

# Interreg

France-Wallonie-Vlaanderen



UNION EUROPÉENNE  
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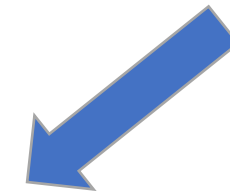
## PSYCHE

**Avec le soutien du Fonds européen de développement régional**  
Met steun van het Europees Fonds voor Regionale Ontwikkeling

# Pretreatment

Dr. Sibel Ügdüler, Prof. Steven De Meester, