CIRCULAR
FoodPack

FINAL EVENT

Circular Packaging for Direct Food Contact Applications

28 November 2024
Brussels

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003806.

Key Findings

- **Tracer-based sorting enables 99% sorting purity** in flexible food packaging from household plastic waste
- Novel delamination & deinking, deodorization treatments: **Ink and odor removal by 95%**
- **Increased purity of PE PCR with solvent based recycling technology** at pre-commercial stage (**25 kg/h**)
- **Cleaning efficiencies of the novel recycling cascades** determined through **challenge tests for PE**
- Traceable, recyclable flexible packaging: **>50% PE PCR** in non-food, **30%** in food packaging behind **functional barriers**
- **Machinability:** Upscaled production (>500 kg) of coffee/cacao pouches, cosmetics sachets, SUPs for HPC
- **56% climate change impact reduction with 34% PCR** in flexible food packaging compared to virgin non-recyclable

Main Outcomes

- Advanced physical recycling processes; deinking, dissolution, re-compounding, deodorization, producing high quality PCR materials from flexible household packaging waste
- Novel traceable recyclable flexible packagings with PCRs for contact sensitive applications

<u>PPWR targets are challenging, yet still doable and sustainable</u>

Key Messages

- Close collaboration along value chain: “Collection/sorting, recyclers, converters, and brand owners”
- Reliable, clear EU regulations and targets for PCR content in packaging, so that financial risk for investments is lower
- Ongoing research needed to address still open challenges

Interactive Presentation of Project Results and Q&A

Fraunhofer IVV – Polysecure – Ghent University – Amcor – National Technical University of Athens

Final Event

“Circular Packaging for Direct Food Contact Applications”

CIRCULAR FoodPack

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 101003806.

6 packaging demonstrators (3 food, 3 non-food) in 3 demo-loops
Use Cases: Food packaging, Home and Personal Care

30% PCR in food packaging
62% PCR in HPC

Project Value Chain

Collection and Sorting

Waste stream supply and analysis
Tracer-Based-Sorting

Pre/Post-Treatments

Delamination & Deinking
Deodorization

Design for circularity

Mono (PE) material packaging
Incorporation of recyclates

Physical recycling

Dissolution based recycling
Recompounding

Collection & Sorting

Markus Reisacher, Polysecure

Final Event
"Circular Packaging for Direct Food Contact Applications"

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Objectives

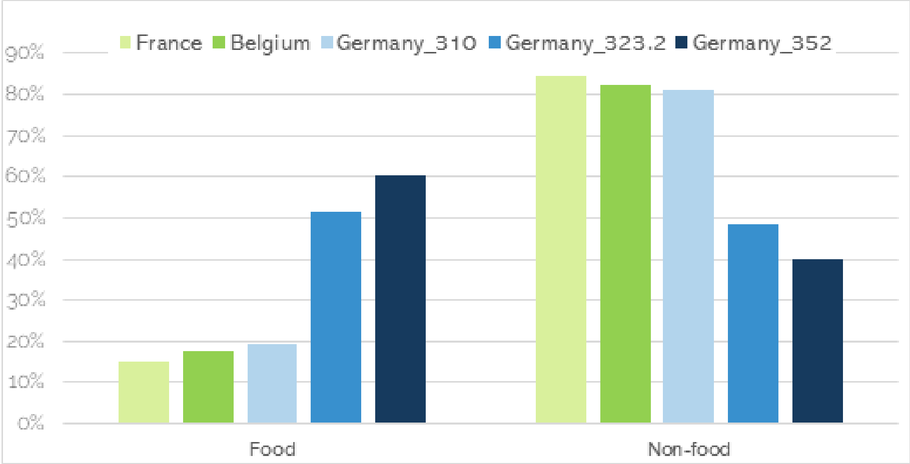
- Motivation:
  - Household waste **not in closed-loop**, food grade[1] waste not available due to non-existing sorting processes dedicated to food packaging
  - EFSA authorizes recycling processes only with **food grade waste** (99% for PO, 95% for PET based food packaging items)
  - Requirements of the PPWR for polyolefin-based food packaging materials: 10% of post-consumer recycled content by 2030
- Objectives:
  - To develop **an efficient Tracer-Based-Sorting (TBS)** for separating food packaging items from post-consumer flexible packaging waste.
  - To **characterize and select fractions** from current End-Of-Life (EoL) packaging, **most suitable for downstream recycling**.

[1] *COMMISSION REGULATION (EU) 2022/1616*

TBS Prerequisites

Analysis of European waste streams

→ Understanding of composition
→ E.g. ratios of food vs. non-food streams[1]



Tracer application via printing inks

→ Tracers can be processed in usual printing processes
→ 100-300 µg tracer per packaging item sufficient
→ **Design Guidelines[2]**

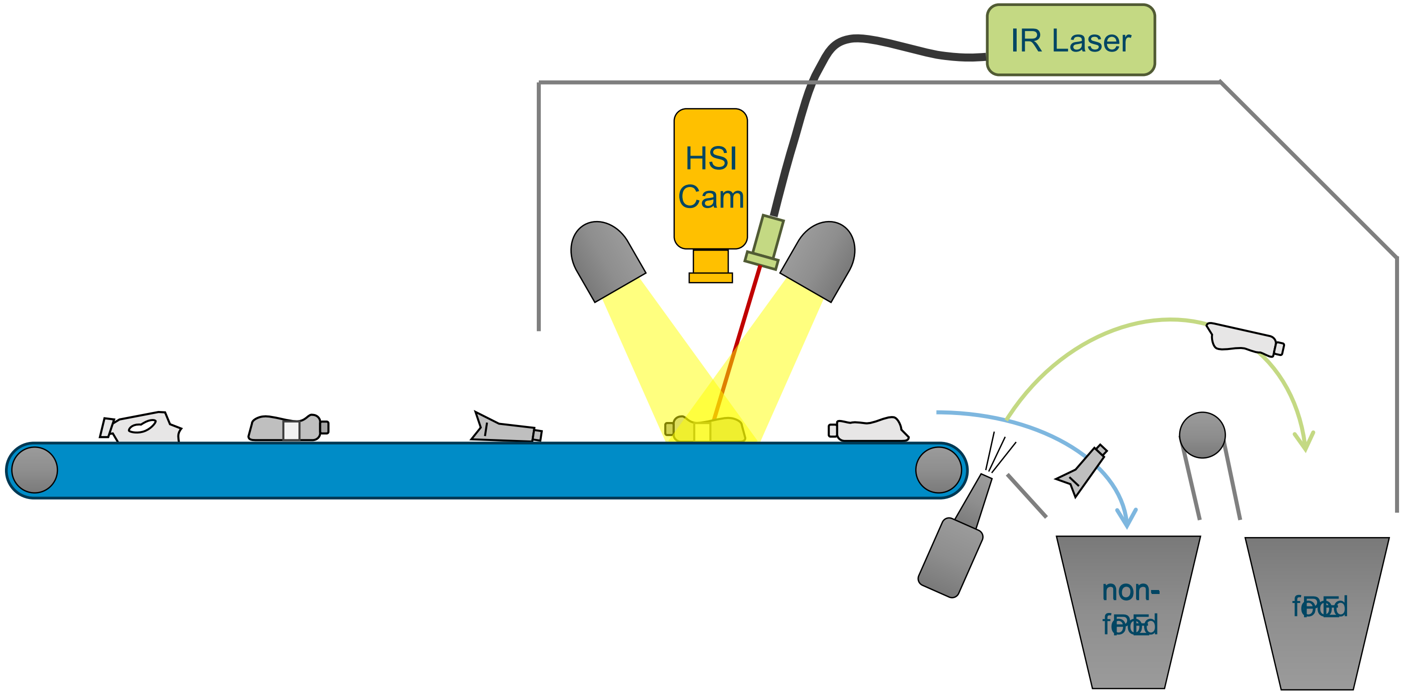
Food contact approval/compliance for tracers

→ FDA approval
→ Conformity with EU regulations

[1] D2.1 (Public): Analysis of flexible packaging waste in 3 EU countries
[2] D3.8 (Public): Guidelines on design for recycling
https://www.circular-foodpack.eu/media-centre/results (online from 03/2025)

TBS Technology

- Enabling conventional NIR sorting lines to sort food from non-food packaging: **Tracer-based-sorting (TBS)**



Sorting Achievements

- Industrial scale sorting trials in CFP
    - 2-step process

TBSlight	
Purity	98%
Yield	78%

Mixing waste in the infeed bunker

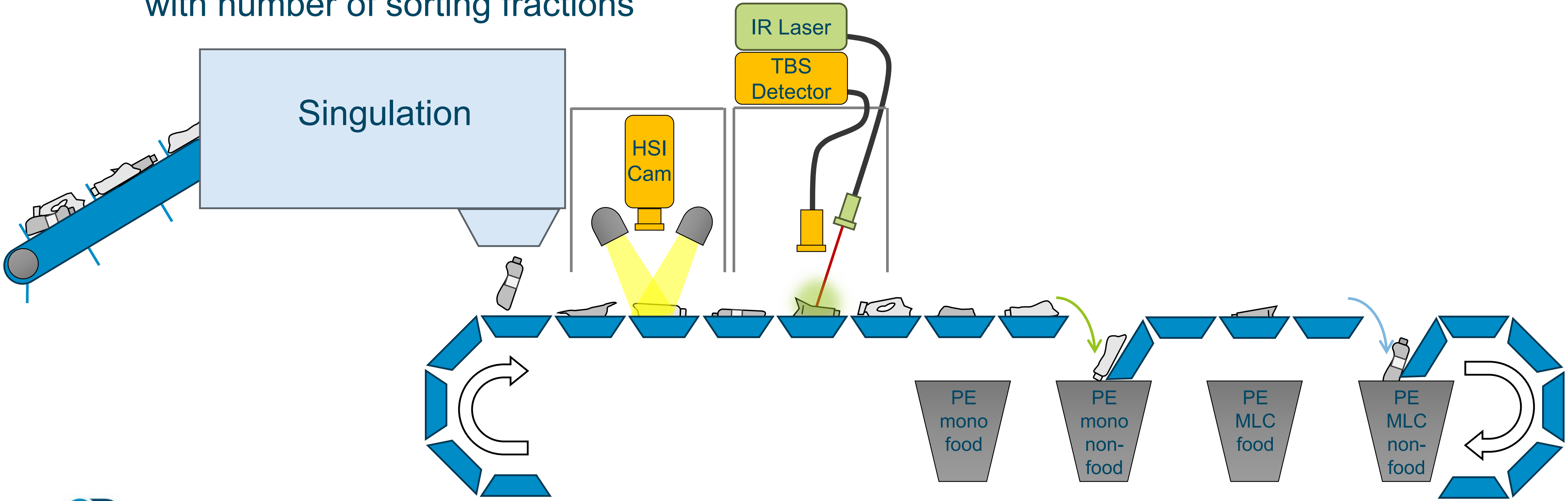
Video not included in pdf document

Ejection of sorted items with pneumatic air nozzles. The arrow on the left marks the detection line

