



# Thermomechanical Recycling of Textiles: State of the Art

Textile EPR Masterclass – 02 April 2026

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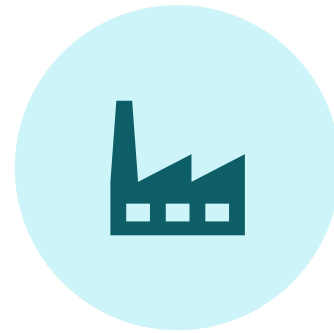
# Thermomechanical Recycling of Textiles: State of the Art



THERMOMECHANICAL  
RECYCLING BASICS



STRENGTHS, LIMITATIONS  
& KEY TECHNICAL  
CHALLENGES



STATE OF THE ART  
SOLUTIONS & INDUSTRY  
EXAMPLES



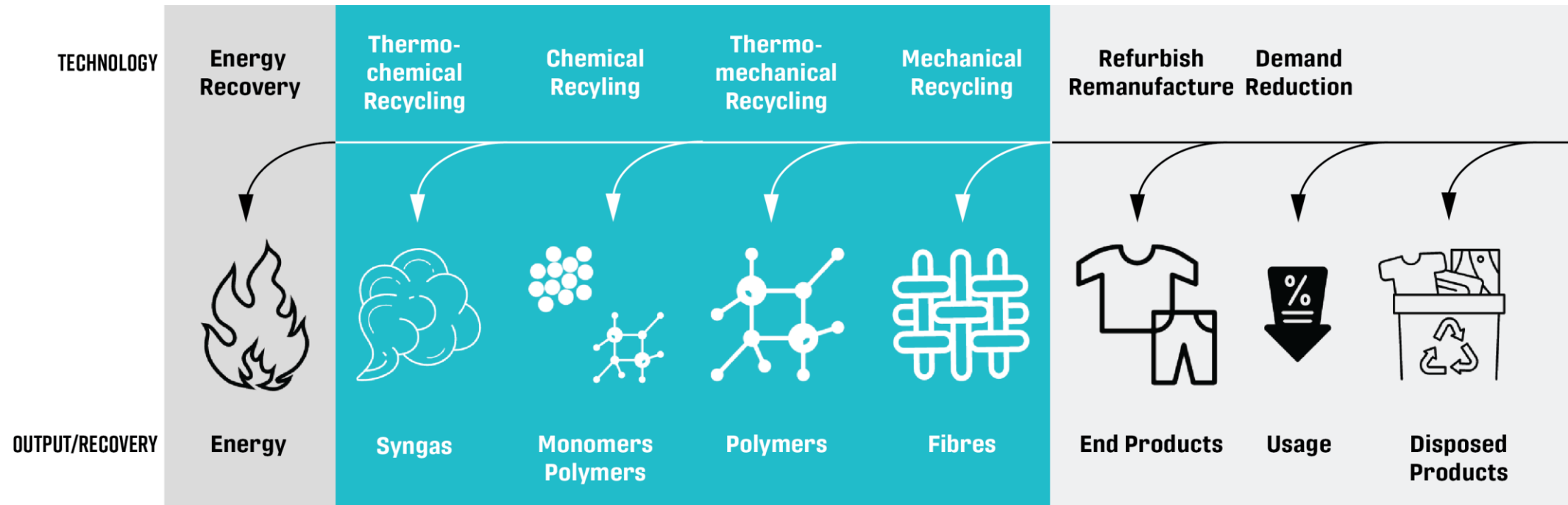
CENTEXBEL RESEARCH:  
INSIGHTS & OUTLOOK



# **THERMOMECHANICAL RECYCLING BASICS**

# Textile recycling technologies

“Different recycling technologies enable recovery at various levels. Higher quality recycling often comes with higher environmental impact — *the challenge is finding the long-term balance.*”



# Thermomechanical recycling technology

Process using heat to melt thermoplastic materials and recover the polymers in the form of regranulate or fibres.

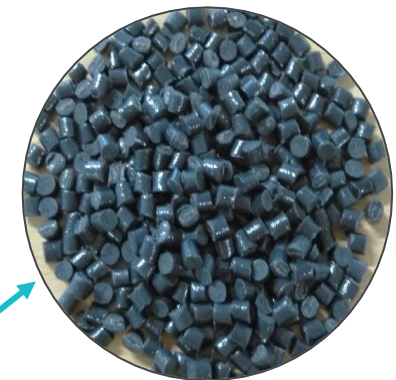
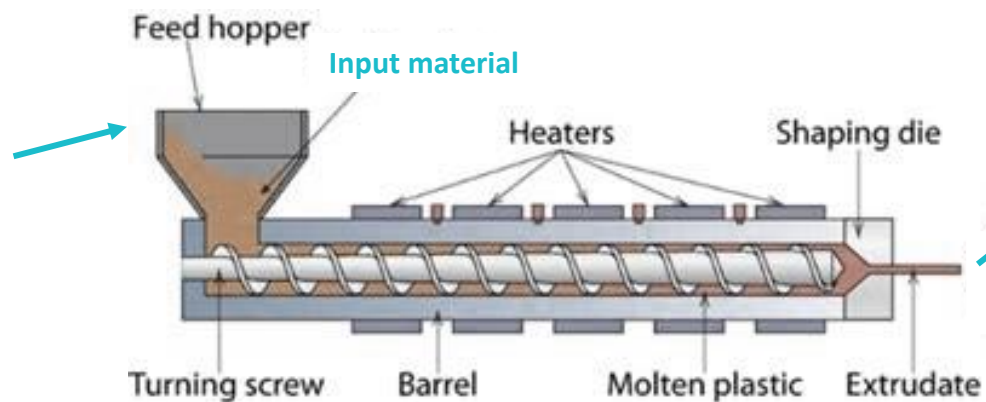
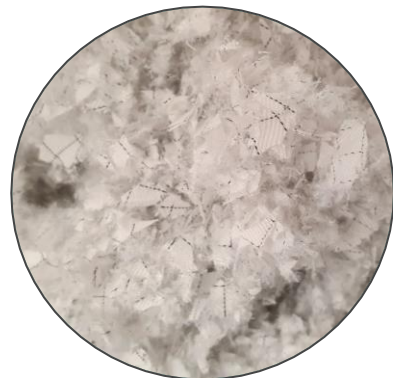
**Technology maturity** level depends on the type and quality of the feedstock:

- **Plastics:** fully mature technology (TRL 9).
- **Clean industrial textile waste:** industrial deployment in place (TRL 8–9).
- **Post-consumer textiles:** pilot/demo lines exist, emerging to pre-commercial (TRL 6–8), dependent on feedstock quality.

