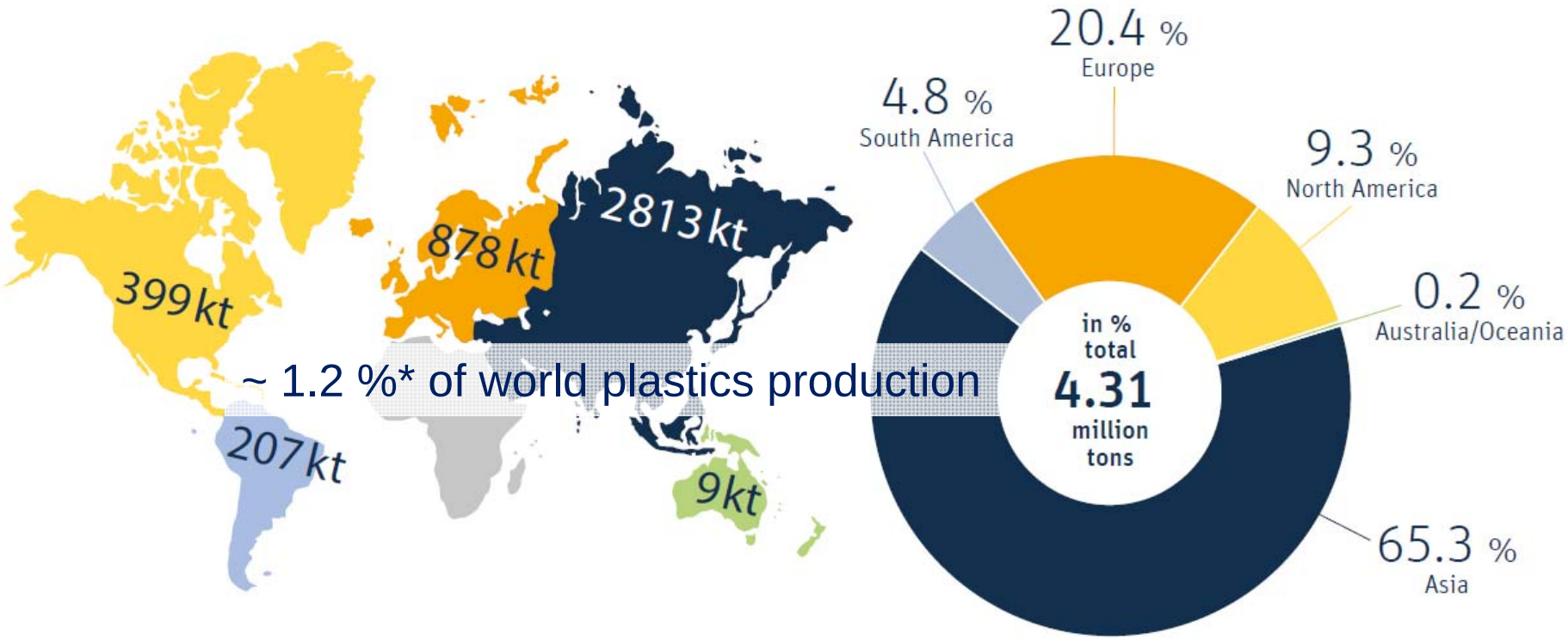
New economy bioplastics production capacities by region 2022



~ 1.2 %* of world plastics production

Extrusion & injection molding are also the biggest applications for bioplastics

* Comparison between production data 2017 and production capacity data 2022

“The bioplastics processing challenges” - The bad news (does not apply for drop-ins)

- Very limited material data available
- Limited processing knowledge available
- Limited information on pre-treatment / drying available
- Bioplastics need to provide "better" data if they want to displace traditional plastics in technical applications
- No/not enough bio-based additives available
- No/not enough bio-based master batches on the market
- Often higher material prices due to low production capacities

“The bioplastics processing challenges”
- The good news

- Bioplastics are also just plastics
- Processing them is normally as complex as switching from one plastics type to another, if there specific needs are observed
- They have very interesting an unique properties which can be beneficial
- Prices drop down with increasing production capacities and demand