Sorted output material

Sorting Achievements

- The step beyond: A novel approach to sorting – Sort4Circle
  - Singulate items first, measure everything, then deposit at determined end point without error
  - better recyclate quality and higher economical efficiency → sorting costs do not rise with number of sorting fractions



Sorting Achievements

- Sort4Circle sorting trials at technical scale
  - Sorting for 2 traced fractions vs. 1 untraced fraction
  - 1-step process
  - manual singulation

Sort4Circle	
Purity	99%
Yield	96%

Sort4Circle demo line: Singulation, two detection chambers, tray sorter

Video not included in pdf document

Deposition of traced pouches in two fractions

Sorted output material. Left: tracer 1, center: tracer 2, right: background waste

Sorting Achievements

- TBSlight
  - Upgrade for existing sorting facilities. Low cost entry point into the technology
  - Needs one (rather two) spare NIR sorters with suitable detection technology
  - High purity achievable, but limitations exist due to the pneumatic ejection
  - Number of tracer codes limited (up to 7)
- Sort4Circle
  - Higher purities and yields
  - Lower tracer concentrations and more codes (15+)
  - Better economical efficiency compared to cascadic sorting
    → Gain increases with number of sorting fractions
  - Lower throughput per line is compensated by parallelisation of lines

Opportunities

- TBS has been **demonstrated** at industrially relevant conditions as a **viable solution** for sorting food-grade from non-food-grade items with high purity and yield
- Further research needed to fully implement Sort4Circle for flexibles
- **Investment** in infrastructure needed to facilitate market uptake
  → Industrial TBS/Sort4Circle **pilot sorting line**
- **Standardisation** of tracer application
- Standardised collection schemes, tailored to the sorting and recycling process chain, have high potential of leveraging efficiency and recyclate quality

Thank you!

Markus Reisacher, *markus.reisacher@polysecure.eu*

WEB www.circular-foodpack.eu

@CIRC_FoodPack

in CIRCULAR FoodPack

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Advanced Mechanical Recycling

Prof. Steven De Meester, Ghent University
& Johannes Schneider, Fraunhofer IVV

Final Event
"Circular Packaging for Direct Food Contact Applications"

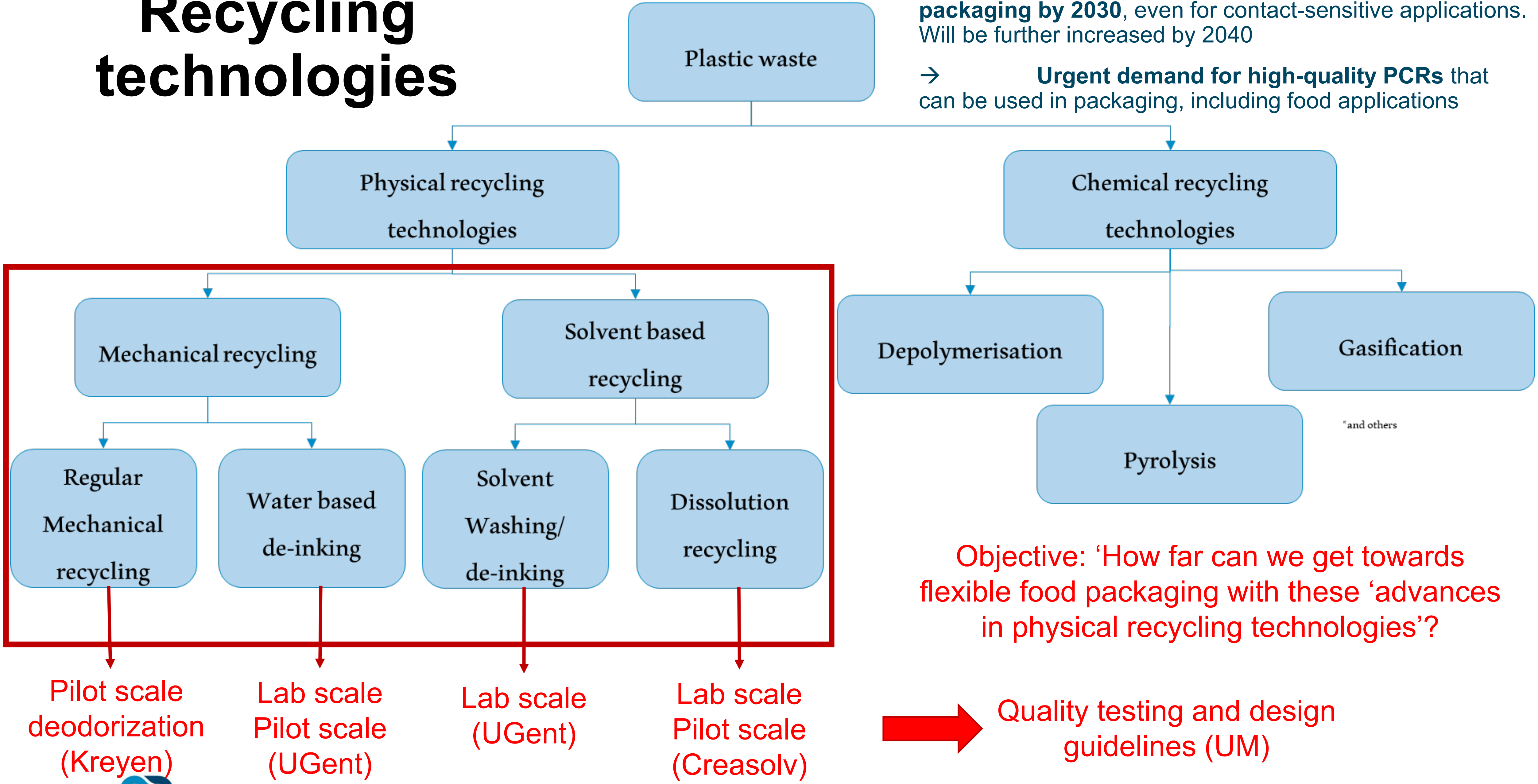
CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Recycling technologies

Context: PPWR sets **mandatory PCR shares in packaging by 2030**, even for contact-sensitive applications. Will be further increased by 2040

→ **Urgent demand for high-quality PCRs** that can be used in packaging, including food applications



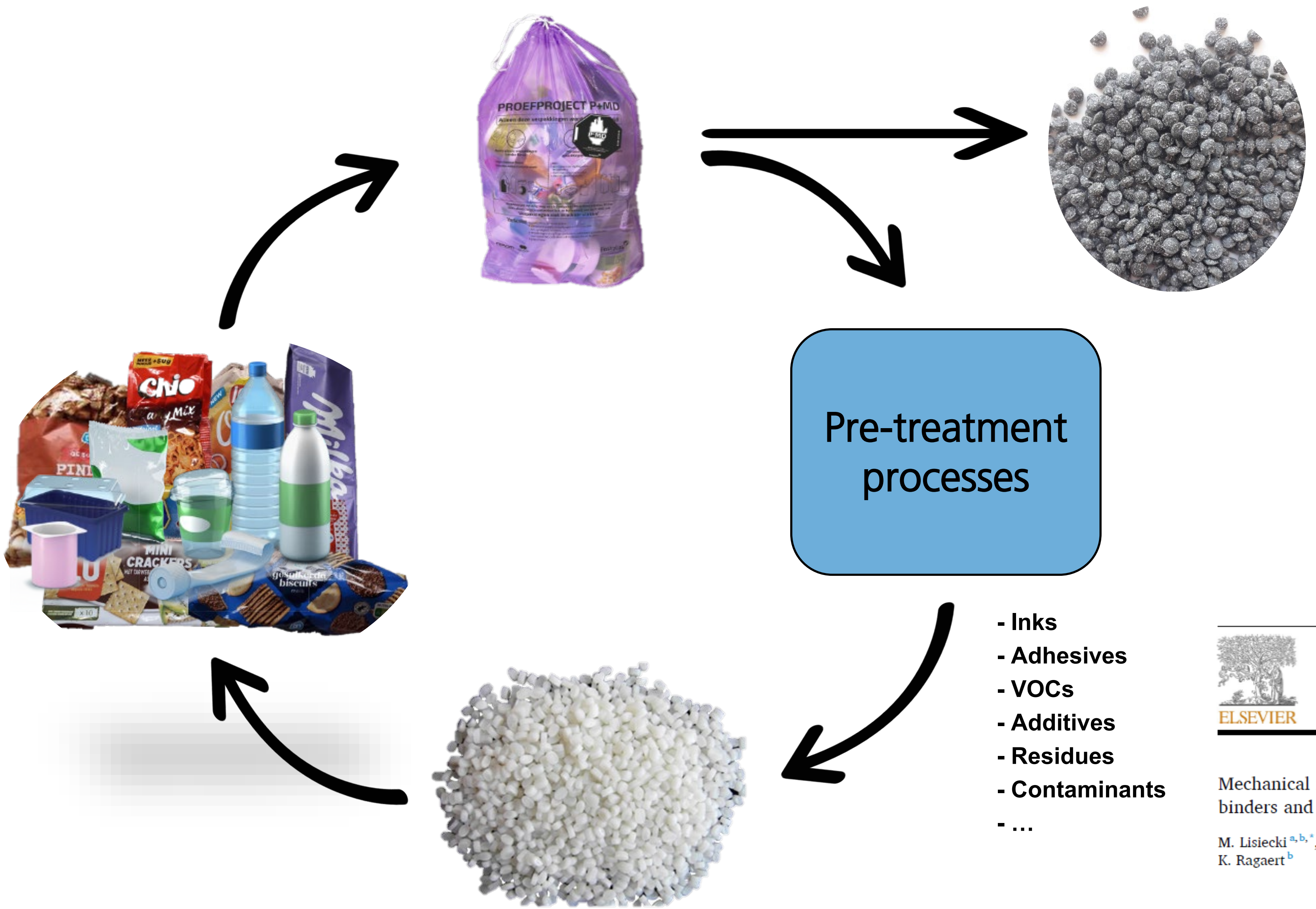
Objective: 'How far can we get towards flexible food packaging with these 'advances in physical recycling technologies'?

Quality testing and design guidelines (UM)

Fig. based on Gerald Altnau

Part 1
Water based de-inking

Towards closed-loop recycling



Contents lists available at ScienceDirect

Journal of Hazardous Materials

journal homepage: www.elsevier.com/locate/jhazmat

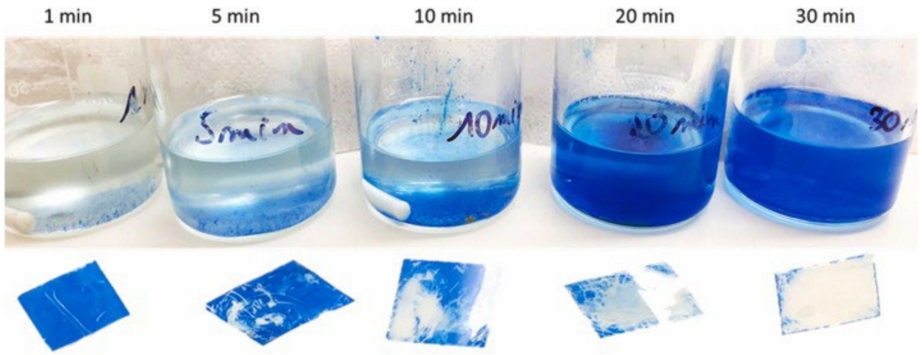
ELSEVIER

Mechanical recycling of printed flexible plastic packaging: The role of binders and pigments

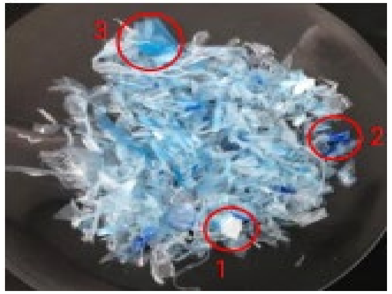
M. Lisiecki [a,b,*], Tiago G.A. Belé [c,d], S. Ügdüler [d], R. Fiorio [b], T.F. Astrup [a,e], S. De Meester [b,d], K. Ragaert [b]

Optimizing water-based de-inking

- ❑ Water-based deinking typically at 85°C, with 2-5% NaOH and detergents
- ❑ Optimization of the process conditions
- ❑ Particle size, temperature, solid/liquid (S/L) ratio, reagent concentration, and contact time



Adjustments in S/L ratio (friction vs oversaturation)

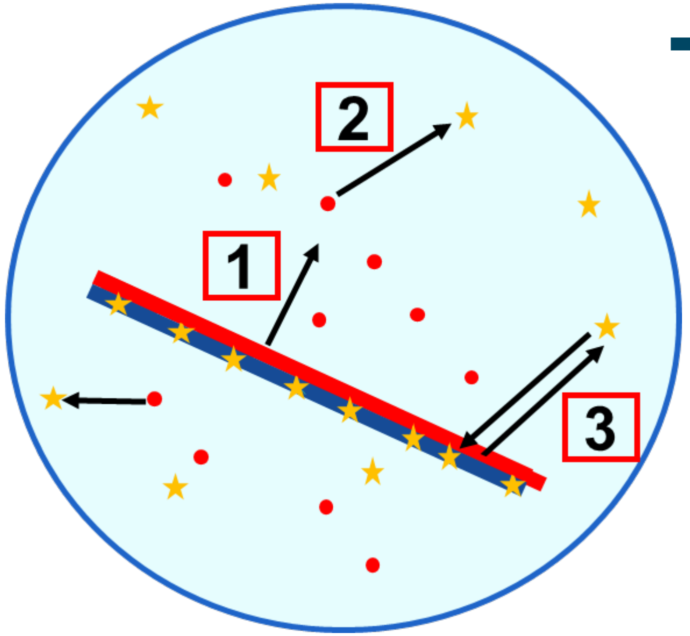


Optimizing NaOH conc.