## Process basics

### Pretreatment

*Collection & sorting, shredding, washing/cleaning, compacting...*



# Recycling inputs & outputs

## Input

### Theoretical:

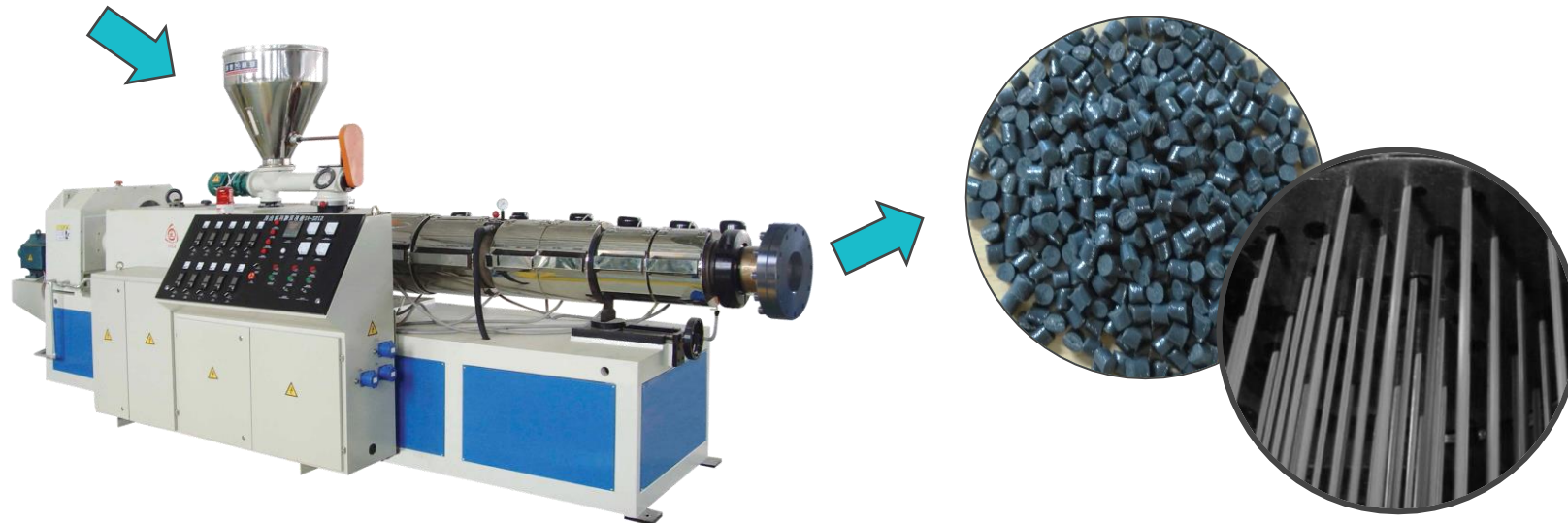
Any thermoplastic material (PET, PP, PE, PA, PLA...)

### In practice:

Polymer blends and contaminants require careful consideration, especially when melt spinning is the goal

## Output

- Polymer pellets or textile fibres
- Polymer composition, chemical content, and color remain the same as the input, except for:
  - Volatile components removed through degassing
  - Non-melting particles filtered out





## **STRENGTHS, LIMITATIONS & KEY TECHNICAL CHALLENGES**

# Advantages & limitations of the process

## Pros

- Cost-effective, efficient, and well-established process
- Easily implemented
- Minimal emissions during processing – only volatile contaminants (e.g. from disperse dyes or polymer degradation) are released.

## Cons

- **Low bulk density:** Using textiles as input makes feeding into the extruder more challenging.
  - **Viscosity challenges:** Polymer degrades with each cycle, and melt spinning is highly sensitive to molar mass/viscosity.
  - **Contaminations:**
    - Colourants remain in the polymer, requiring **colour** sorting or the addition of dark pigments.
    - Non-volatile chemicals persist in the recycled material, potentially conflicting with **REACH** regulations.
    - Strict **feedstock requirements:** Even low contamination levels can affect melt spinning quality.
- Mainly applied to production waste and specific, well-defined post-consumer waste streams.



# Key challenges – Low bulk density

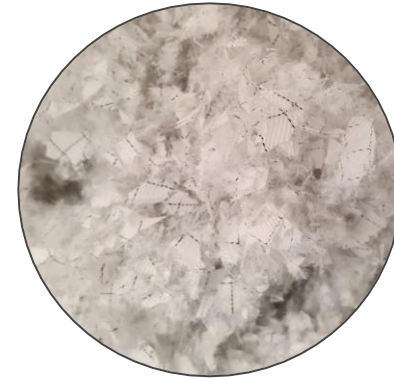
Shredded textile waste has very low bulk density making feeding difficult

## Solutions:

- Densification via compacting equipment
- Adapted feeding systems
- Integrated shredder-extruder combinations
- Preconditioning units with compacting function

## Results:

- ✓ Improved throughput & more stable processing
- ✓ Allowing continuous operation



CEN  
TEX  
BEL

Flat die  
pelleting  
press

# Key challenges – Viscosity

Viscosity loss during recycling can compromise melt spinning performance.

