

Uhde innovate 2024

The sustainable technologies of Uhde Inventa-Fischer

06.06.2024 | Udo Mühlbauer
Uhde Inventa-Fischer

engineering.tomorrow.together.

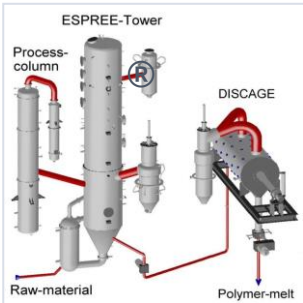


thyssenkrupp

Uhde Inventa-Fischer – world’s leading technology licensor and engineer

Who we are

Proprietary
Technology
Licensor
& Engineer



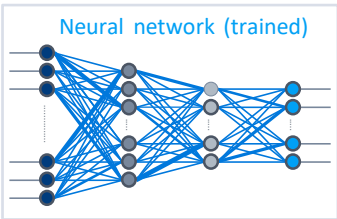
Polyester
Polyamide
PLA & LA
Biopolymers
Recycling

Lab & Pilot plants
Design of
Proprietary
Equipment



Technology
Innovation

Digitalization
Performance &
Quality
monitoring



Spares &
Services

Our USP



Lowest in
CO₂ Footprint
and OPEX



Circular
Economies



Recycling &
Bio based
raw materials

Who we serve



Packaging & Bottles



Textiles



Biodegradable Plastics



The leading Technology Licensor for the transformation to Green Polycondensation Technologies

Product Portfolio	Average exp. Sales Split	People and Locations	Selected Customers
Recycled Polyester (rPET up to 50%)	Fully integrated PET recycling process with lowest CO2 footprint MTR® Technology, producing materials for virgin like packaging with ratios up to 50 % FTR®+ and FTR®maxx , 100% currently in development)	~50%	150 highly qualified engineers located in
Lactide Acid and Polylactide Acid	Biopolymer PLA process for packaging and textile applications. Lactide Acid Process for raw Material LA owned and in the final stage of industrial scaling.	~10%	Berlin & Domat/Ems, Switzerland and Shanghai
other Biopolymers (Bio based/-degradable)	For packaging, textile and compounds, incl. Bioplastics (PBAT/PBS , PA11 , PA6.10)	~5%	Strong focus on R/D with R/D Center in Berlin and Semi Commercial PLA Plant in Guben, leading to
Co-operations rDMT to 100% rPET rCPL to 100% rPA6	Re-Polymerisation (MTR®) of substituted oil based raw materials through 100% chemical recycled PET and PA6	~10 % increasing share over time	~450 Patents
Others, Polyamides incl. future recycling of PA6	Polyamide Process still standard oil-based product; however, R/D activities for use of recycled material started	~25%	~150 Trademarks

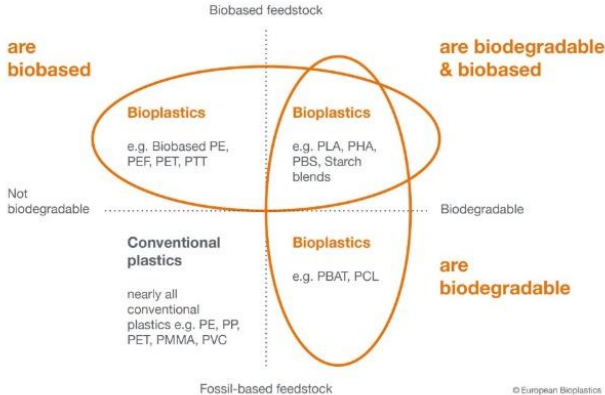


Overview Biopolymers

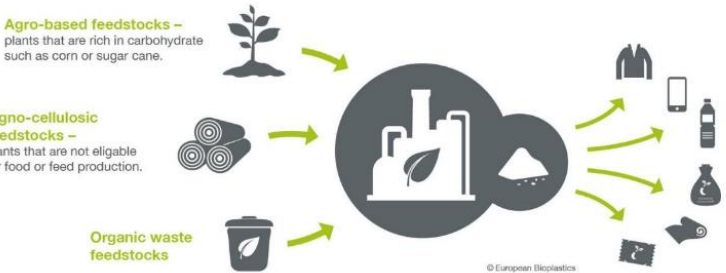
Material coordinate system for bioplastics

Bioplastics are biobased, biodegradable, or both.

Source: Institute for Bioplastics and Biocomposites (IBB) and European Bioplastics (EUBP)



Biobased plastics are made from a wide range of renewable **biobased feedstocks**.