Practical problem: curling

Adjustments in T, residence time and particle size

The staining problem



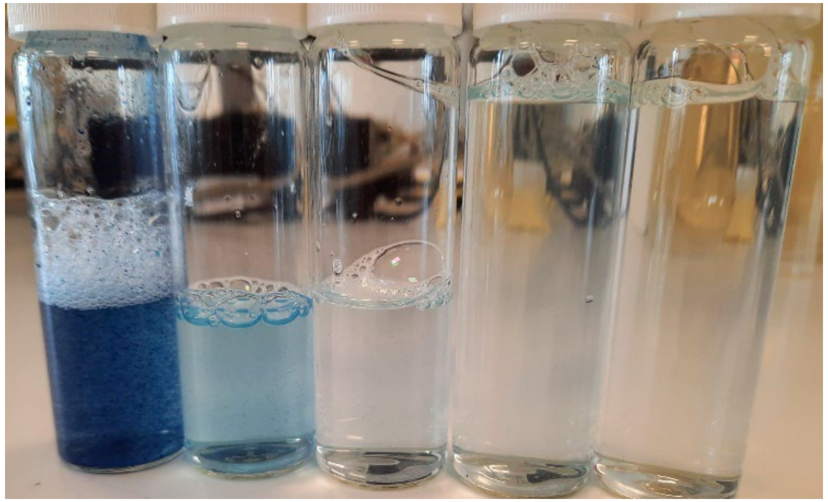
1st deinking step

2nd deinking step

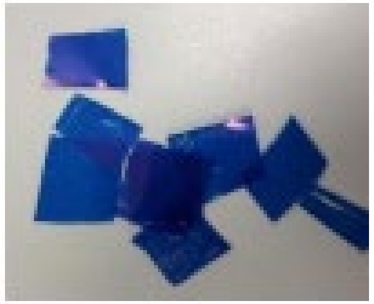
3rd deinking step

4th deinking step

5th deinking step



Equilibrium between plastics and washing medium

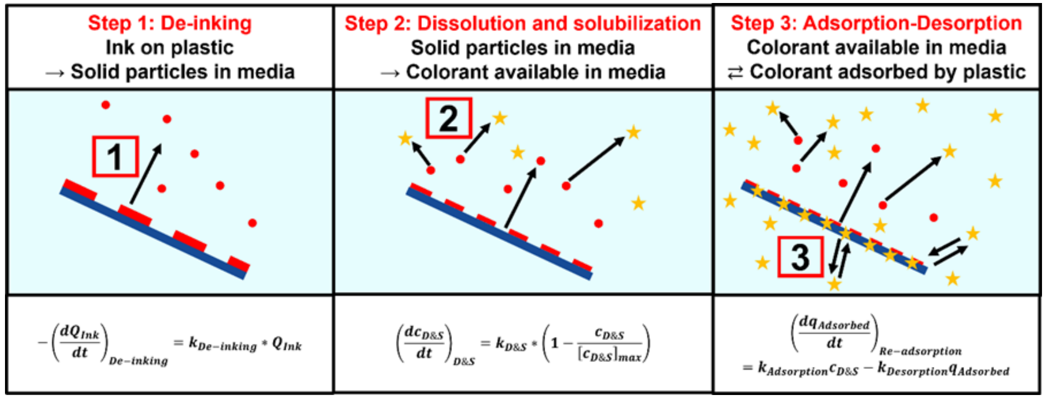


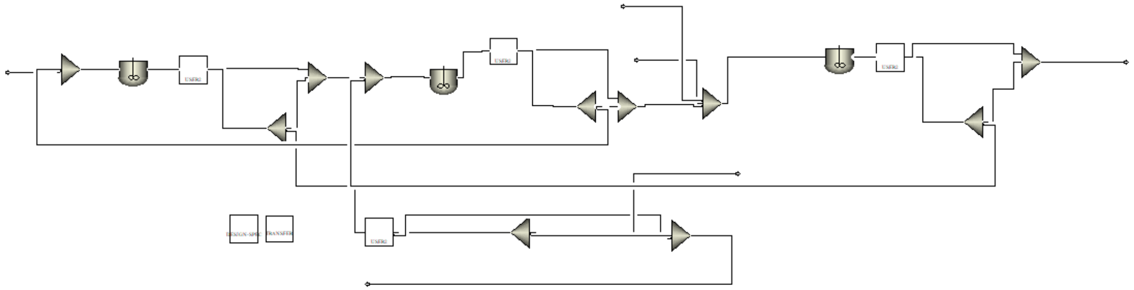
1st deinking step

nth deinking step

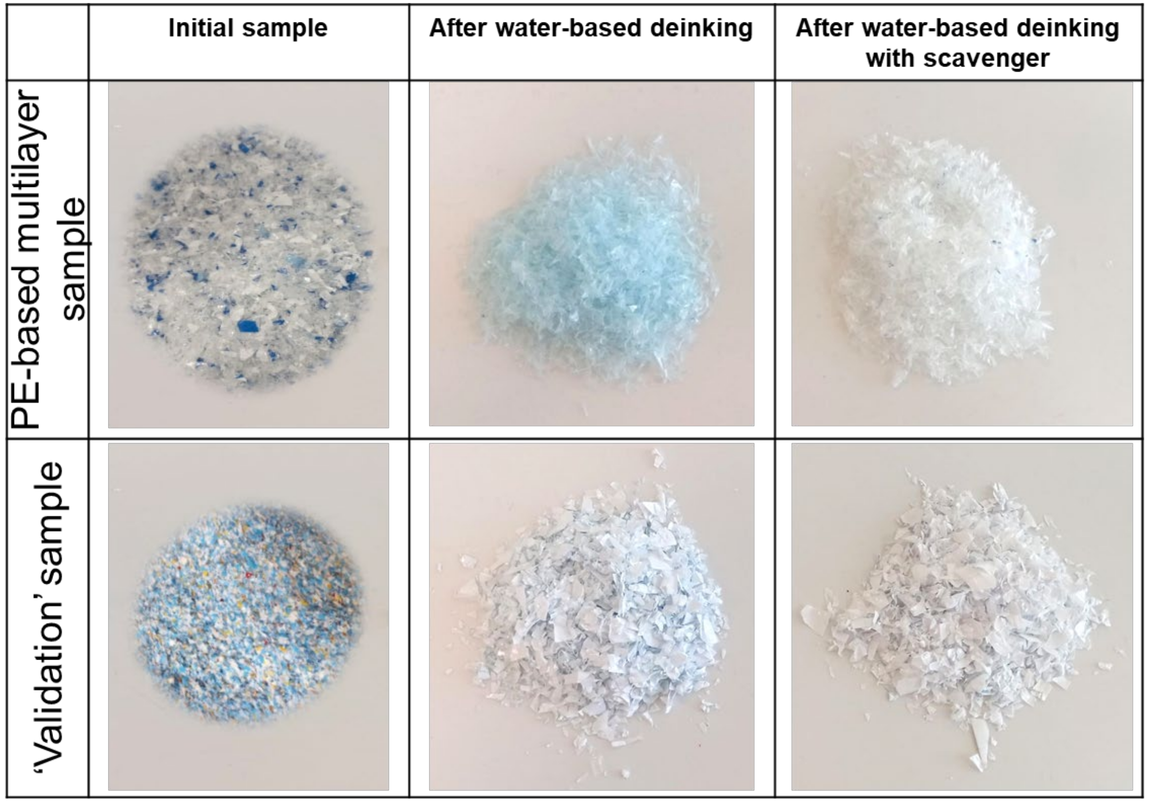
Solving the staining problem

A model to optimize the reactor system



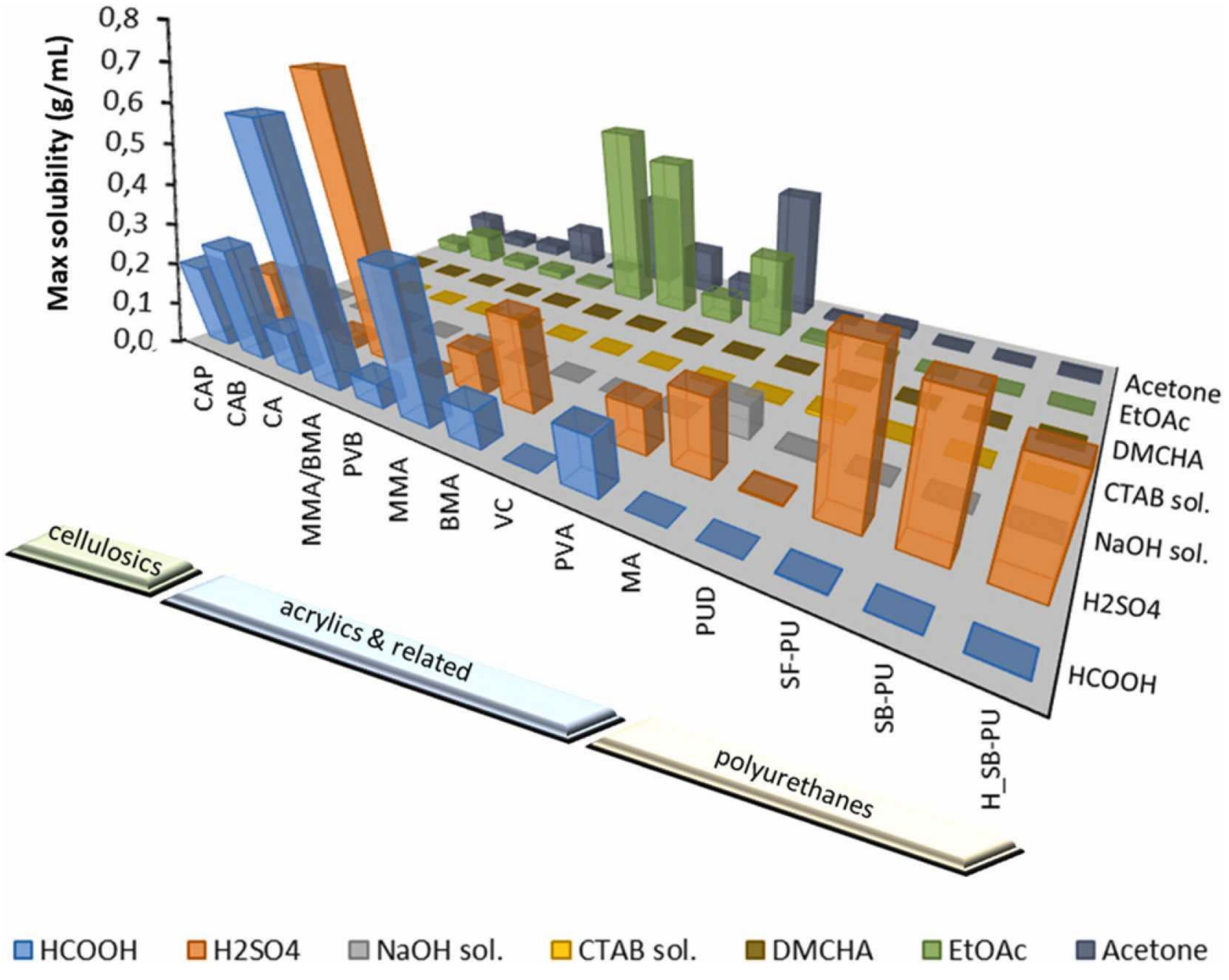


Development of scavengers



Part 2
Solvent based de-inking

Potential of solvent-based medium

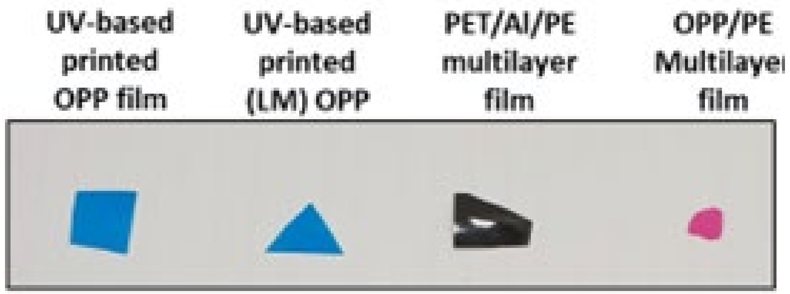


ELSEVIER
Journal of Hazardous Materials
Volume 452, 15 June 2023, 131239

Understanding the complexity of deinking plastic waste: An assessment of the efficiency of different treatments to remove ink resins from printed plastic film

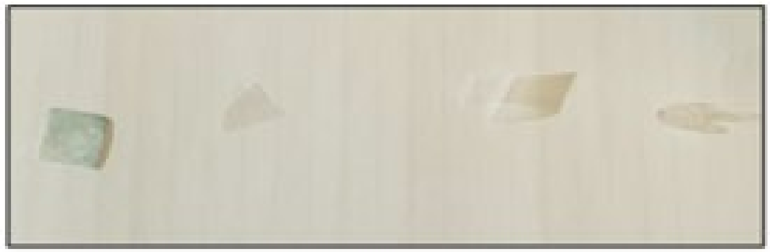
Sibel Ügdüler [a], Tine Van Laere [a], Tobias De Somer [a], Sergei Gusev [a], Kevin M. Van Geem [b], Andreas Kulawig [c], Ralf Leineweber [c], Marc Defoin [d], Hugues Van den Bergen [e], Dirk Bontinck [e], Steven De Meester [a 1]

Potential of solvent-based de-inking medium



Solvent 1 based de-inking

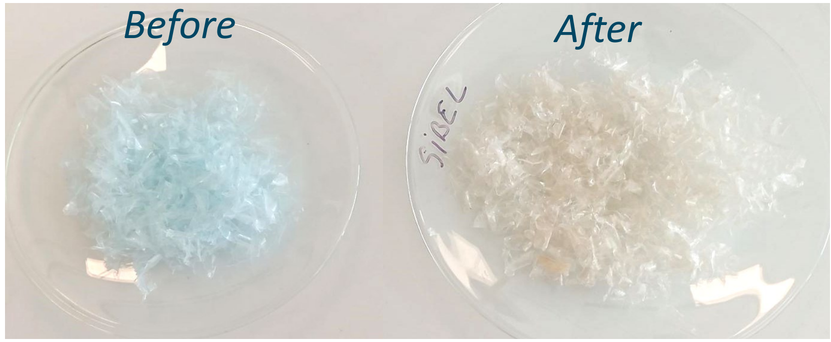
Solvent 2 based de-inking



‘Tailored’ non-water deinking medium

- Less readsorption

- Can remove the readsorbed pigments (after deinking with a water-based solution)



Achievements/leassons learnt on de-inking

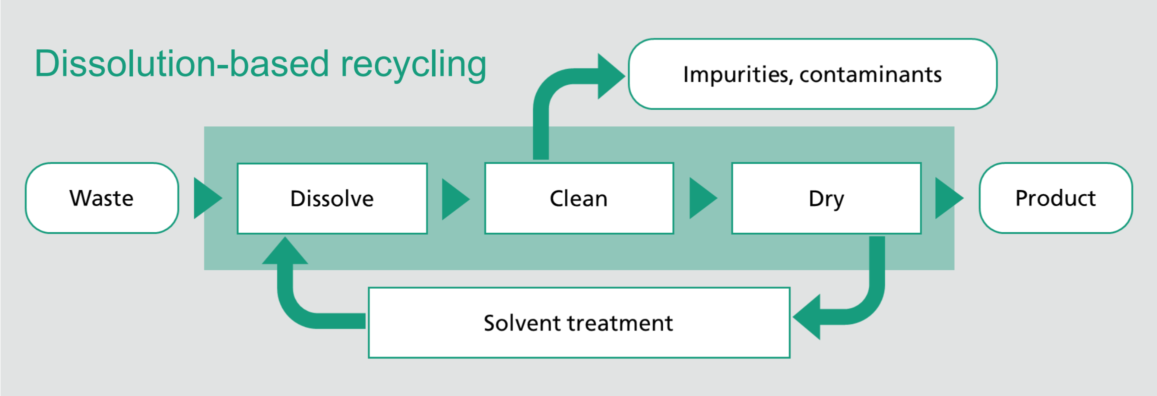
- ✓ Color staining mitigation method developed in the project
- ✓ Over 95% deodorization and deinking efficiency
- ✓ 50% PCR incorporation into FC packaging
- ➢ Not effective on all types of multilayer plastic packaging
- ➢ Not effective on removal of all types of inks e.g. UV-based
- ➢ Delamination primer facilitates water based de-inking
- ➢ Solvent based de-inking might help for some problems/films

Water based de-inking at beginning of project

Water based de-inking at end of project

Part 3
Dissolution-based recycling

Methodology/Technology Developments



Laboratory Scale
Dissolution, cleaning, and drying parameters

Small-Technical Scale
5-10 kg per day using stainless steel equipment (100-250 L)