Melt spinning requires a controlled IV, too low or unstable IV leads to:



Extrusion instabilities



No melt strength



Weak fibres/  
Filament fracture

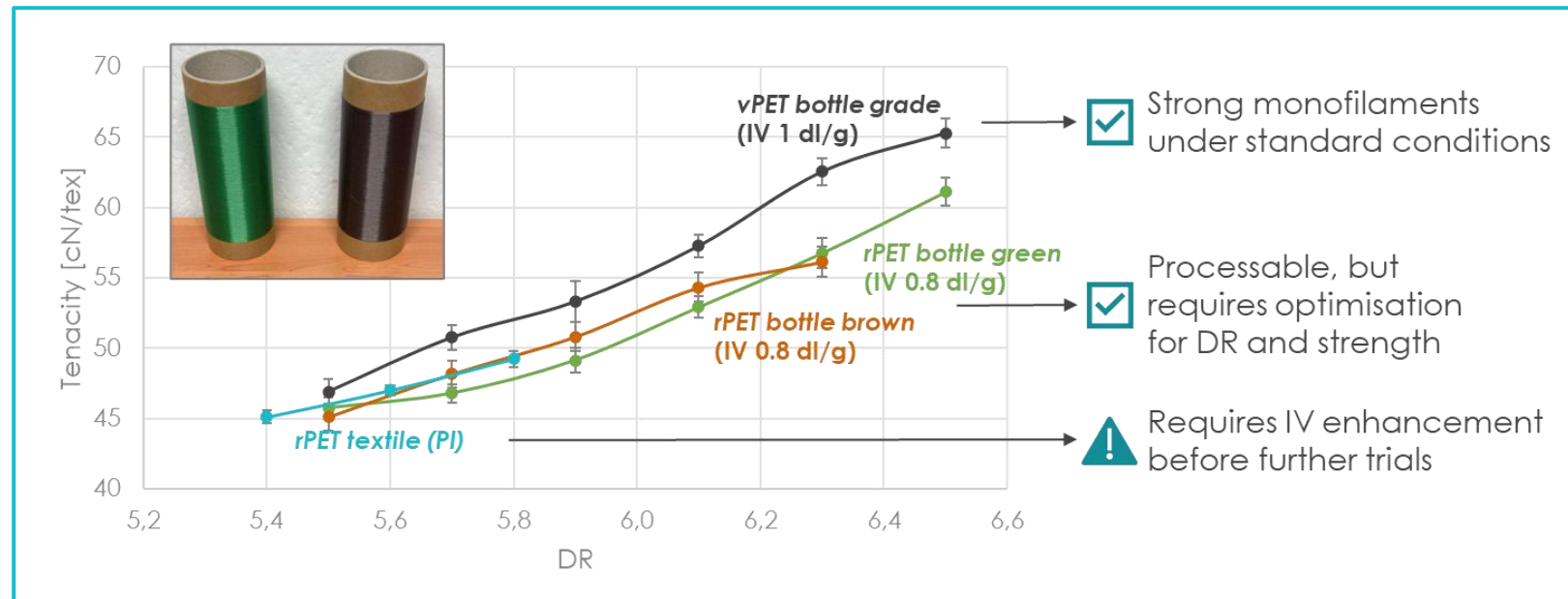


Inconsistent dyeing



DigInTraCE

**Case study:**  
Monofilament  
extrusion



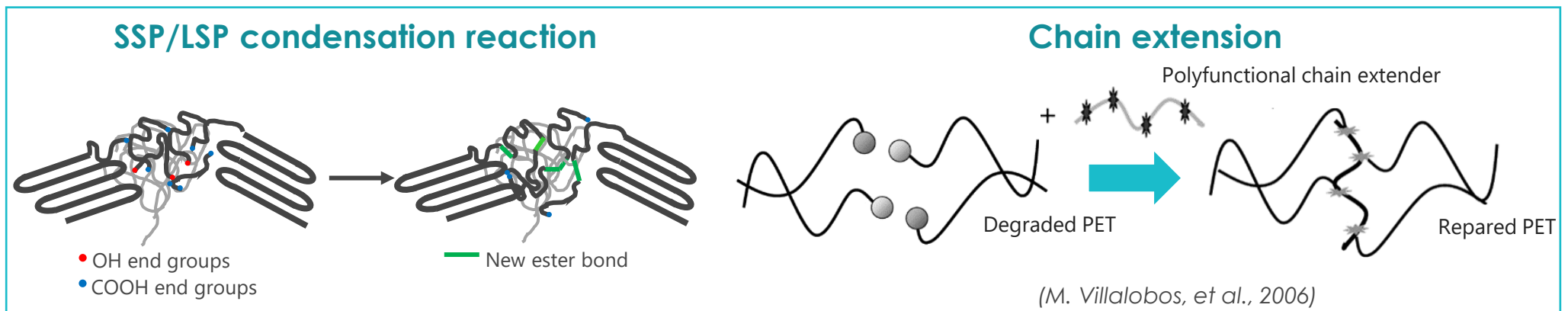
# Key challenges – Viscosity

Viscosity loss during recycling can compromise melt spinning performance.

## Solutions for polyester

- Prevent
  - Proper drying before processing
  - High-vacuum degassing
- Restore
  - Solid-State Polycondensation (SSP)
  - Liquid-State Polycondensation (LSP)
  - Chain extension

	SSP	LSP	Chain extenders
<b>State of PET</b>	Solid	Liquid (melt)	Liquid (during melt processing)
<b>Environment</b>	Inert gas ( $N_2$ ) or vacuum ( $\leq 10$ mbar)	High vacuum ( $\geq 1$ mbar)	Atmospheric (during extrusion)
<b>Temperature</b>	200-240°C	270-290°C	260-280°C
<b>IV increase</b>	0.01-0.06 dl/g per hour	0.01-0.1 dl/g per minute	0.1-0.3 dl/g in minutes