Biobased plastics help to defossilise the economy

Substituting the annual European demand* for fossil-based polyethylene (PE) with biobased PE would save around

73 million tonnes of CO₂**

* Based on the European demand for conventional polyethylene in 2020 (Plastics Europe).
** Based on -3.09 CO₂/kg biobased PE (Breakers, I'm Green**)

This is equal to the CO₂ emissions of
20 million flights around the world per year!

© European Bioplastics

END-OF-LIFE OPTIONS FOR BIOBASED AND BIODEGRADABLE PLASTICS

Closing the loop

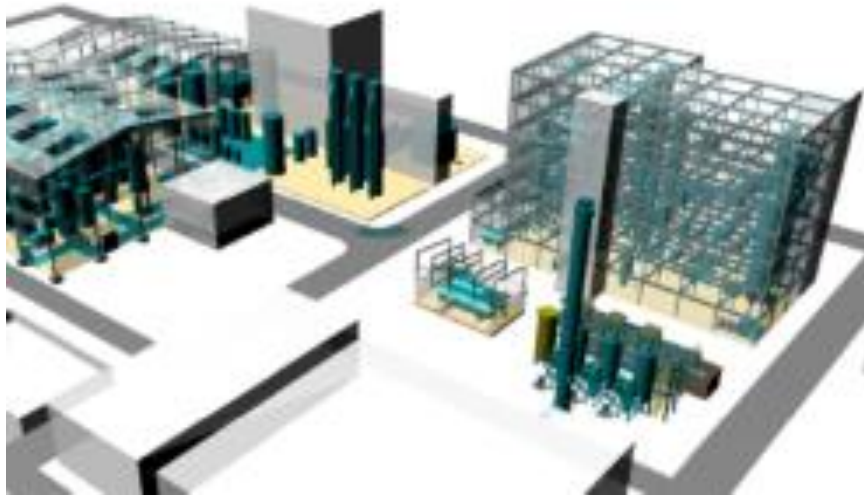


- REUSE** ranks higher than recycling in the EU waste hierarchy and should be considered first. Biobased plastics offer numerous opportunities for creating reusable products.
- MECHANICAL RECYCLING** recovers (biobased) plastic waste through mechanical processes to recreate resins without changing the chemical structure. It's an end-of-life option for the majority of biobased plastics.
- CHEMICAL RECYCLING** comprises different varying technologies that convert (biobased) plastic waste into an upstream feedstock resulting in secondary raw materials that have the same quality as virgin materials.
- ORGANIC RECYCLING** includes industrial composting and anaerobic digestion. Compostable plastics save valuable organic waste from landfill and incineration and help turning waste into beneficial high-quality compost.
- ENERGY RECOVERY** is an additional end-of-life option for biobased and/or biodegradable plastic materials where an alternative waste management infrastructure does not exist. In the case of biobased plastics, renewable energy can be obtained from the **biogenic carbon** – a significant advantage compared to fossil-based plastics.

europeanbioplastics



Poly lactide Technology



De- Carbon

- 100% biobased; no fossil carbon in the polymer
- Better CO₂-footprint than fossil-based polymers
- Biodegradable and compostable: reduction of plastic littering
- OPEX savings through high raw material conversion and energy recovery system



LA and PLA Technology

- PLA Technology based on proven PET and PA process
- Successful scale-up from pilot plant to industrial scale production plant
- Small Lactic Acid Market, only a few licensors of technology
- Huge Market potential for PLA needs LA plants and technology to be fully exploited



Further Developments

- Finalize Process Design Package for a **Lactic Acid** plant
- Establish **PLA Recycling**
- Further reduction of **CO₂-footprint** through use of **renewable energies** for production
- **2nd generation feedstock**: use of waste streams or cellulosic raw materials to produce LA and PLA - no food for plastic



PLA: a biobased and biodegradable Polymer



Broad Range of Applications

- Properties between PET and PS
- Blending with PBAT and PBS -> PE and PP
- Packaging, catering, cosmetics, textiles



Low Fossil Fuel Use by Nature

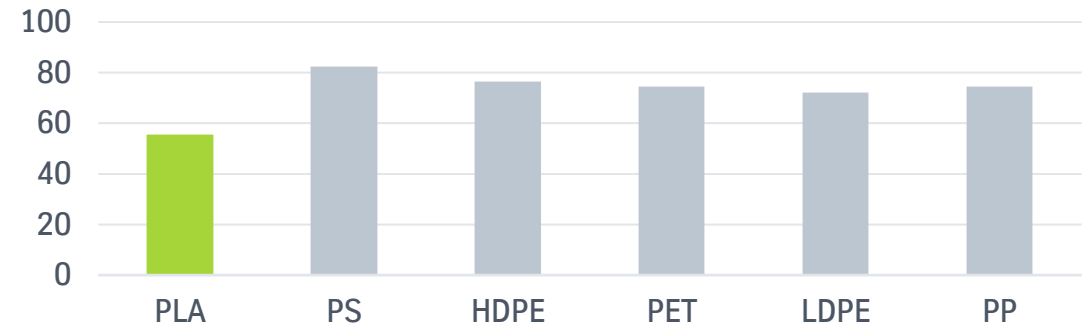
- On average 20 MJ/kg less Fossil Fuel Use than comparable petro-based polymers at standard production conditions



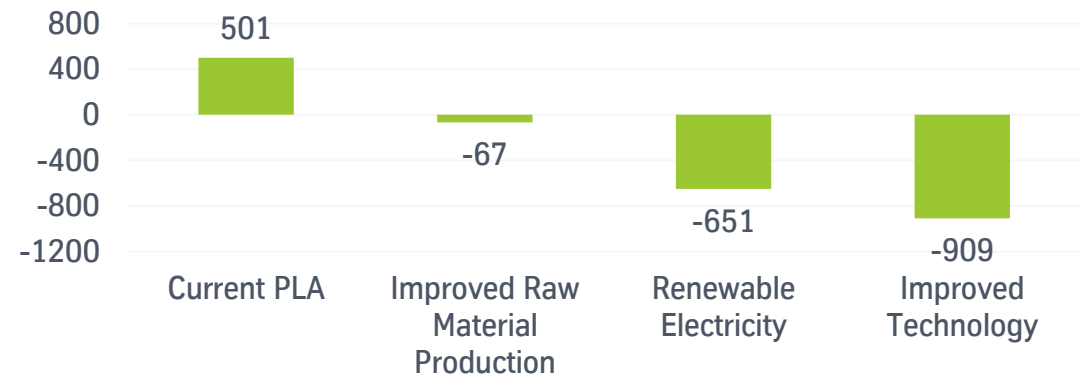
Negative Global Warming Potential Possible

- Use of renewable energies and new technologies
- Cradle-to-Gate LCA: Reduction from 501 kg CO₂/kg to -909 kgCO₂/kg

Life Cycle Cradle to Pellet Fossil Fuel Use in MJ/ kg polymer*



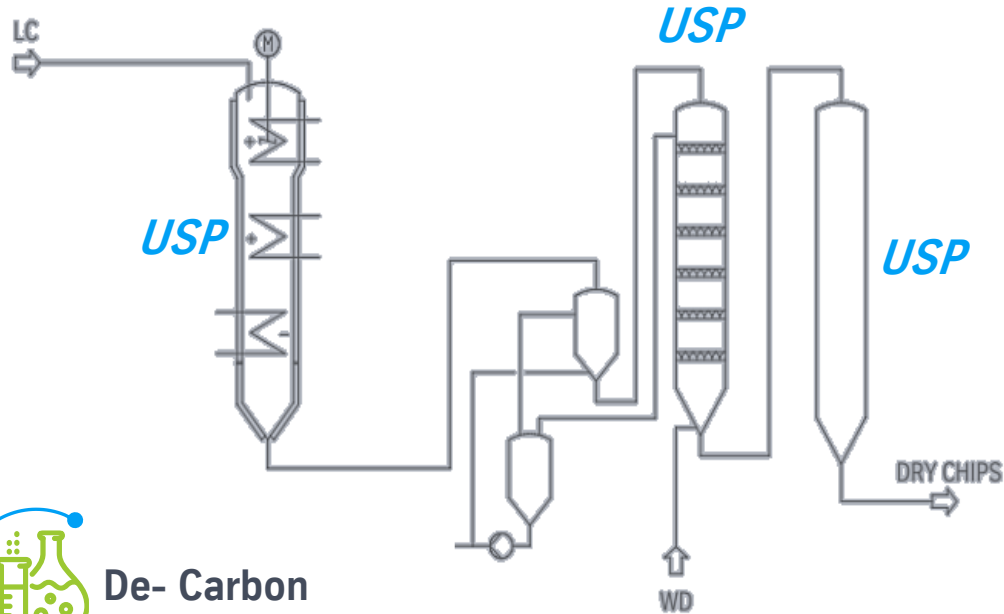
Global Warming Potential in kg CO₂.Eq/ton pla**



