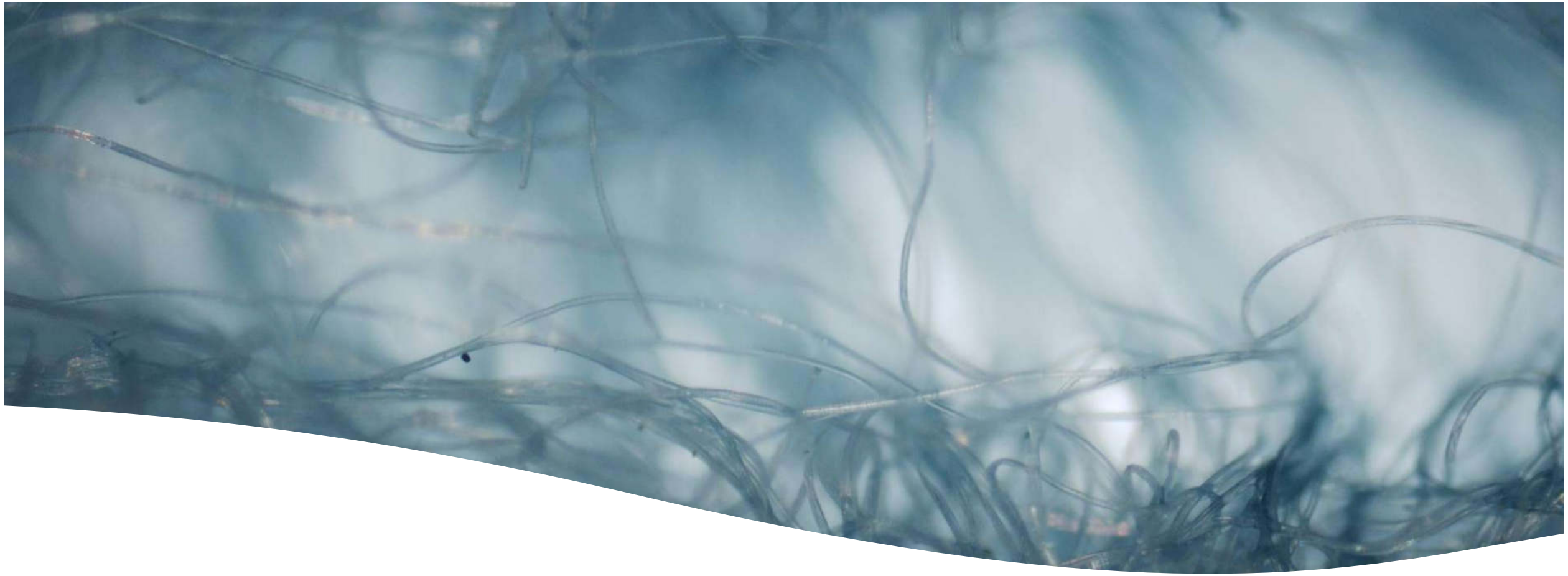

Melt Processing Technologies

Lien Van der Schueren - May 2025

Sustainability as core research goal

- Renewable, bio-based, sustainable alternatives to fossil-based thermoplastics
- Improving properties of biomaterials to match and if possible exceed those of conventional materials
- Functionalisation of thermoplastic polymers (chemical, physical)
- Creation of fibre-reinforced or self-reinforced composites
- Implementation of new technologies (such as Additive Manufacturing) in traditional production processes
- Recycling and closed loop

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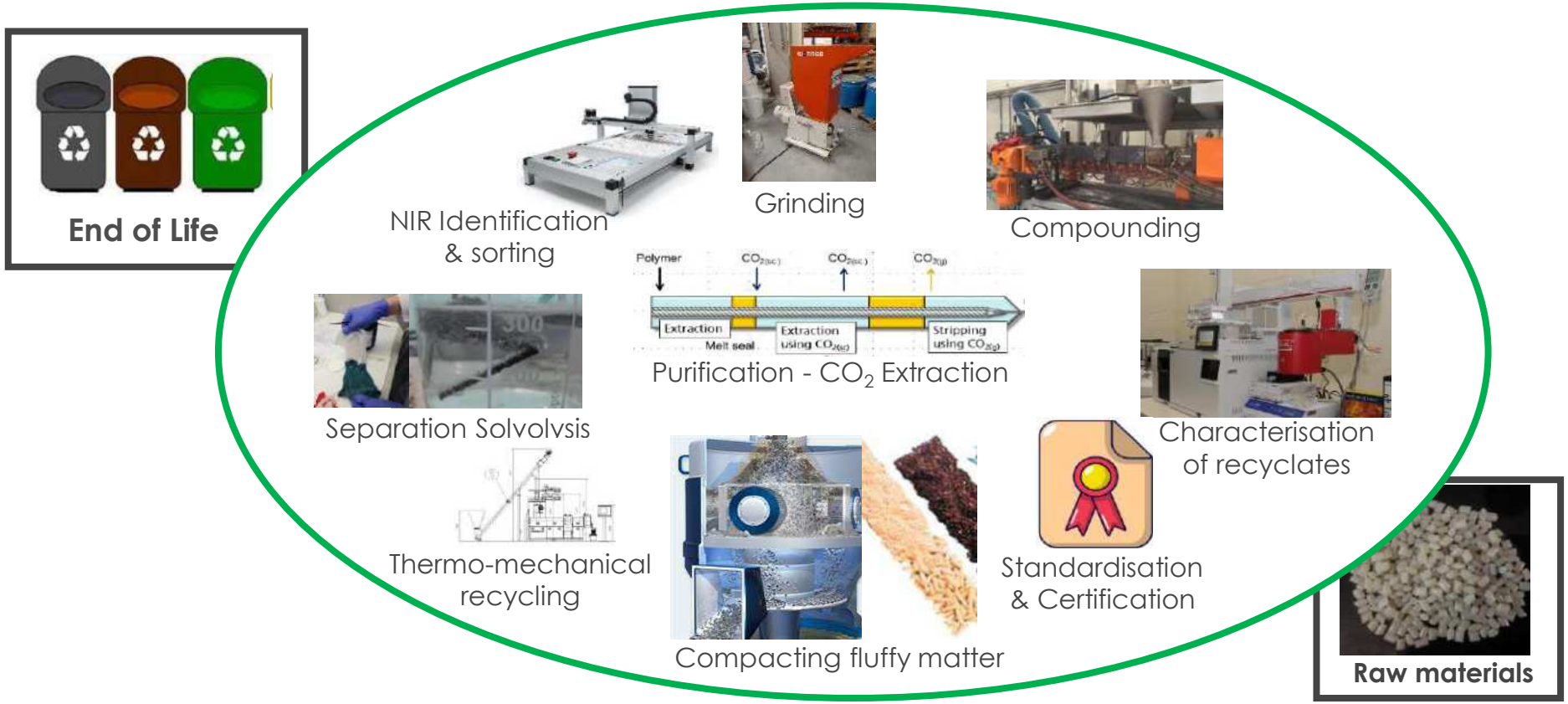
- **Recycling** and closed loop

Expertise on bio-based

- Non-exhaustive list of investigated bio-based materials:
  PLA, PHA, PBS, PTT, bio-PA, lignin, starch, bio-PU, …
- Over full textile & plastics value chain
  - Processing to mono- and multifilaments, also bicomponent
  - Extrusion to films & foils: blow & cast film
  - Processing into plastic parts: injection moulding, 3D printing
  - Compounding for functionalisation, e.g. FR, anti-microbial, stabilisers, …
  - (Textile) intermediates: knitting, weaving, embroidery, …
  - Textile coating, finishing & (digital) printing