Processing Bioplastics
- The bioplastics processing project

Manufacturing and Processing of Bio-Based Plastics and Establishment of a Competence Network within the Biopolymer Network maintained by the FNR (project management)

Task I	Task II	Task III
Determination Of Process Data	Knowledge Transfer	Integration Into The FNR Network

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Processing Bioplastics
- Thermoplastics – Extrusion

Decision-making aids for a switch over from oil-based plastics to bio-based plastics (concerning twin screw extrusion)

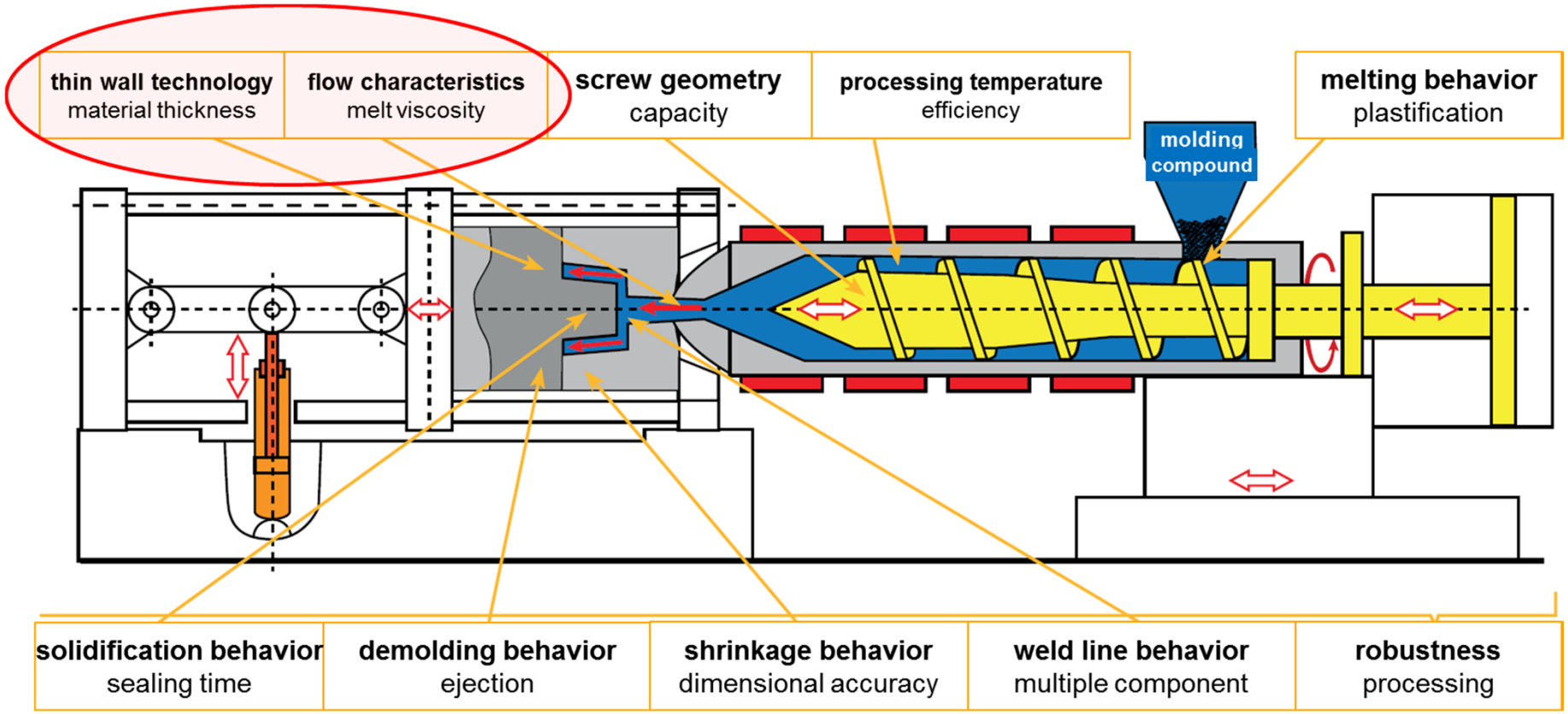
Processing instructions

Material	Processing instructions	processing temperature range [°C]	drying time	drying tempera-ture [°C]	max. moisture [%]