* See Grossman, Polylactic Acid, 2010, p. 435; ** LCA of PLA from Sugarcane in Thailand, Journal of Polymers and Environment, August 2019



Polyamide Polycondensation Technology



De- Carbon

- 100% utilisation of feedstock (OMDP®)
- Best in class quality with highest utilisation (lowest off-spec/waste content) along the value chain
- CAPEX saving by lowest plant area per annual ton of product and consequently CO2 footprint
- OPEX savings by lowest energy consumption



Recycling Polyamide

- Early phase of market development (growing demand)
- Small recycling facilities are installed for a limited feedstock (Post Industrial waste, Fish Net)
- For a sustainable growth some technological challenges are to overcome to expand the feedstock (post-consumer waste)
- Recycling is driven by brand owners and consumers (missing regulatory and product identification “PA6”)

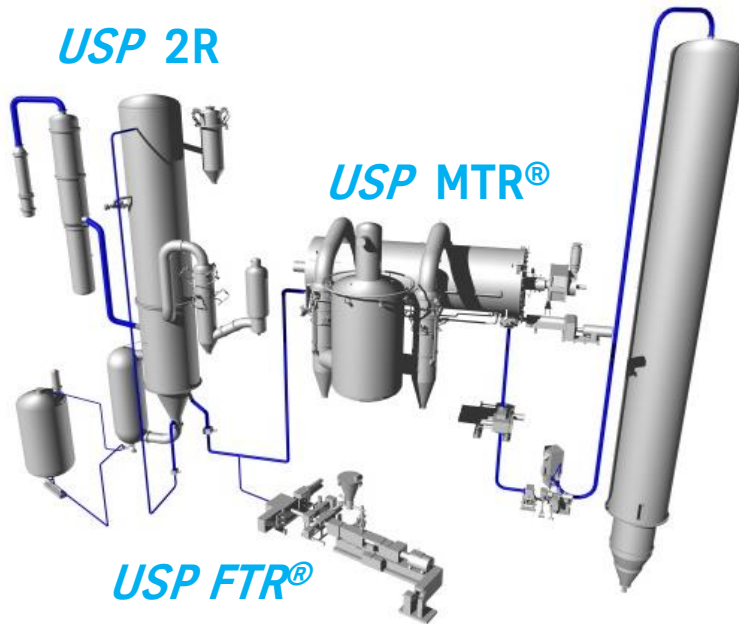


Further Developments

- **rPA recycling**: Processes are being re validated to achieve a feedstock expansion
- Spill over Chemical Recycling (100% De-Polymerisation) for **best-in-class rPA technology**
- **rPA pilot plant** set up after re validation of processes
- PA66(6) and PA12 market opportunities



Polyester Polycondensation Technology



De- Carbon

- Best in class utilisation of feedstock (MTR®)
- Best in class quality with highest yields (lowest off-specs/waste) along the value chain
- lowest plant area per annual ton of product and consequently lower CO2 footprint
- OPEX savings of 25-30 EUR per tons of PET



Recycling Polyester truly closing the loop

- Integrated and proven **FTR®** technology for high content of post-consumer PET
- Hans Uhde award winning **FTR®plus** for much lower OPEX and better quality; prove of concept plant start-up Q1 2024
- **FTR®maxx** R&D project chemical recycling for 100 % R-PET content is set-up
- Recycling is driven by legislators, brand owners and consumers



Further Developments

- **Efficiency boost:** further energy saving options
- **Hydrogen** as primary energy source
- **Modularization** of complete PET plant for specific locations
- **MTR®plus** technology for high viscosity applications



Uhde Inventa-Fischer's Recycling Technologies Solutions for PET, PA and PLA





Chemical Recycling Technology for Polyester

FTR®

<15% use of recycled PET

Well-developed and proven technology
(FDA and EFSA approved)

Applied for over ten years

Eight lines in operation / execution



FTR®-Plus

>50% use of recycled PET

Project in execution and time to market
expected until end of 2023

Reduction in both capital cost investment
by 50% and operational costs by 90% on
core equipment