Expertise on circularity & recycling

- Toolbox for circularisation



Technologies & Equipment

Polymer/Material Characterisation

Pre-treatment & Compounding

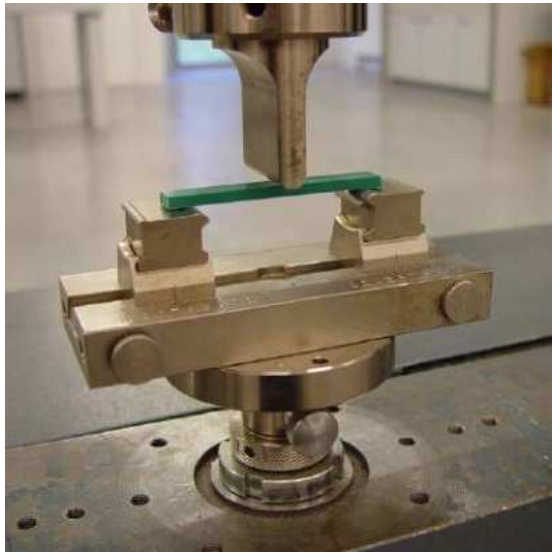
Yarn Extrusion

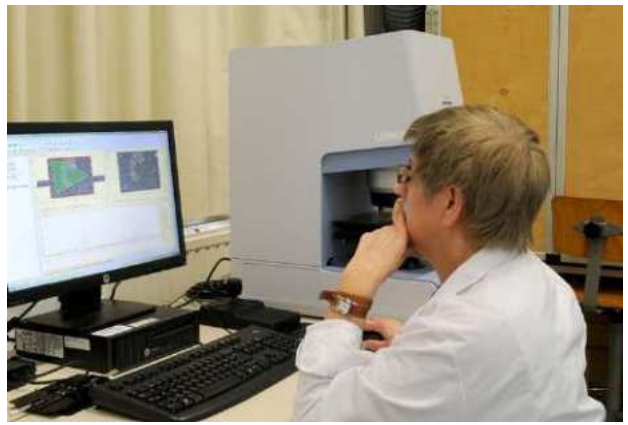
Plastic Processing

Polymer & material characterisation

Polymer & material characterisation

- Rheology
- Mechanical properties
- Thermal properties
- Material identification
- Microscopic analysis
- Characterization / REACH compliancy of recycled fractions



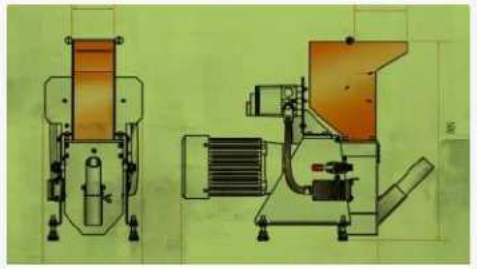


Pre-treatment & Compounding

Pre-treatment & Compounding

- Optimising & tuning material properties before further processing
- Pre-treatment: removal of contaminants, moisture, etc
- Compounding: enables precise formulation of polymer blends with additives or fillers to achieve specific properties

Technologies @ Centexbel



Shredding

Reducing volume. Optimizing downstream processing!

Compacting

Fluffy Inputs. Solid Outputs. Minimized Waste.

Supercritical CO2 Extraction

Ecologic extraction of legacy additives from recyclates

Solid State polymerisation

Elevating PET, Empowering Recycling.

Compounding

Mixing and blending polymers and additives when they're in a molten state to make plastic formulations.

VacuLite Erema

Compact Power for Next-Gen Fibre-to-Fibre PET Recycling.

Solid State Polymerisation

- Controlled increase in molecular weight through further polycondensation
- Typically used for polyester (PET) to increase viscosity
  - PET suitable for more demanding applications
  - Increase processability of recycled PET fractions