PLA	• Pre-drying necessary → hydrolytic degradation • At humidity > 0.025 % H20 influ-ence of hydrolysis increases; the material becomes more flowable through chain degradation (low viscosity) • Smaller fusing range • Sharply-defined fusing zone • Tiered temperature profile → Fast + gentle fusing (good for fibre incorporation) • After extrusion → drying in crystalliser	180–200	6 h	80	–
PLA blend	• No general statement, as high number of combinations possible • Dependent on miscibility, a relatively sharply-defined mixing zone should be chosen				
PLLA	• Processing comparable with PLA	190–220	6 h	80	< 0.025
TPS	No data available				
TPS blend	• No general statement, as high number of combinations possible • TPS proportion leads to hydroscopic properties (moisture absorption)				

Source: © IfBB

Processing Bioplastics
- Thermoplastics – Injection Molding

- Rheological properties



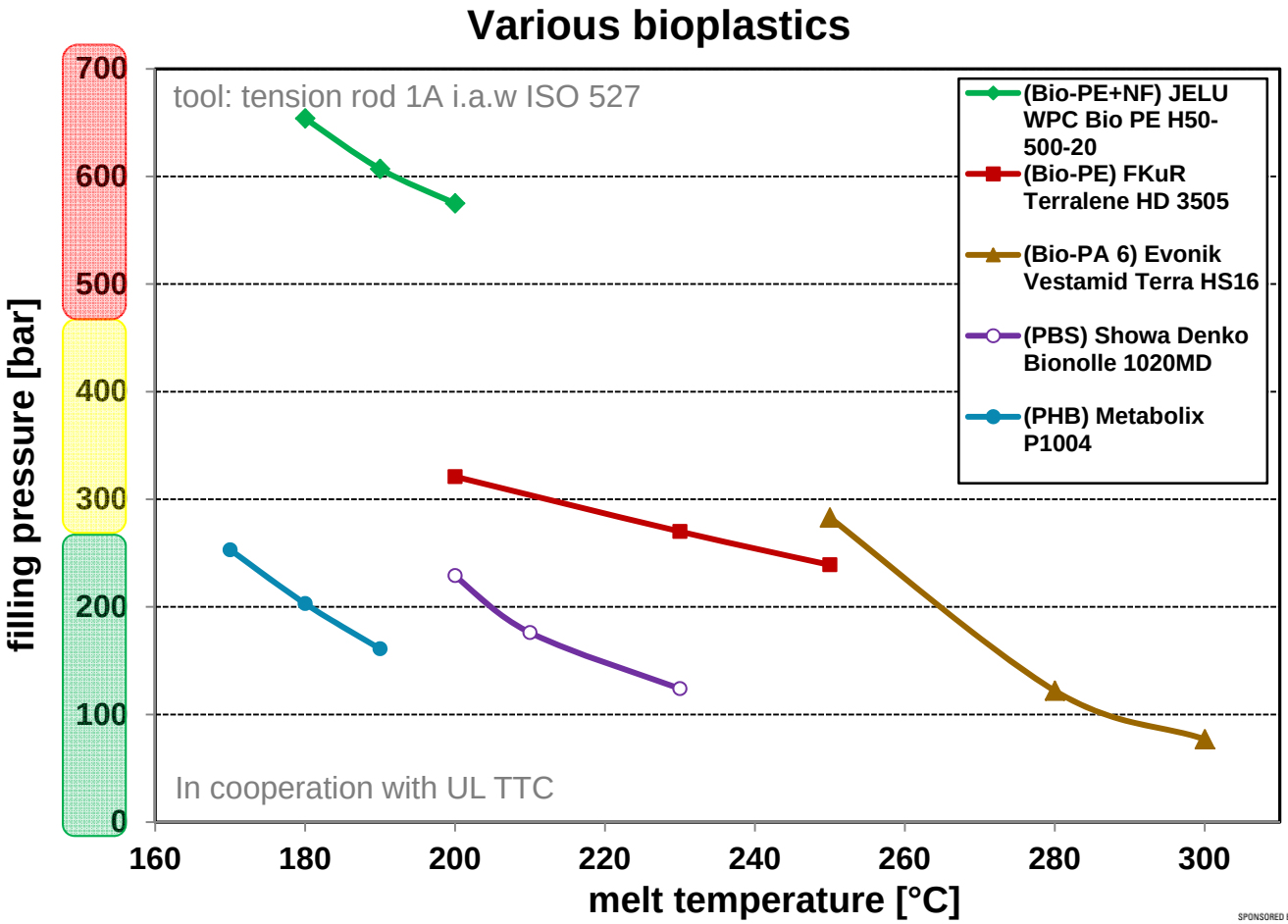
Processing Bioplastics
- Thermoplastics – Injection Molding