# Key challenges – Viscosity

## Case study: Extreme IV boost with chain extenders

Transforming PI PET flakes into high-quality rPET for monofilaments



PET flakes

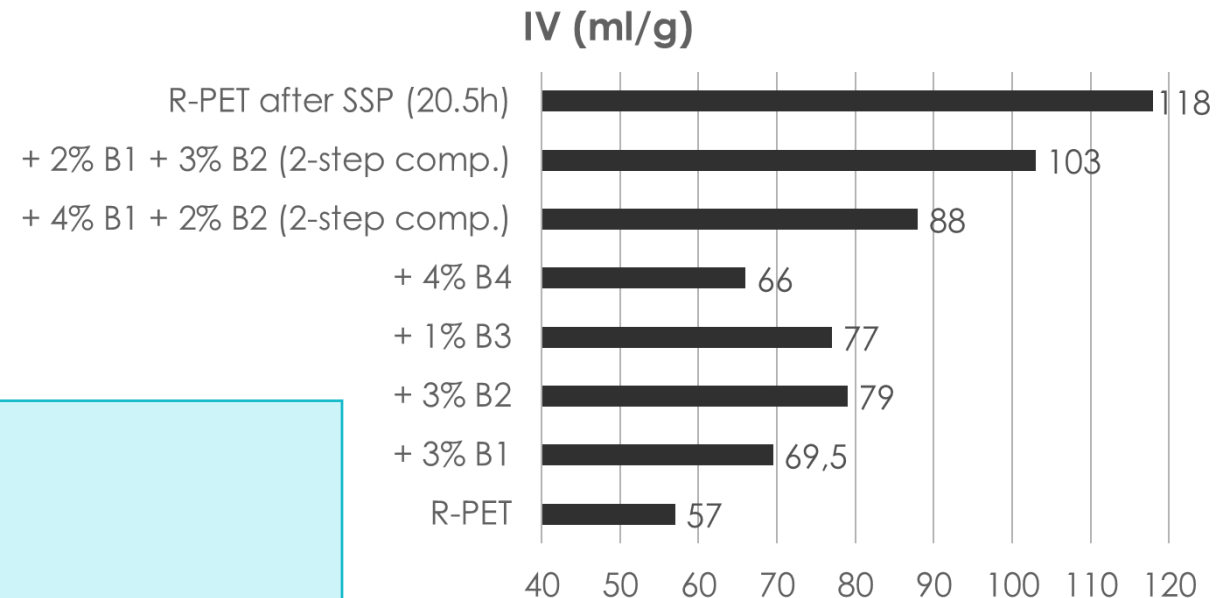
IV = 57 ml/g



PET pellets

Target IV = 100 ml/g

Impact of different types of chain extenders on the IV of rPET



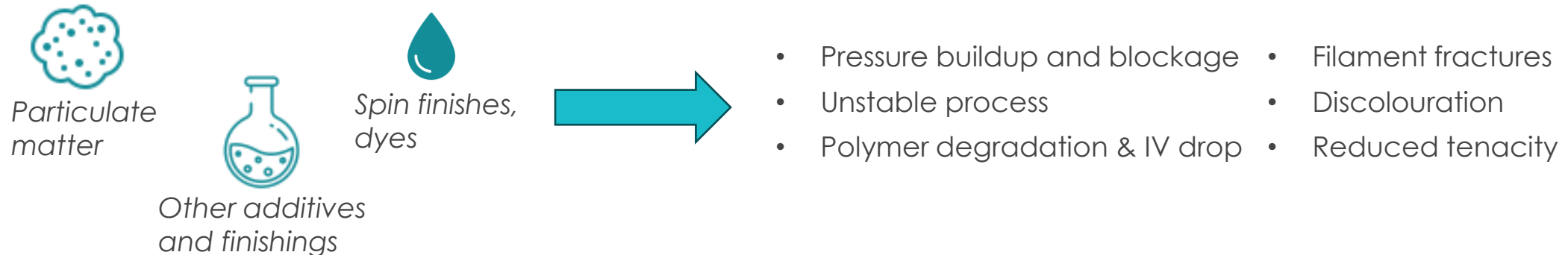
### Conclusions

- ✓ **Instant** effect – can be added during extrusion
- ✓ Improved processability & fibre tenacity
- ⚠ Challenges: difficult to control, risk of inhomogeneity & gel formation

# Key challenges – Contaminations

## Foreign matter, dyes & additives reduce recycle quality and reprocessability

Melt spinning is highly sensitive to contaminations causing processing issues and quality loss



### Solutions

- Washing of (production) waste
- High-vacuum degassing for volatiles
- Advanced fine filtration systems

### Nevertheless...

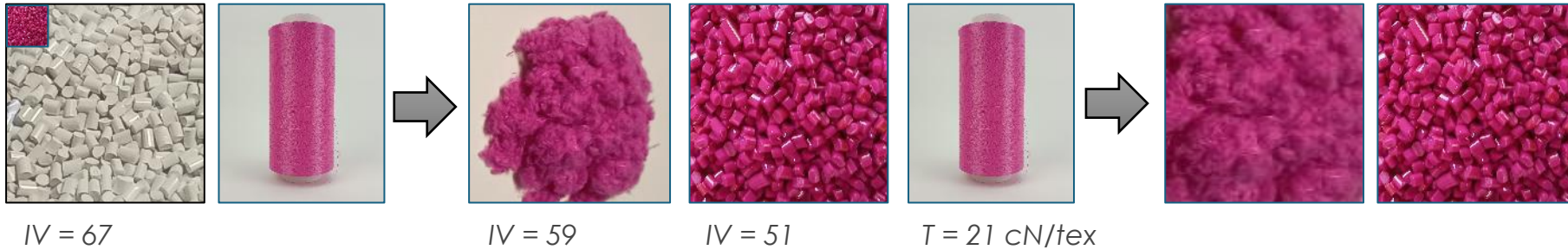
Contamination limits remain strict, particularly for melt spinning.

**Key enablers:** advanced sorting, tracers/DPP & ecodesign  
→ cleaner, mono-material flows

# Key challenges – Contaminations

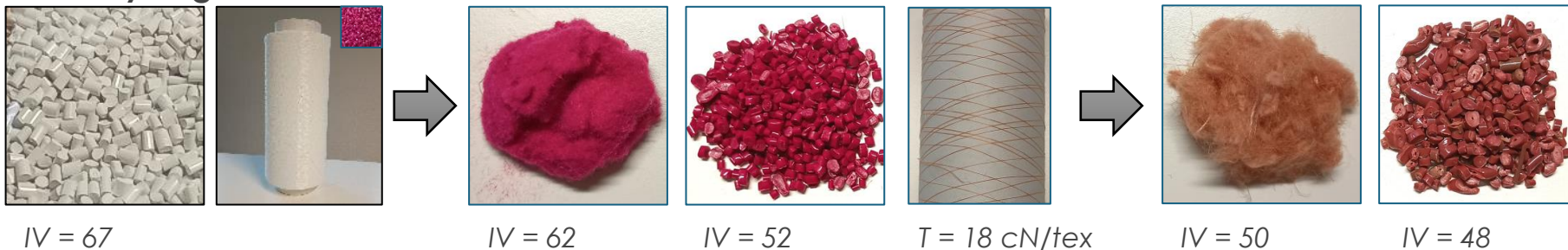
## Case study: Effect of colorants on recycling

### Mass coloration



Experiments ongoing

### Batch dyeing



No bobbin,  
too unstable

**Impact on IV & reprocessing:** similar for both methods

### Impact on color:

- Better retention with mass coloration, but
- Easier to bleach pre-recycling with batch dyeing



# STATE OF THE ART SOLUTIONS & INDUSTRY EXAMPLES

# Key players in thermomechanical recycling technology

## State of the art solutions

- Integrated shredders and size-reduction units
- Material preparation, preconditioning and feeding units integrating cutting, homogenization, heating, drying, compacting, buffering and dosing
- High-vacuum degassing
- Fine filtration down to 20µm
- SSP reactors & LSP systems for PET IV homogenisation and increase
- Inline IV and melt-quality monitoring & control units
- Inline spinning

## Industrial technology providers



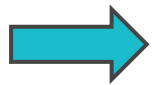
# Auping

## Auping circular mattress

100% PET polyester textiles and steel wire pocket springs connected with Niaga®, a nontoxic reversible adhesive

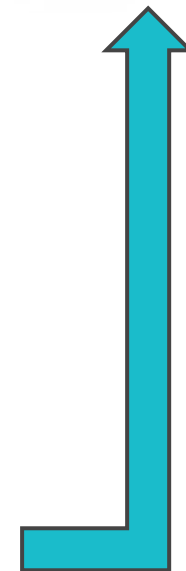


Collects, sorts, and separates materials



Converts polyester textile components back into rPET pellets & staple fibres

# Auping



Production of nonwovens

# Project Re:claim

Joint venture between Salvation Army Trading Company and Project Plan B

*First commercial-scale, post-consumer polyester thermomechanical recycling plant*



Capacity: 3000 tonnes per annum

Feedstock

- Mono-fibre polyester garments
- Banners & flags
- Post-consumer polyester clothing
- Hospitality textiles
- Soft furnishings
- Uniforms & workwear
- Bedding & linens