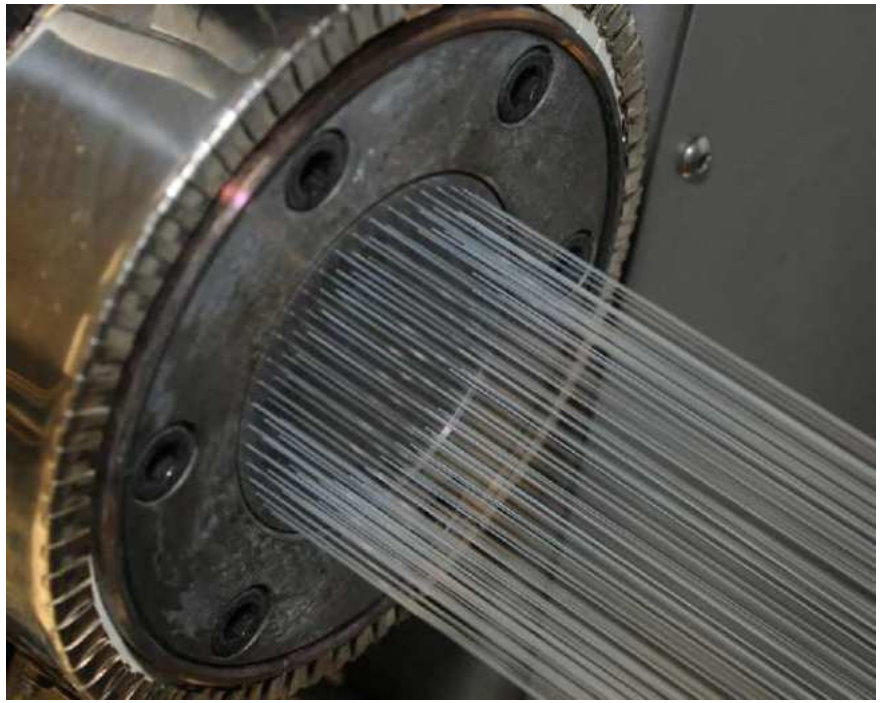
VacuLite Erema

- Thermo-mechanical processing of polyester (PET)
- Integrates degassing, fine filtration, and an optional solid state polymerization (SSP) unit to maximise value of recycled PET

Yarn Extrusion

Yarn extrusion

- Evaluate spinnability of new polymer grades and recyclates
- Evaluate processability and properties of new masterbatches and additives
- Produce prototype yarns for further testing
- Optimise extrusion process



Technologies @ Centexbel

Lab-scale filament extrusion

Monofilament / tape extrusion

Multifilament extrusion

Multifilament extrusion

- From lab (starting from 100g) to pilot scale (up to 20 kg/h) available
- Assessment of processability and the determination of optimal draw ratios & resulting yarns
- Yarn applications: garments, technical textiles, carpets etc

Plastics processing

Plastic processing

- Processability assessment
- Formulation optimization
- Prototype production under simulated manufacturing conditions

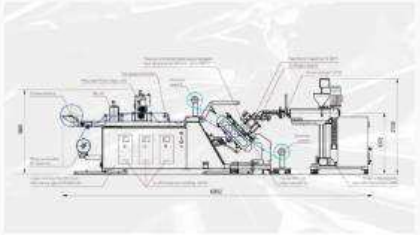
Technologies @ Centexbel

Blown Film Extrusion

Labtech LF400 COEX - 5-Layer Blown Film Extrusion Lab Line

Stunning versatility in Blown Film Extrusion R&D

Blown Film Extrusion

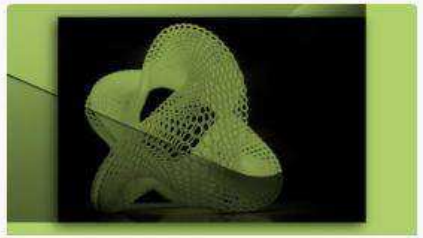


Cast Film Extrusion

For multilayer film production & functionalisation!

Injection Moulding

Small-Series Production for Technical Validation.



3D Printing

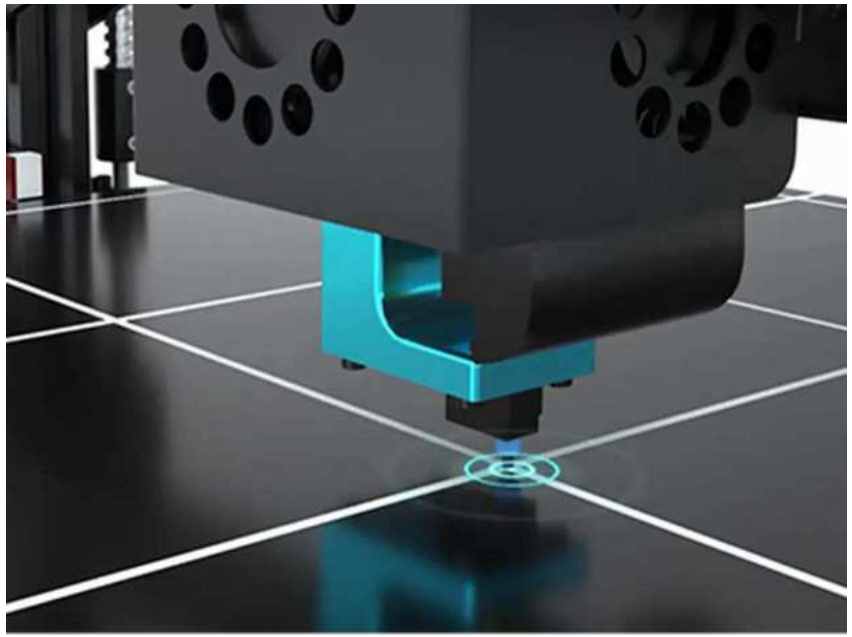
Bringing Ideas to Life, Layer by Layer!