- Filling pressure vs. melt temperature

High viscosity cf. PC amorphous

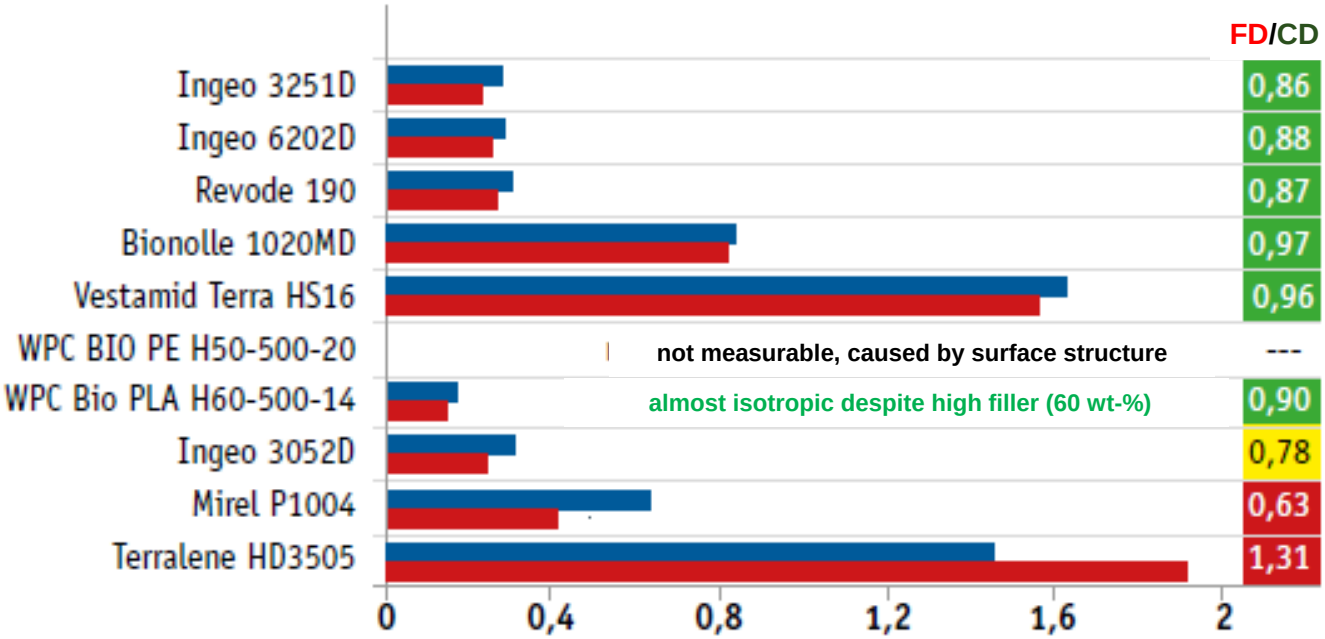
Increased viscosity cf. PBT filled

low viscosity cf. PA 6



Processing Bioplastics
- Thermoplastics – Injection Molding

- Dimensional stability (Traffic light rating)
  - Shrinkage and warpage of bioplastics



Processed according to ISO 294

In co-operation with UL TTC

Flow direction (FD)

Cross-flow direction (CD)