SALVATION ARMY  
TRADING  
COMPANY



PROJECT  
PLAN B

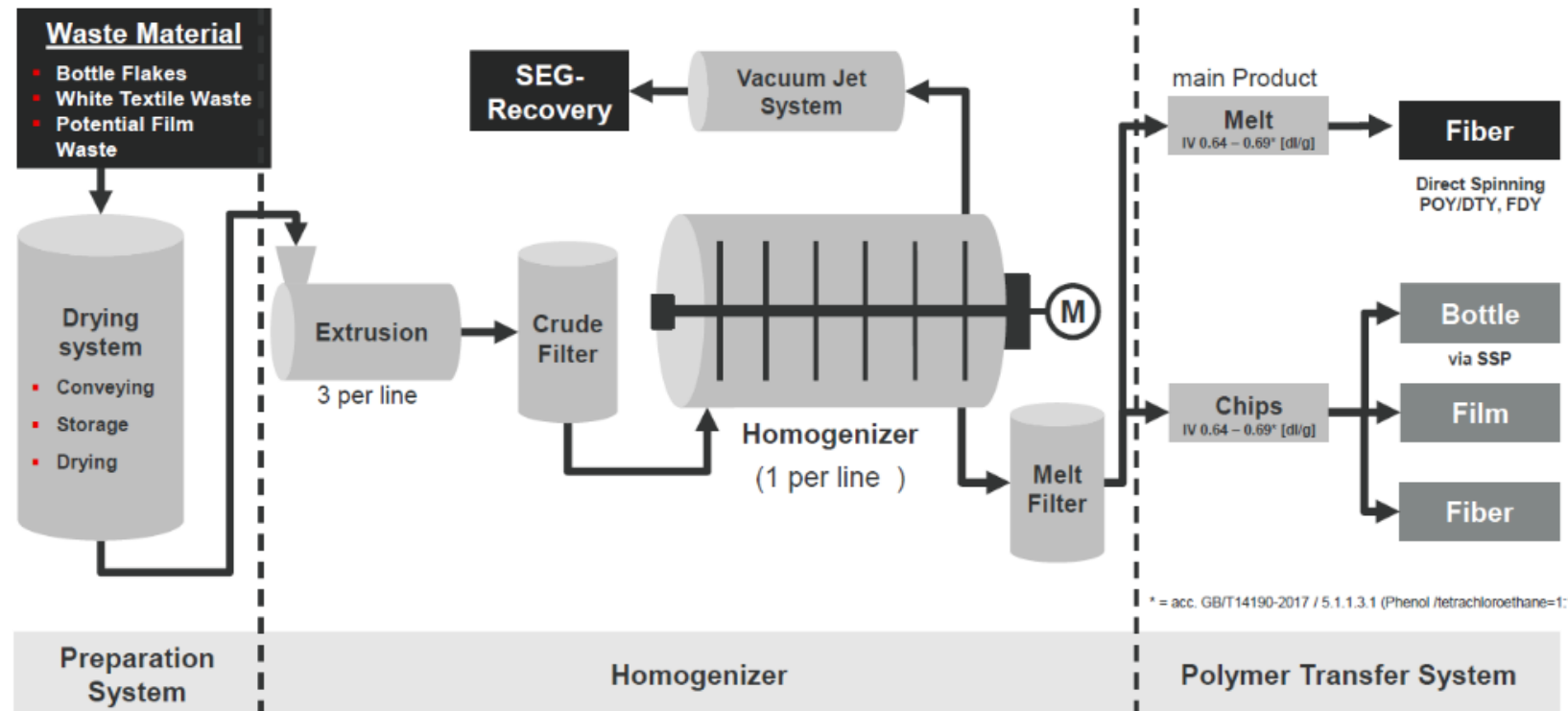
PURE LOOP  
MEMBER OF EREMA GROUP

# Oerlikon Barmag/Reo eco

## Reo eco thermomechanical recycling facility (China)

540t/day direct spinning thermomechanical recycling → 250,000 ton filament yarn per year

Example Reo Eco - Technology Overview (3 lines 180t/d each)



reo eco

oerlikon  
barmag

# Other industrial examples



## **Antex (ES)**

*Synthetic yarn producer thermomechanically recycling polyester for reintroduction into spinning.*



## **RE&UP (NL-TR)**

*Circular tech company using advanced thermomechanical and mechanical processes to separate and convert polycotton streams into new fibres.*



## **Muovi (FR)**

*Startup performing thermo-mechanical recycling of polyester waste into granules.*



## **Nurel (ES)**

*Polymer, fiber and biopolymers producer thermomechanically recycling nylon production waste into 100% recycled PA6 yarn.*



## **Unifi (US)**

*Bottle-to-fibre recycler since 2007; now also performing fibre-to-fibre polyester recycling.*

# Other industrial examples – open loop



## Mapea (FR)

Recycling company converting rejected textiles and EOL garments into high-value technical compounds for use in the plastics industry.



**PETEX**

PETEX est une matière qui valorise plus de 90% de PET issu du recyclage textile

Il se substitue au : PET, PBT, ABS



**REGAFIB**

REGAFIB est un alliage de PP ou de PA6 renforcé par une base en coton ou polycoton issue du recyclage textile

Il se substitue au : PP ou PA vierges, chargés en talc ou en verre



**REGAMID**

REGAMID est un alliage qui valorise jusqu'à 90% le polyamide et mélange issus du recyclage textile

Il se substitue au : PA



## beaulieu needle felt

## Beaulieu Rewind (BE)

Latex-free, mono-material PP needle-felt carpet for event and contract use, designed for full recyclability and processed into clean PP recyclate via specialised recycling partners.