Composite Press

For Woven, Non-Woven, and UD Textiles & Polymer Plate Rheology.

3D Printing

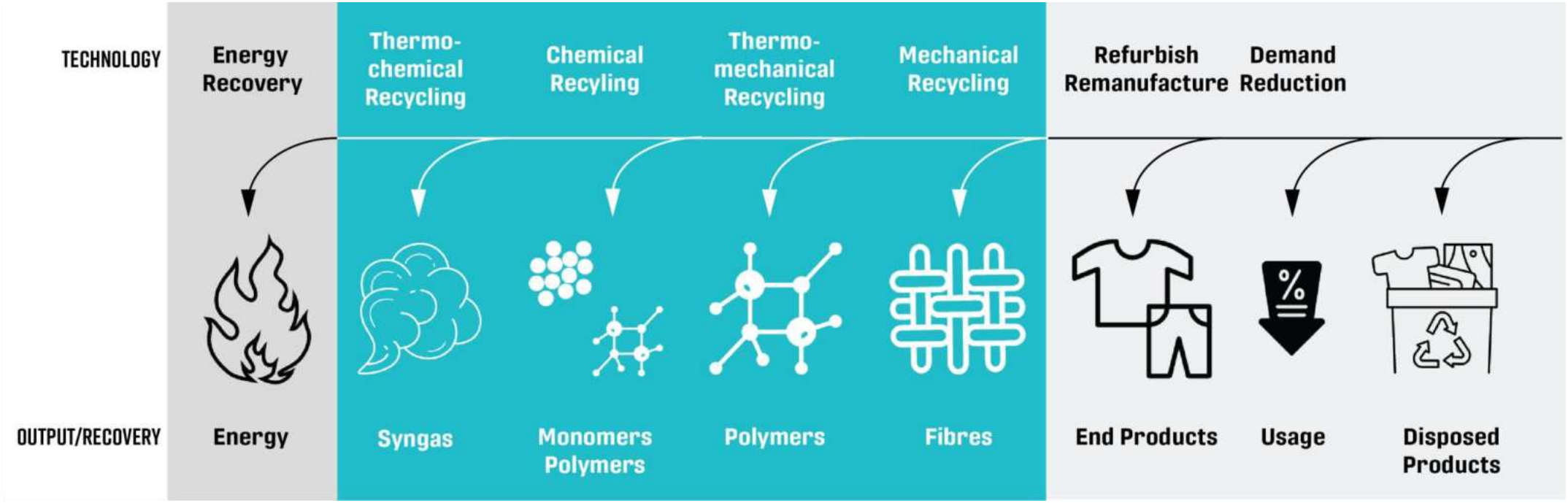
- Extrusion-based 3D printing, utilizing thermoplastic polymers in the form of granulate (pellets) or filament as input materials
- Centexbel expertise
  - new 3D printing materials, including recycled, biobased options
  - Composites
  - Functionalized materials with tailored properties like electrical conductivity



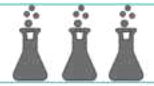
Selected examples of research activities