Test plate 60 x 60 x 2 mm

Anisotropy factor FD/CD

Bioplastics processing hints & information´s - List of contents

Processing Bioplastics

Go to:
hs-h.de/processing-bioplastics

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Further hints & information´s

www.materialdatacenter.com

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Home >> MATERIAL DATA >> Data Sheet

Change Units: SI / US Change Language: en / de

Producer: NatureWorks Polymer: PLA Grade Name: Search Property Search Data Sheet

Data Sheet | Data Table | Compare

Show marked grades only Clear marked grades

30 materials

Grade Name	Polymer	Producer
Ingeo™ 10361D	PLA	NatureWorks
Ingeo™ 2003D	PLA	NatureWorks
Ingeo™ 2500HP	PLA	NatureWorks
Ingeo™ 3001D	PLA	NatureWorks
Ingeo™ 3052D	PLA	NatureWorks
Ingeo™ 3100HP	PLA	NatureWorks
☑ Ingeo™ 3251D	PLA	NatureWorks
Ingeo™ 3260HP	PLA	NatureWorks
Ingeo™ 3D850	PLA	NatureWorks
Ingeo™ 3D860	PLA	NatureWorks
Ingeo™ 3D870	PLA	NatureWorks
Ingeo™ 4032D Film	PLA	NatureWorks
Ingeo™ 4032D General	PLA	NatureWorks
Ingeo™ 4043D Film	PLA	NatureWorks
Ingeo™ 4043D Monofilament	PLA	NatureWorks
Ingeo™ 4044D	PLA	NatureWorks
Ingeo™ 4060D	PLA	NatureWorks
Ingeo™ 6060D	PLA	NatureWorks
Ingeo™ 6100D	PLA	NatureWorks
Ingeo™ 6201D	PLA	NatureWorks
Ingeo™ 6202D	PLA	NatureWorks
Ingeo™ 6252D	PLA	NatureWorks
Ingeo™ 6260D	PLA	NatureWorks
Ingeo™ 6302D	PLA	NatureWorks
Ingeo™ 6362D	PLA	NatureWorks
Ingeo™ 6400D	PLA	NatureWorks

* A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Producer data | Project data

Ingeo™ 3251D | PLA | NatureWorks

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Producer data

Processing/Physical Characteristics	Value	Unit	Test Standard
ASTM Data			
Melt Flow Index, MFI	80	g/10min	ASTM D 1238
Temperature	210	°C	-
Load	2.16	kg	-

Mechanical properties	Value	Unit	Test Standard
ASTM Data			
Tensile Strength at Yield	62	MPa	ASTM D 638
Flexural Strength	108	MPa	ASTM D 790
Izod Impact notched, 1/8 in	16	J/m	ASTM D 256

Thermal properties	Value	Unit	Test Standard
ASTM Data			
Melting Temperature	162	°C	ASTM D 3418
Glass Transition Temperature	57.5	°C	ASTM E 1356

Other properties	Value	Unit	Test Standard
Density	1240	kg/m³	ASTM D 792

Processing Recommendation Injection Molding	Value	Unit	Test Standard
Processing humidity	≤0.01	%	-
Melt temperature	188 - 210	°C	-
Mold temperature	25	°C	-
Feed temperature	166 - 177	°C	-
Zone 1	182 - 193	°C	-
Zone 2	188 - 205	°C	-
Nozzle temperature	188 - 205	°C	-

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Further hints & information´s

Areas of expertise:

hs-h.de/ifbb-areasofexpertise

Bio-Based Plastics - Recommendations for Product Communication

hs-h.de/ifbb-productcommunication

In action for biocomposites: Residual materials:

hs-h.de/ifbb-residualmaterials

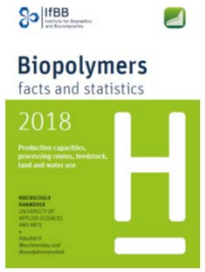
Processing of Bioplastics

hs-h.de/processing-bioplastics

Marine Degradability of Bioplastics

hs-h.de/ifbb-marinedegradability

Biopolymers – facts and statistics 2018:



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