# CENTEXBEL RESEARCH: INSIGHTS & OUTLOOK

# Centexbel infrastructure – recycling flow



# Addressing viscosity challenges – our toolbox

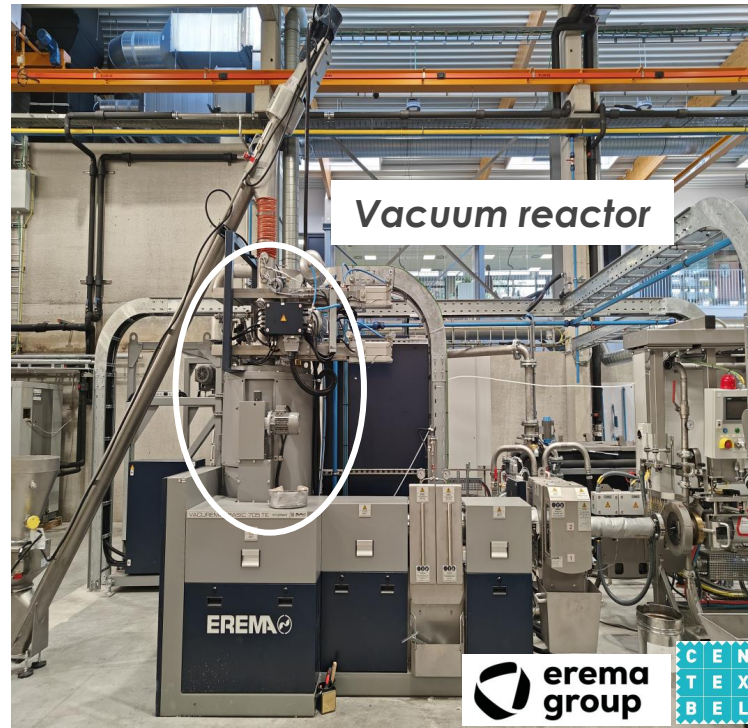
## SSP lab scale unit

Boosts IV through solid-state reaction



## Compact VACUREMA®

Batch SSP mode for minor IV enhancement



## Chain extenders

In compounding or during filament extrusion



# Addressing contamination challenges at lab scale

## Development of contamination removal via scCO<sub>2</sub> extraction

### Supercritical CO<sub>2</sub>

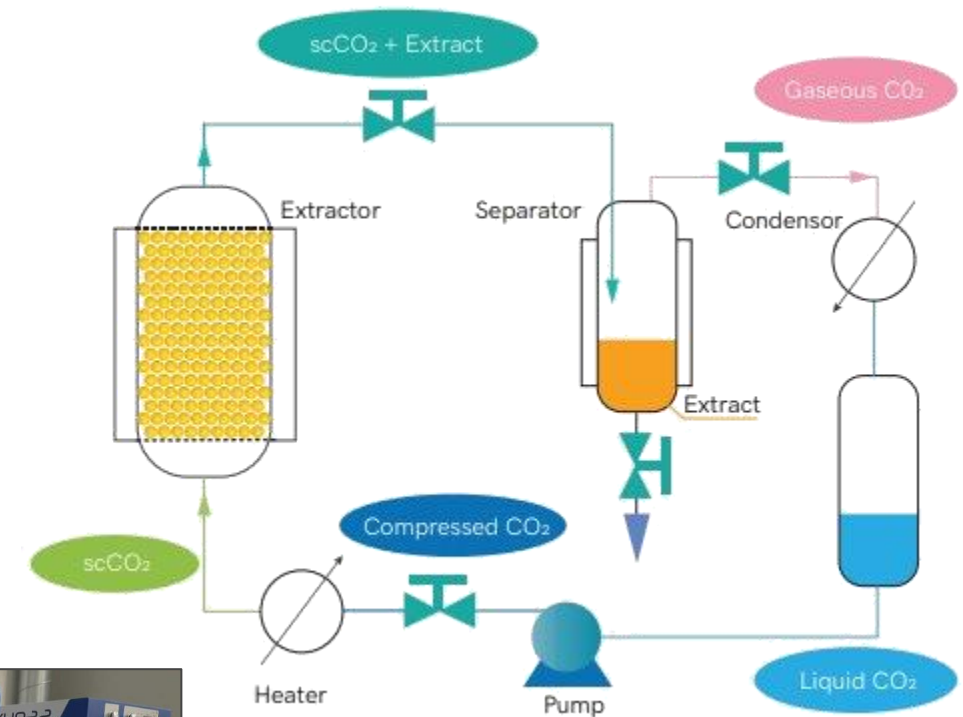
- combines the advantages of a gas and a liquid
- when heated to a temperature (>31.1°C)
- and pressure (>73.8 bar) above its critical point.

### Properties

Green solvent, non-polar, easily recyclable, non-toxic, non-flammable

### Applications

Removal of odours, additives, dyes...