Textile recycling technologies

Recycling is one of the main solutions to solve the textile waste problem



Definitions & overview

	Thermo-chemical	Chemical monomer	Chemical polymer	Thermo-mechanical	Mechanical
Based on	Heating	Chemical reactions	Dissolution	Heating	Physical forces
Description	**Partial oxidation** of polymers producing low molar mass components that can be used as **feedstock** for the chemical industry (or thermal degradation of polymers to monomers)	**Degradation** of polymers into the constituent monomers	**Extracting** polymers and re-spinning them	**Melting** of thermoplastic polymers and reprocessing	Unravelling/ garneting/tearing…
Output	Syngas	Monomers	Polymers	Polymers	Fibres
Energy use					
Water use					
Chemicals					
Process cost					
Ability to return to virgin quality	High	High	Medium/high	Medium	Low
Ability to handle impurities	High	High	Medium	Low	Low
Scale (kt/y)	25-50	25-50	50-100	10-30	5-36

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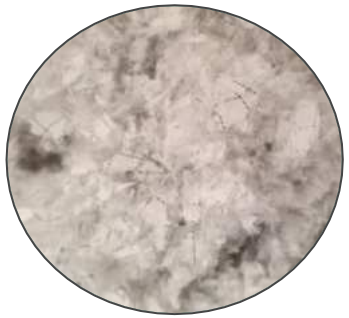
Ability to achieve virgin quality ➔ Higher environmental impact

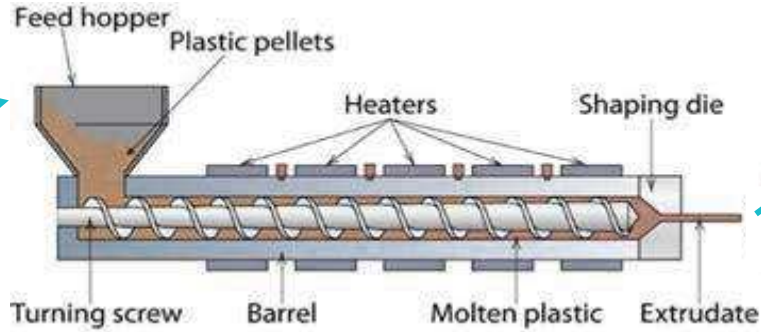
A long-term solution?
Variety of recycling technologies
(which may even work together to achieve synergies)

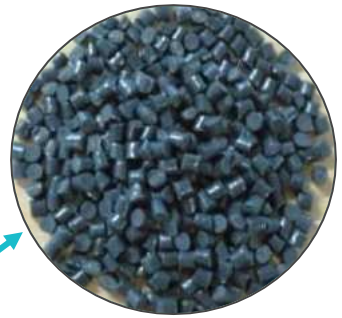
Thermomechanical recycling

- Process using heat to **melt thermoplastics** & recover polymers in form of **regranulates**
  - Well-established technology (TRL 9) for plastics
  - At lower scale for textiles (≤ TRL 7): recycling production waste internally and/or pre- and post-consumer PO carpets/artificial grass, PET textiles, typically blended with virgin
- Low acceptable contamination levels, **close to 100% purity required**
  - Sorting and separation technologies, as well as tracers and digital product passports, essential to improve material purity and recyclability

Pretreatment
Collection & sorting, shredding, washing/cleaning, compacting…







Thermomechanical PET recycling

- **PET Intrinsic Viscosity (IV) critical for strength, durability, and processing**
- Especially melt spinning highly sensitive to viscosity fluctuations
- PET hydrolyses in presence of moisture at high temperatures, leading to **IV drop**
- Potential **IV increase technologies**
  - Solid-State Polycondensation (SSP)
  - Liquid-State Polycondensation (LSP)
  - Chain extenders, but
    - Difficult to control → polydispersity
    - Inhomogeneous
    - Risk of chain branching & gel formation

Inline liquid-state polycondesation drastically improves recyclability

Development of circular garments via fibre-to-fibre recycling of polyester

- **Sorting** : Improved sorting, including dismantling of unwanted parts
- **Thermo-mechanical processing**
  - Conventional process: shredding, compacting, compounding
  - Erema line for Fibre to Fibre liquid-state polycondensation, fine filtering

erema group

- **Re-processing to yarns**:

  Standard melt spinning equipment

Input	Processing details	% recycled to virgin	Tenacity to virgin
PCR	Improved sorting & standard thermo-mechanical processing	10%	45% ↘
PIR	Improved thermo-mechanical recycling	100%	similar

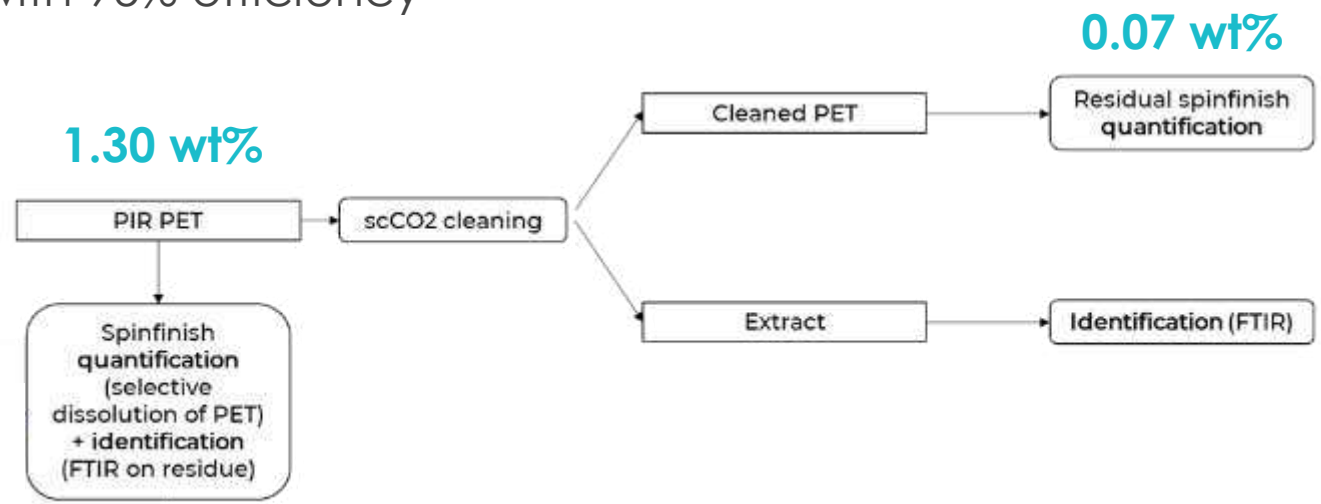
PCR: post consumer recycled
PIR: post industrial recycled

CEN TEX BEL VKC

CISUTAC Circular and Sustainable Textiles and Clothing

Decontamination

- **Super-critical CO2** (scCO2)
  - Efficient process **extracting additives** like plasticizers, dyes and stabilizers from polymers without degrading base material
  - **Eco-friendly technology** avoiding use of harsh chemicals
  - Technology may enhance plastic recyclability by purifying materials
- Example from textile recycling: Spin oil contamination in post industrial recycled waste
  - Can complicate fibre-to-fibre recycling or at least cause discolouration
  - Removal via scCO2 with 95% efficiency



Use of PLA for garments

- PLA promising for use in garments, e.g. mechanical properties, UV stability, low moisture regain, low odour retention
- Melt spinning process for PLA yarns for clothing optimised on pilot scale equipment Centexbel
  - Yarn properties: 30-35 cN/tex strength & 25% elongation
  - Excellent sweat resistance
  - Washing resistance up to 40 °C
  - Successful colouring via dye-doping
  - Successful processing into knits/weaves
- Chemical recycling trials succesfully performed

PLA textiles with improved comfort

- Improve comfort/softness PLA by blending with other biopolyesters (5 – 25%)
- No effect on mechanical properties
- Significantly improved softness
  - Evaluation of softness via panel
  - Softness score: 1 ‘soft’, 5 ‘hard’