Industrial Demonstration Scale
100-1000 kg sample production
Validation of mass and energy balances

Materials:
Mono-Material based laminates containing Tracers for TBS

SOA post-consumer flexible packaging waste

Achievements

Dissolution-based recycling of TBS sorted packaging allows extensive purification from inks and tracers

Tracer-based sorted food packaging

Recyclate from dissolution-based recycling

ICP-MS:

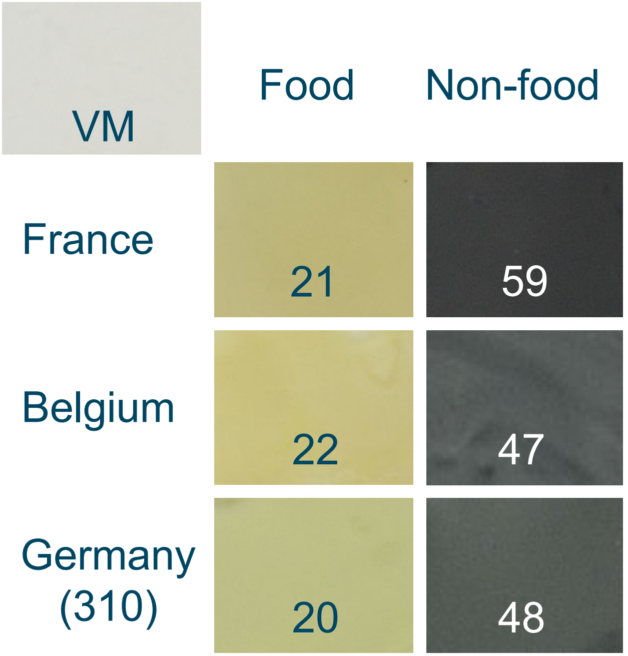
> 99 % removal of Tracers

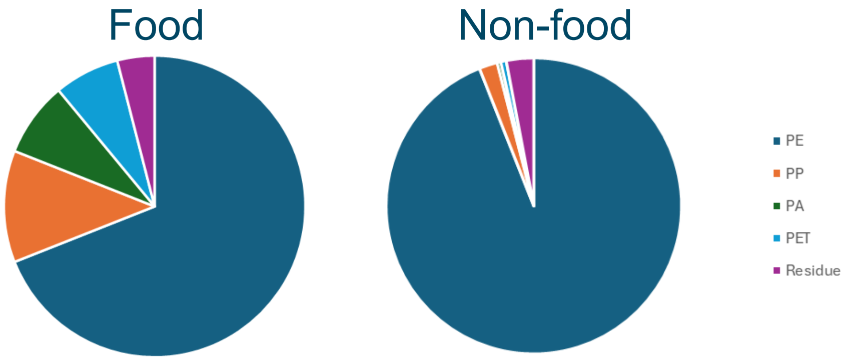
Achievements

Separation of food and non-food packaging in sorting will influence the recycling processes and recyclate quality

- Higher VOC load of food packaging[1]
- Less visual impurities in recyclate from food packaging, despite a greater share of printing in food packaging
- → Black masterbatched non-food films dominate the recyclate color
- Higher share of foreign materials in food packaging due to the greater share of multilayer packaging in food applications[2]

Recyclate color difference to virgin material (VM)





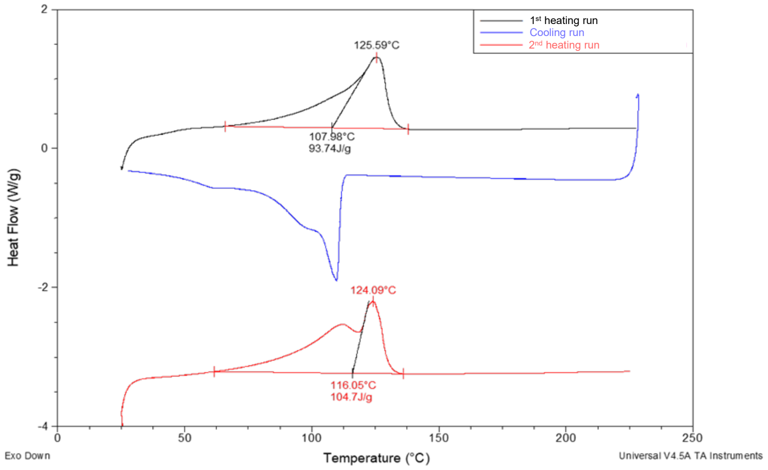
[1]https://doi.org/10.1016/j.chemosphere.2023.138281

[2]https://doi.org/10.3390/ma17133202

Achievements

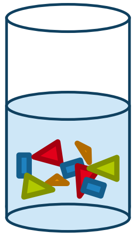
Removal of foreign materials by dissolution-based purification

→ DSC measurement of recyclate:
Pure PE PCR



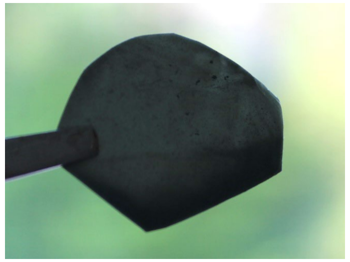
Reduction of visual impurities with excluding black films or adding purification units to the dissolution-based recycling process

Post-consumer household waste

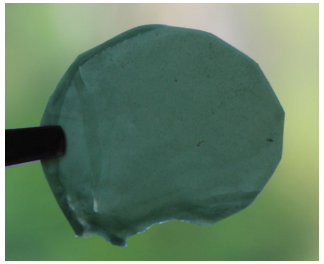


Dissolution-based Recycling (laboratory scale)

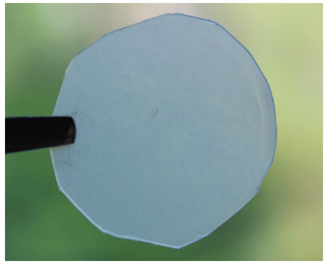
Without purification



Removal of black films



Additional Purification



500 µm press films of recyclate from dissolution-based recycling

Achievements

Scale-up of solvent-based purification from laboratory to small-technical and industrial demonstration scale (nominal capacity 25 kg/h)

Post-consumer household waste

SOA mechanical recycling

Contaminated film with defects → SOA recycling not applicable

Small- technical scale equipment for dissolution-based recycling

Industrial demonstration scale dissolution-based recycling plant

Recyclate and 100% PCR film without and with additional purification

Recyclate from production at industrial demonstration scale

Demonstrator packaging for detergent pods

Achievements

Challenge-Test proved high cleaning efficiency of dissolution-based recycling

With improved purification, a reduction below the limit of quantification is achieved for all contaminants

Artificial contamination of with selected contaminants for the Challenge-Test

→ Extractive purification of dissolution-based recycling **allows substantial cleaning** not only for volatile compounds but **also higher molecular weight contaminants**

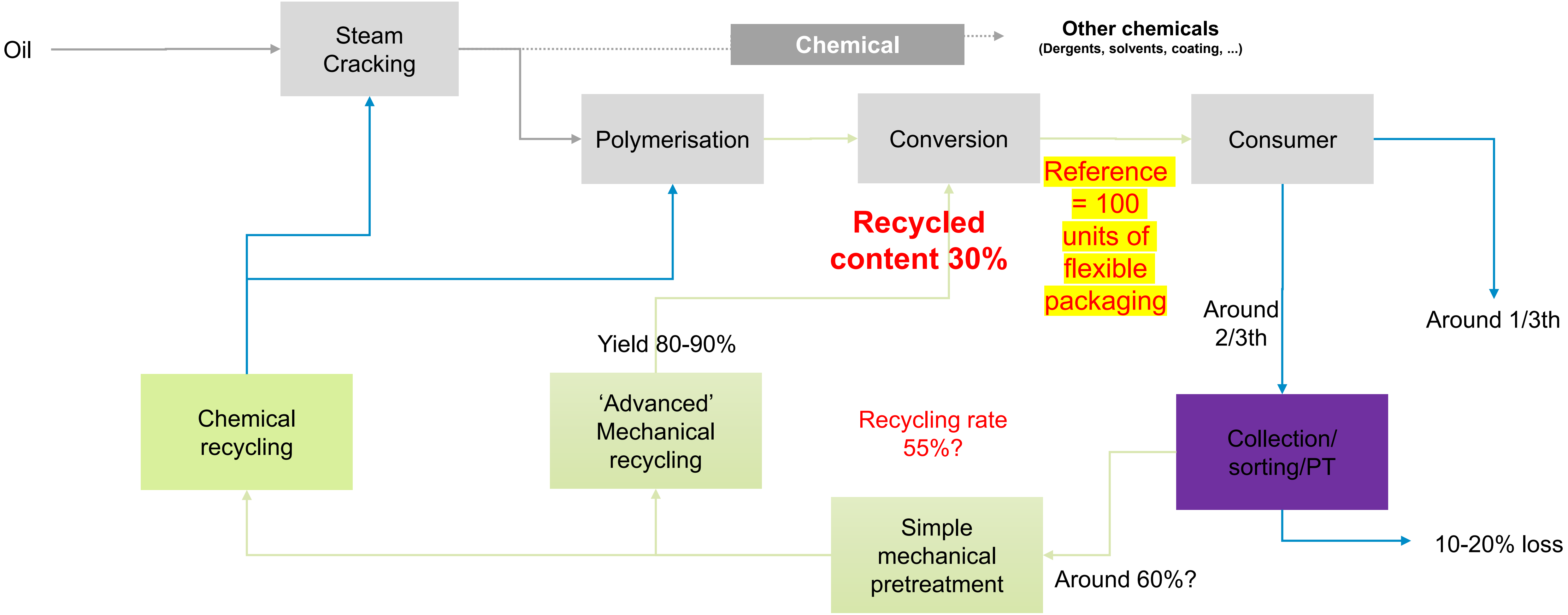
Opportunities

- **Sorting into food and non-food packaging** creates new opportunities but also new challenges for the recycling processes (e.g. higher VOC and foreign material content)
- **Dissolution-based recycling** already **enables recycling of mixed waste** streams into high-quality PCR, which can be used in new packaging, even for high-level applications