FTR®-Maxx

100% use of recycled PET

Key focus of R&D activities

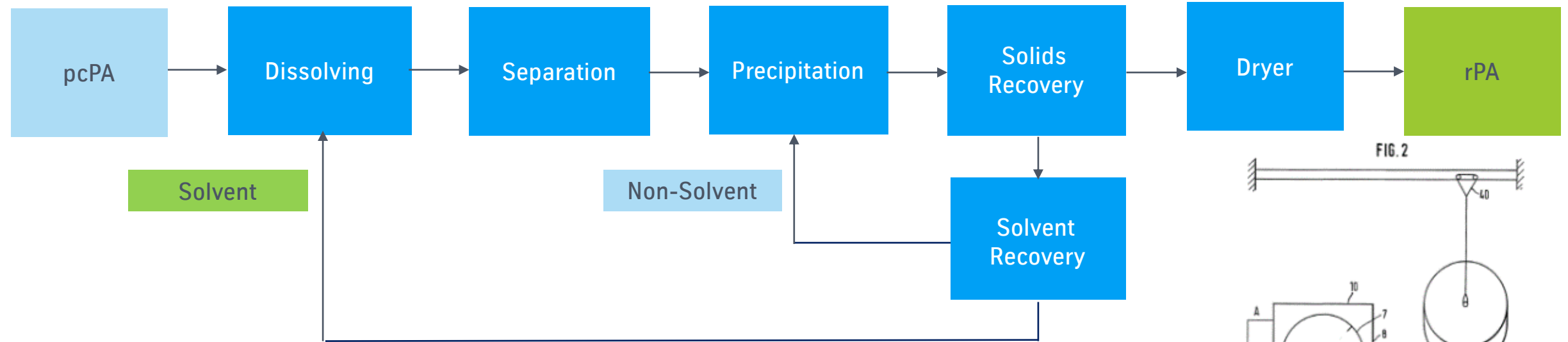
Target to use 100% recycled materials
(mixed flakes)

Pilot Testing ongoing, first promising results
of depolymerisation to BHET

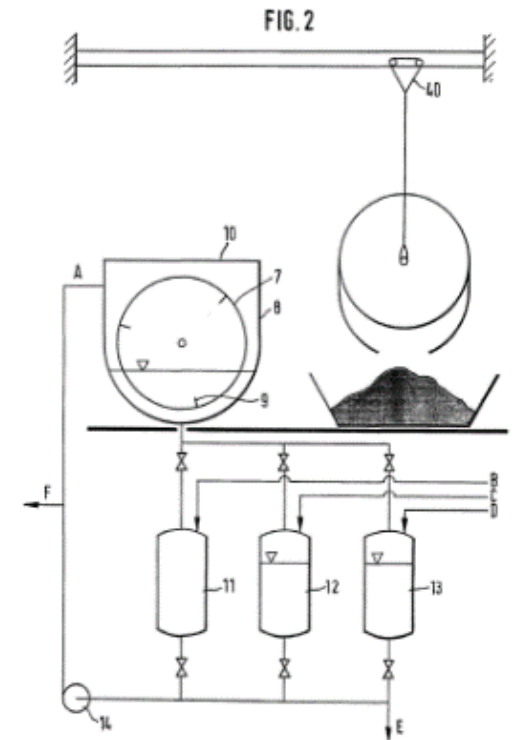
Market entry expected in 18 to 24 months



Solvent based Recycling Process for Polyamides



- For various types of polyamides possible (PA6, PA6.6, PA12 etc..)
- Dissolving of PA in a solvent e.g. formic acid
- Separation from undissolved material (other polymers, dirt, etc.)
- Precipitation of PA with a non-solvent, e.g. water
- Recovery of solvents e.g. by distillation
- Minimum loss of polymer properties, complete recovery of solvents = green process



Key Drivers and Market Expectations for Green Polymers



Recycling

- PET recycling worldwide growth >40%, being in growth phase
- EU regulations require PET recycling to be tripled by 2025, requirement well addressed by UIF's FTR®-plus technology
- Further technology development of FTR®-maxx to use 100% recycled PET materials
- Polyamide (PA) recycling: patented process for solvent based technology



Biopolymers

- Biopolymer Market triple in next 5 years, Bioplastics market 2% of global plastic market
- Proven technology available for the three most important Biopolymers PLA, PBAT and PBS
- PA11 and PA5.6, 100% from this Polyamides can be made from the green feedstock castor oil.



Lactic Acid for PLA

- Worldwide growth >10% with strong upside potential
- Own process for polymer grade LA developed
- UIF as one-stop shop technology provider as one of few active LA producers



Further Technology Developments/ Cooperations

- Spillover of Chemical Recycling Growth for best-in-class polycondensation technologies adapted to recycled monomers
- recYcled Caprolactam for 100% rPA6
- rTPA, rDMT and r-BHET for 100% rPET





Thank you for your attention



Head of Research & Development



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