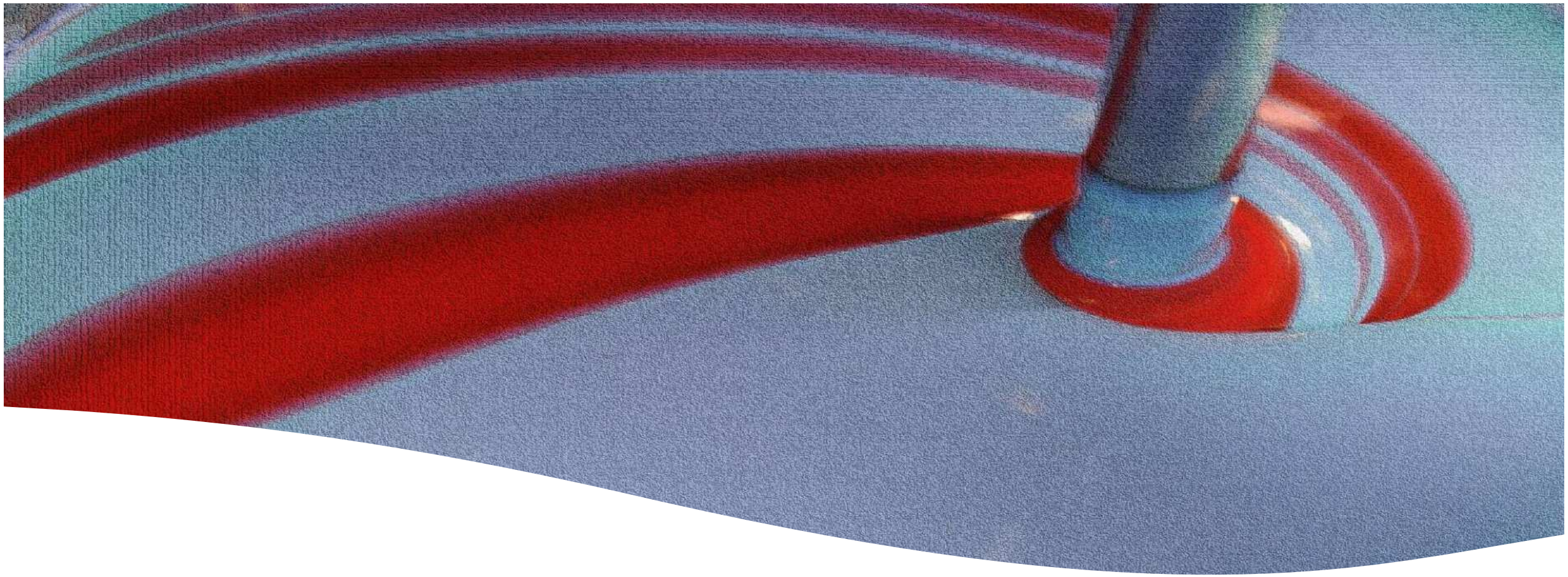
Composition	Softness score (1-5)
PLA	3-4 4
Polyester reference	3
PLA + 10% biopolyester	2
PLA + 20% biopolyester	1-2

EU projects bio-based (non-exhaustive)

- **HEREWEAR**: Empowering locally produced circular and biobased textiles
- **BIO-UPTAKE**: Bio-composites in smart plastic transformation processes
- **SUSPENS**: Sustainable structural sandwiches and hollow composites parts for automotive, boat and aerospace markets
- **BIO4SELF**: Biobased self-reinforced composite materials based on high performance PLA fibres
- **BIONTOP**: Biobased packaging films and textiles with tailored end of life and performance
- **CUBIC**: Improving the circularity of complex plastic multi-material composites using novel biobased materials in B2B semi-finished product
- **TERRIFIC**: Next generation circular biobased flagship packaging: a catalyst for the green transition

EU projects circular (non-exhaustive)

- **CISUFLO**: Towards more Circular and Sustainable Floor coverings in EU, a systemic approach
- **CISUTAC**: Circular & sustainable textiles & clothing
- **ALIGNED**: Aligning Life Cycle Assessment methods and bio-based sectors for improved environmental performance
- **TEXTENDED**: Knowledge Based Framework for Extended Textile Circulation
- **PESCO-UP**: Textile fibre recycling from mixed streams of PESCO textiles
- **REMADYL**: Removal of Legacy Substances from PVC via a continuous extrusion process
- **DECOAT**: Recycling of coated and painted textile and plastic materials



Contact

Lien Van der Schueren (lsc@centexbel.be)

www.centexbel.be