# Addressing contamination challenges

## De-inking of printed textile using scCO<sub>2</sub>

Choice of cosolvent is very important

- Green solvent
- Good Removal
- Tailored to specific polymer and additives

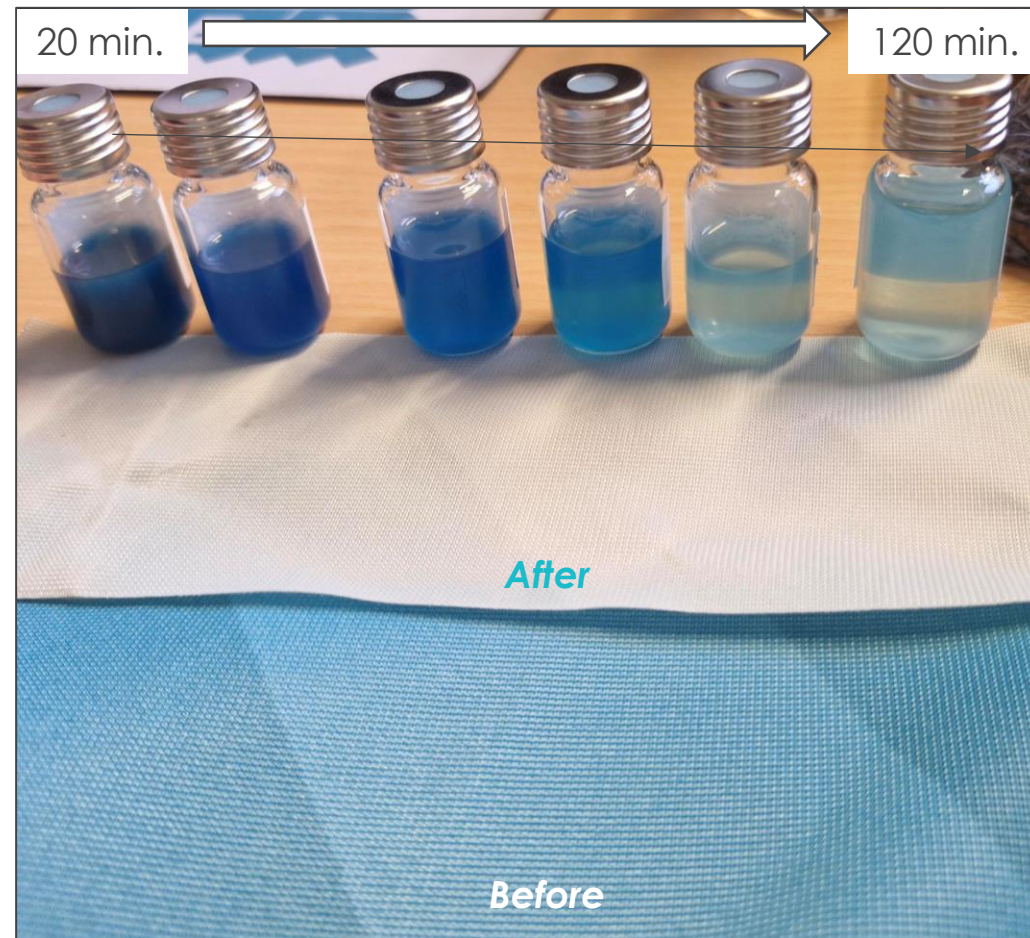
Ethanol



Acetone



## CrossS3 RE-APS



# Addressing contamination challenges at pilot scale

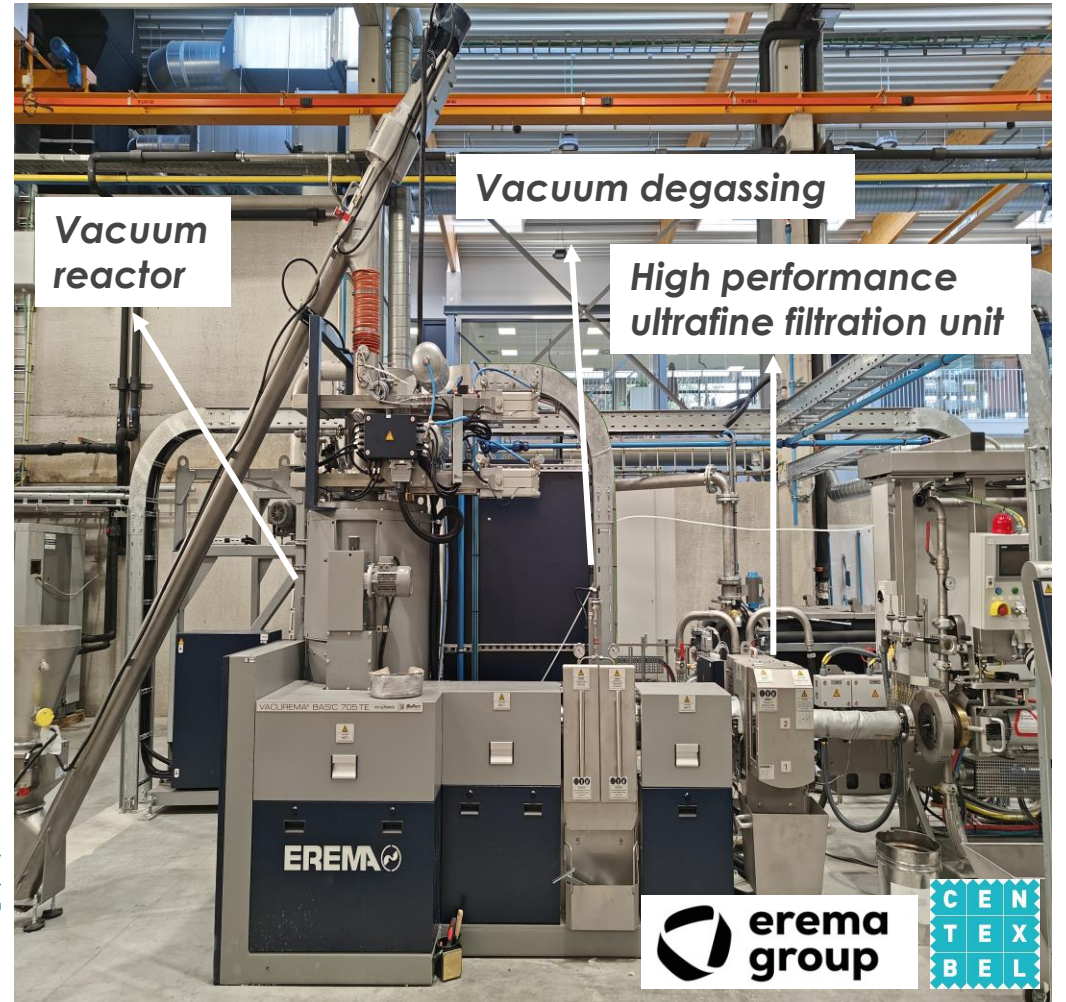
## Removal of volatile and non-melting contaminants

### Twin screw compounder

Vacuum degassing



Rotating screen melt filtration unit



Compact  
VACUREMA® line

CISUTAC  
Circular and Sustainable Textiles and Clothing

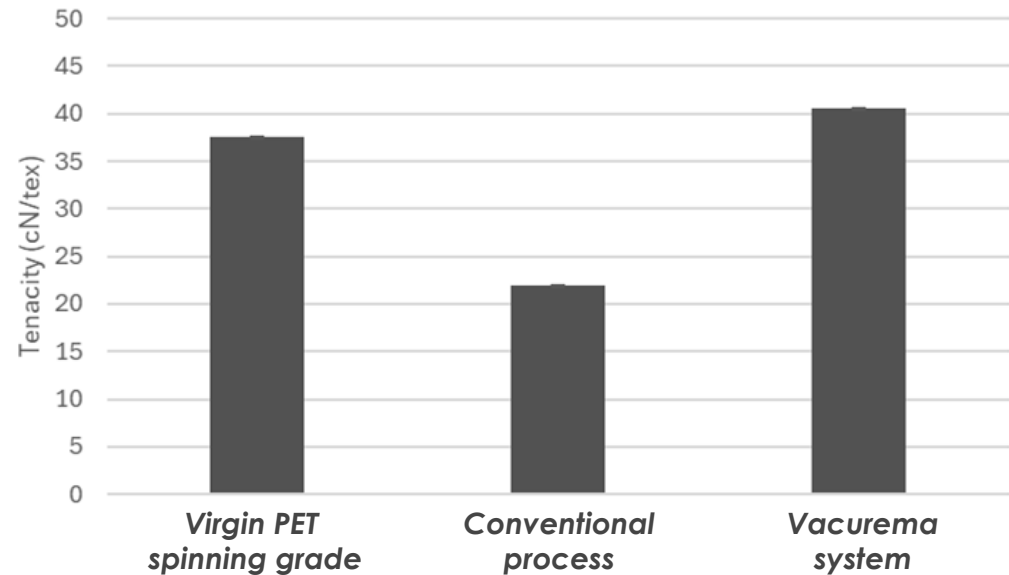
tExtended

# Impact of the recycling process on multifilament extrusion and yarn quality

## Multifilament extrusion

- Conventional process with melt filtration  
→ Not processable, melt viscosity too low
- Conventional process without melt filtration  
→ Pressure build-up & leaks at the spinplate
- Vacurema® system  
→ Stable extrusion process

## Yarn tenacity



### Conclusion – 1st Vacurema trial:

- Vacurema enables stable extrusion and restores virgin-like tenacity, outperforming the conventional process
- ▶▶ Exploring the capabilities and limitations of the technology with additional waste streams

# Acknowledgements



DigInTraCE



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Interreg



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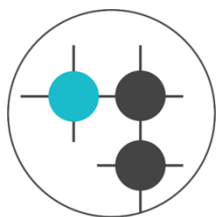
CrossS3  
RE-APS



met de steun van  
west-vlaanderen  
de gedreven provincie



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# Thank you!

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