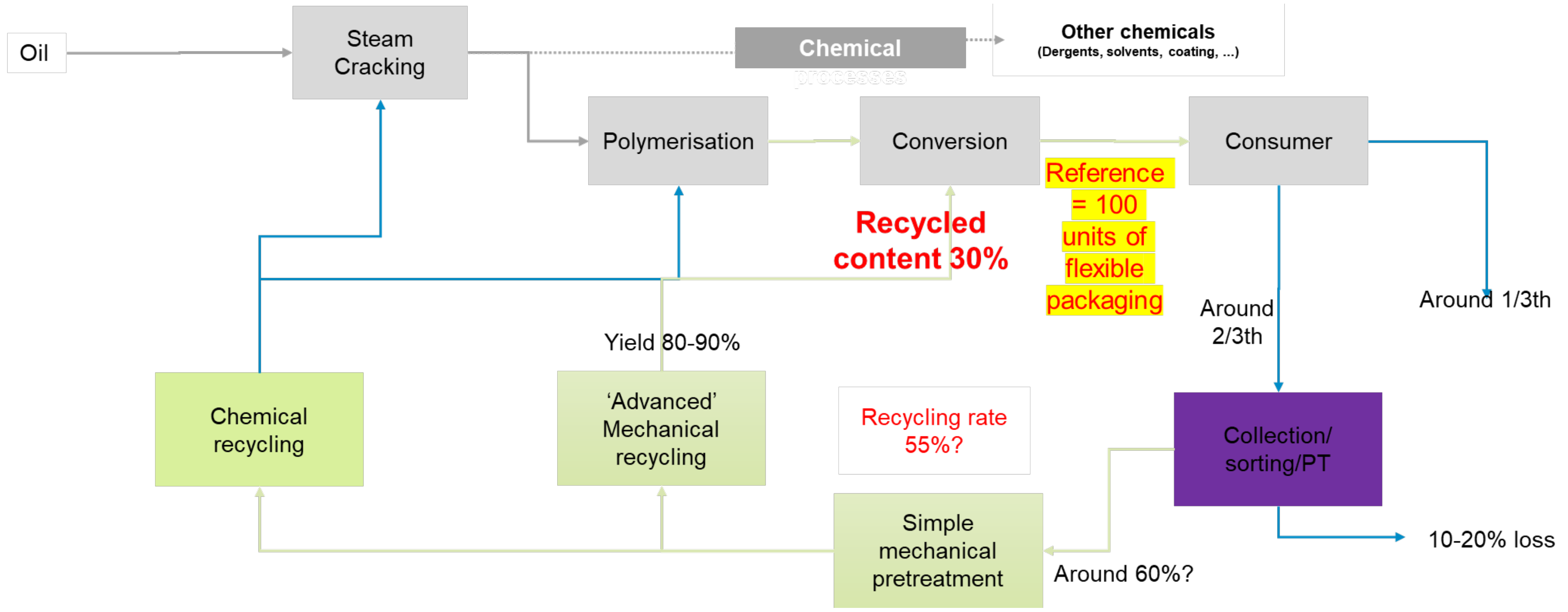
  → Can help to achieve PCR share targets in the future
- **High cleaning efficiency** of the dissolution-based recycling even **towards non-volatile substances**. Purity can be further increased by additional cleaning units
- High-purity PCR may potentially enable future **use in food packaging** (most likely in combination with novel sorting technologies and functional barriers)

Part 4
Putting the research in context

Ball park number slide



Ball park number slide



Conclusion 1: Yield is a multiplier of the different steps in the chain, including collection and sorting
➔ The recycling process itself starts from what comes out of the sorting plants to achieve EU targets (max 60%?)

Conclusion 2: 'Circular Foodpack' project shows that 'advanced mechanical recycling' technologies allow to fulfil PPWR to go beyond >30% from quality perspective (up to even 60% in non-food flexible packaging)

Conclusion 3: Recycled content can probably not go beyond 60% because of collection and sorting in the EU?
➔ Should we go for 100% packaging with 60% recycled content or 60% of packaging with 100% recycled content

Thank you!

Johannes Schneider, Fraunhofer IVV, *johannes.schneider@ivv.fraunhofer.de*

Steven De Meester, UGent, *steven.demeester@ugent.be*

WEB www.circular-foodpack.eu

@CIRC_FoodPack

in CIRCULAR FoodPack

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Safety & Compliance

Dr. Diana Kemmer, Fraunhofer IVV

Final Event

"Circular Packaging for Direct Food Contact Applications"

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Objectives

Definition – Evaluation – Assessment

innovative recycling strategies

newly developed packaging structures

Safe re-use of recycled polyethylene
in flexible packaging for food and personal care applications

- Scientific evidence for future legislative requirements & standardization
- Food compliance of newly developed packaging
- Cleaning efficiency of the different envisaged recycling treatments
- Testing concepts for compliance / safety assessment of recycled materials
- Functional barrier concepts to ensure safety and regulatory compliance

Achievements

Comprehensive analytical characterisation & monitoring

– input materials
(waste and designed packaging films)

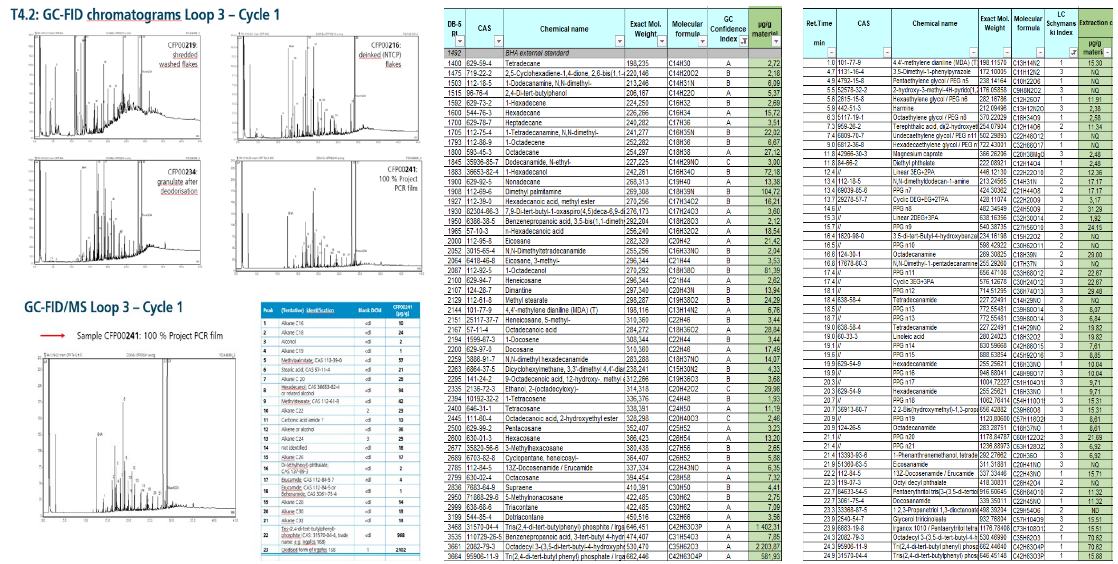
– output recyclates

Following the decontamination pathways

– Water-based Deinking – Mechanical Recycling – Deodorisation Cascade

– Solvent-based Recycling

Databases for identification of chemical contamination



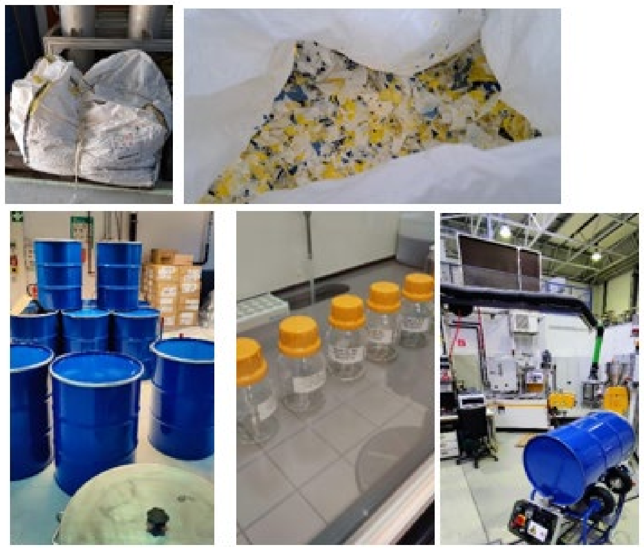
Following the recycling cascades by instrumental analyses

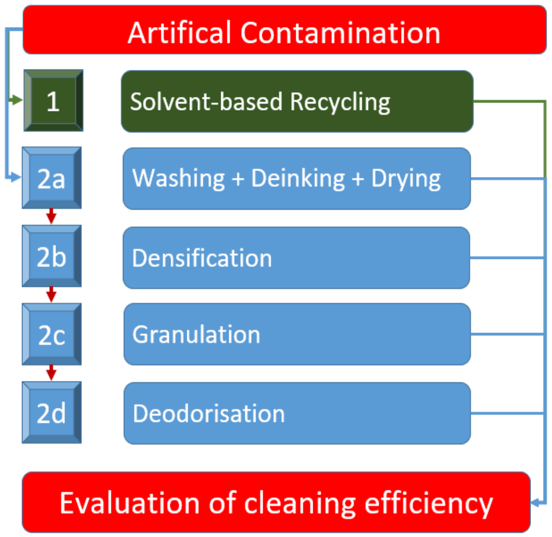
- *Headspace-GC-MS* ✓
- *GC-FID/MS* ✓
- *LC-HR-MS-CAD* ✓
- *ICP-MS* ✓
- *Bioassays* ✓
- *Mineral oil* ✓

Achievements

Challenge test for demonstrating cleaning efficiency of applied decontamination / recycling technologies for PE flakes

- Artifical contamination with 9 surrogates
- Shreeded PE films (flakes) as input
- Cleaning efficiencies established in the range of at least 81 - 98 % depending on molecular weight of the surrogates
- Optimization of contamination process for film flakes, selected surrogates and analytical method for quantification needed

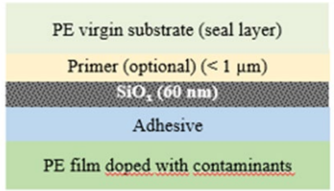




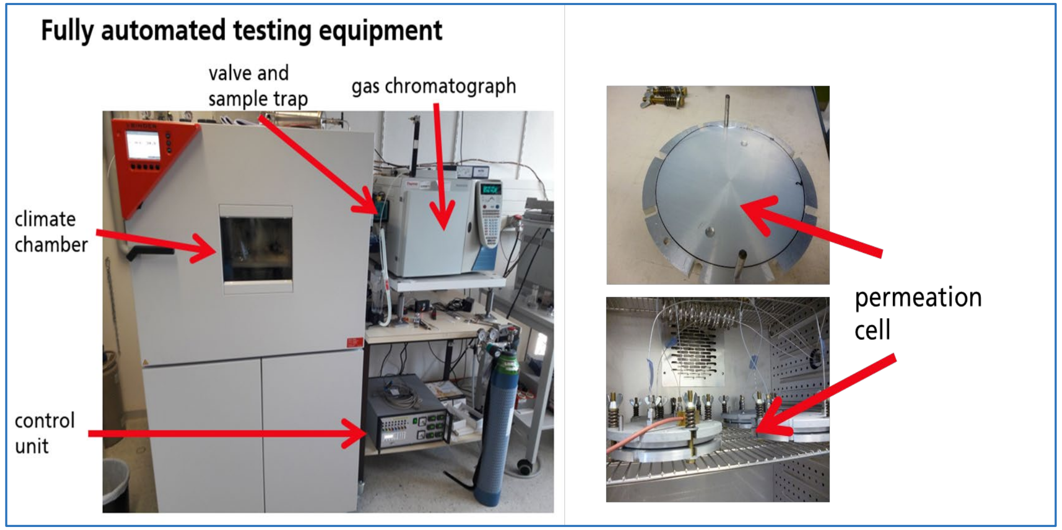
→ Need to establish a “standard procedure for polyolefins“

Achievements

Design and validation of functional barrier concepts



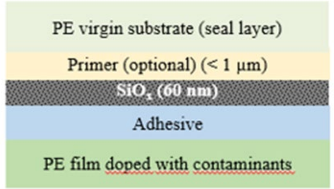
- Permeation kinetics of model contaminants from a spiked PE layer
- Permeation testing (desorption kinetics)
- Fully automated testing equipment with high measuring density
- Calculation of Barrier Improvement Factor (BIF) (permeation without / permeation with barrier layer)



Barrier layers (or combinations thereof) with effective functional barrier properties were identified that are be capable to reduce the transfer of undesired contaminants from the PE recyclate into packed food ✓

Achievements

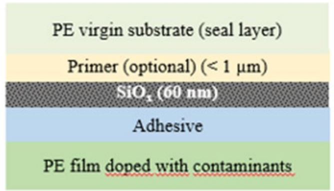
Design and validation of functional barrier concepts



Barrier layers shall ensure that contaminants potentially present in the PCR layer remain below certain migration limits or levels of toxicological concern:

- A migration limit value of **10 µg/kg** is typically applied in the evaluation of functional barriers as laid down in the European Plastics Regulation (EU) No 10/2011.
  - applies to non-authorized / non-evaluated substances may be used in multilayer material
  - provided that the substances are not classified as mutagenic, carcinogenic or toxic for reproduction (CMR)
  - Migration of these non-evaluated components into the food shall not be detectable at a detection limit of 0.01 mg/kg (10 ppb).
- As a conservative approach, potential contaminants in the recyclate are considered as genotoxic compounds since some of the post-consumer substances cannot be identified by instrumental analysis
  - Threshold of Toxicological Concern (TTC) approach
  - threshold value for the oral uptake of genotoxic compounds is set at 0.15 µg/person/day
  - corresponds to a concentration of **0.15 µg/kg** (ppb) of the respective substance in food

Achievements



Design and validation of functional barrier concepts

CFP project‘s functional barrier concept:

“Transfer of contaminants shall be reduced by barrier layer to concentrations below toxicological concern”

✓ Barrier’s efficiency and capability to reduce the transfer of contaminants strongly depends on the **level of the residual contaminants in the PE recyclate** (c_{po}), which is directly linked to

- **level of contamination in the input materials** (“pre-processed”)
  - → Characterization of the produced recyclates (instrumental analytical techniques and bioassays)
- **efficiency** of applied **decontamination technologies**
  - → Challenge tests for the recycling cascade and solvent-based recycling

✓ Estimation based on permeation properties and BIF: CMR substance potentially present in the recyclate should not exceed ~10 - 50 ppm for efficient barrier structures

- Defined and controlled **input material**: inherent (known) IAS and NIAS components may be present at ~ 1000 ppm
- Substances with (potential) CRM properties are not expected to be present in such high concentrations

Thank you!

Dr. Diana Kemmer, *diana.kemmer@ivv.fraunhofer.de*

WEB www.circular-foodpack.eu

[@CIRC_FoodPack]

[CIRCULAR FoodPack]

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Design for Circularity

Bert De Schoenmaker, Amcor

Final Event

"Circular Packaging for Direct Food Contact Applications"

CIRCULAR FoodPack

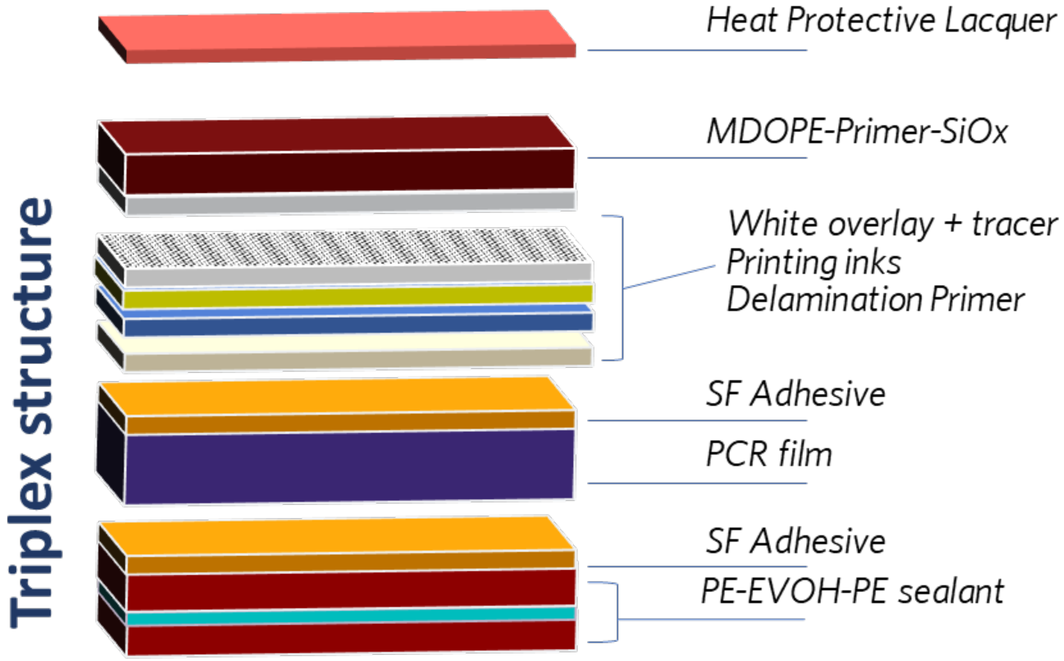
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

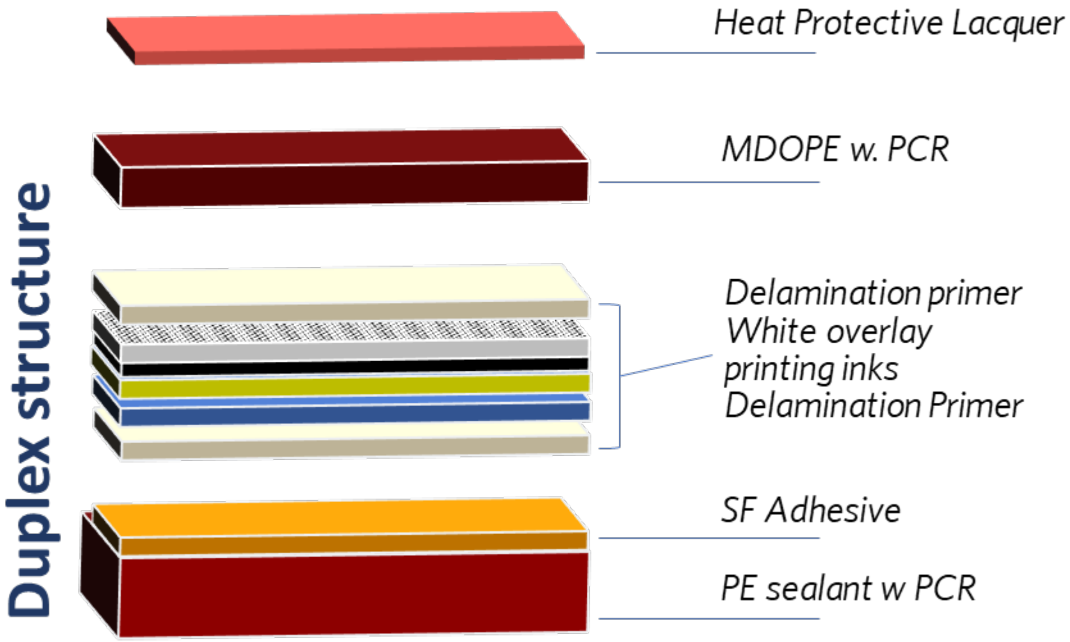
Objectives

- Ensure Functional Performance
  → *Maintain necessary packaging performance despite increased PCR content*
- Effectively Incorporate High PE PCR Levels and Maintain High Quality Control
- Incorporate Functional Barriers Safely
  → *Minimize risks of offset migration during lamination or coextrusion*
- Keep D4R compliance

Achievements

- Developped two building block structures to be finetuned to each packs performance requirements



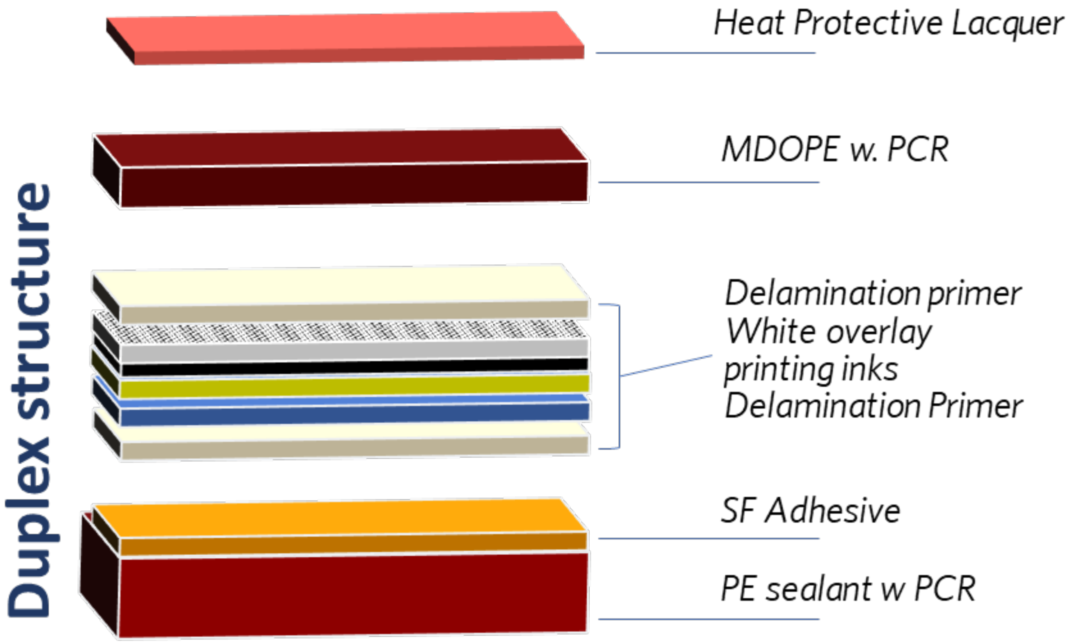


Achievements

- Developed two building block structures to be finetuned to each pack's performance requirements

NON-FOOD CONTACT APPLICATIONS

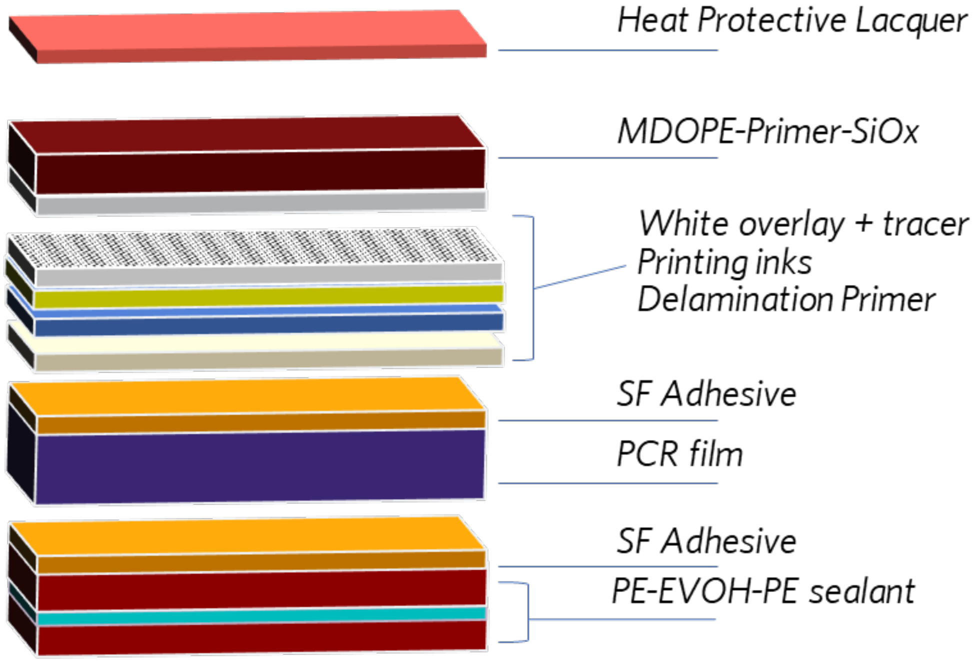
- Machine Direction Oriented PE PCR film augmenting overall PCR level of the structure
- PCR content ranging from 45m% - 62m% depending on pack performance requirements
- Delamination primer to ensure high purity PCR at pre-treatment level when reprocessing



Achievements

- Developped two building block structures to be finetuned to each packs performance requirements

Triplex structure

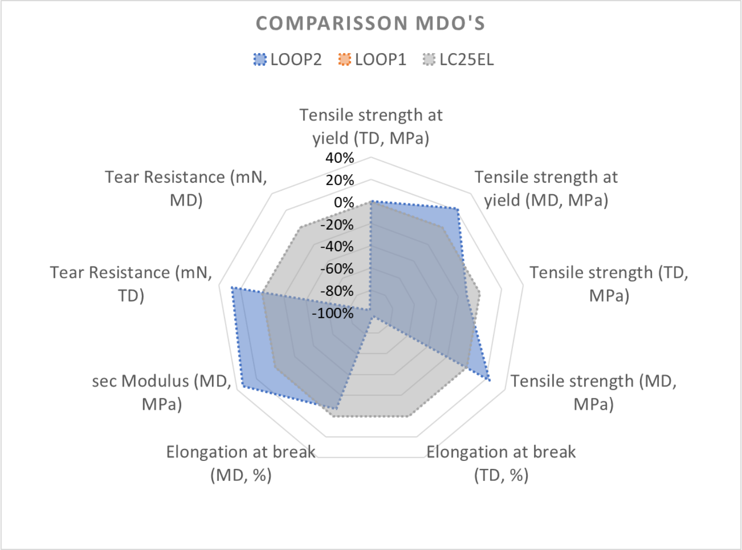


FOOD CONTACT APPLICATIONS

- Double functional barrier encasulating PCR layer
  - Functional barriers screened and tested via challenge testing (surrogate testing)
- PCR content ranging from 34m% - 50 m% depending on pack performance requirements
- Tracer based technology incorporated in ink formulation to enable closed loop recycling
- Delamination primer to ensure high purity PCR at pre-treatment level when reprocessing
- Triplex lamination to avoid offset migration
- HPL to ensure hermetic sealing on packaging line

Achievements

- Developed MDO film with 50 m%PCR to further increase the amount of PE PCR in a functional way
  - Mechanical performance on par with commercial MDOPE
  - Good transparancy, discoloration due to remaining pigments or masterbatch unavoidable



Achievements

- 6 demonstrators produced to showcase applicability and range of the developped building blocks

	Temperature °C (vertical and horizontal)			
PPM	120	110	100	90
60	0,003667			
50	0,004667	2,0925		
40		1,27725		

LOOP1 packaging trial: Hermetically sealed packs possible at highest pilot operating line speed

Results/Achievements

- ✓ Packaging trials on pilot machines (4 trials)
- ✓ Various formats, w and w/o product
- ✓ Hermeticity achieved
- ✓ Operating window determined

Video Production of Gusseted Bag Pouches (with 30% PCR) on Vertical Form Fill and Seal Packaging not included

Opportunities

- Upscaling the Creasolve process for a full industrial extrusion trial, focusing on converting MDO-PE PCR
  → *Upscaling the deodorization process for a full industrial extrusion trial*
- Investigation on how to avoid considerable cross-contamination during coextrusion and/or sequential lamination with PCR
- Design for recycling of wet chemistries applied (ink pigments, adhesives, lacquers)
- Optimize the conversion process using the SB delamination primer
- Further increasing the purity of PCR materials.

Thank you!

Margaux Joetzjer, *Margaux.Joetzjer@amcor.com*
Nicolas Mys, Nicolas.Mys@amcor.com

WEB www.circular-foodpack.eu

@CIRC_FoodPack

CIRCULAR FoodPack

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Economical and market aspects

Prof. Aggelos Tsakanikas, National Technical University of Athens

Final Event
"Circular Packaging for Direct Food Contact Applications"

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.

Market analysis and identification of stakeholders' preferences, acceptances and expectations

Industry key messages:

- Innovative approach including the whole value chain. **Scalable collection and sorting infrastructure crucial.**
- Processors at different levels of the value chain have shown interest in the packaging approach proposed by the Circular Food Pack.
- The new **regulatory landscape** is encouraging brand owners to adopt new standards, with PE PCR emerging as a viable option.

Market analysis and identification of stakeholders' preferences, acceptances and expectations

Consumer preferences:

- **Consumers are generally in favour of sustainable packaging**, such as the solution offered by Circular FoodPack, and prefer recycled materials.
- Consumer surveys have confirmed that the solution proposed by CIRCULAR FoodPack can be widely accepted by consumers once the introduction of the new material is **accompanied by appropriate communication.**
- Reduce the effort and complexity linked to recycling, **shift the burden of "correct behaviour" from the consumer-citizens to the industry and to the retail.**

3 Key Exploitable Technologies identified

KER No.1: Design 4 PCR: development of recyclable flexible laminates that are intended for food and non-food packaging.

KER No.2: Sorting and Physical recycling cascades: processing chain for sorting and recycling the packaging waste in order to produce high-quality PE recyclates (PE PCRs).

- Collection and sorting
- Pre-treatment (oversorting, shredding, washing, grinding and float-sink separation)
- Purification and recycling (CreaSolv® or mechanical recycling combined with deinking and delamination)
- Post-treatment (deodorization)

KER No.3: PCRs with certified quality: evaluation of the performance of the PCRs and the compliance with regulatory safety requirements, development of innovative and improved testing methods for evaluating the compatibility of recycled materials with food products, their safety when incorporated in food packaging, as well as their purity.

Technical Feasibility for production of: A. PE PCR, B. Laminates

Results / Achievements

- Market entry potential: an increased need for PE PCR at a competitive price
- Comparison to competitive technologies: significant benefits for solvent-based recycling and tracer-based sorting
- Both dissolution-based and water-based deinking technologies result in feasible business cases, giving competitive PE PCR costs to the virgin PE costs.

	Household waste with SoA sorting Dissolution-based recycling cascade	B2B waste Dissolution-based recycling cascade	B2B waste Water-based deinking, mechanical recycling	Household waste with SoA sorting and TBS
PE PCR cost compared to market price for virgin PE	**-3%**	**-24%**	**-16%**	**-8%**

- Purification and pre-treatment steps are the most expensive
- Packaging films containing PE PCR are economically feasible both for food and non-food applications, with a calculated price competitive to the current market price → ≈ 1.50 €/m^2

Lessons Learnt

- The processes that were introduced can lead to a PE PCR and laminates with competitive costs
- The processes economics could be improved by improving efficiency in purification and pre-treatment steps and integrating renewable energy sources.
- There is room for improvement (economies of scale, etc), in the various most “expensive“ steps that could benefit the final cost.

Thank you!

Prof. Aggelos Tsakanikas, *atsaka@central.ntua.gr*

WEB www.circular-foodpack.eu

@CIRC_FoodPack

CIRCULAR FoodPack

CIRCULAR FoodPack

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003806.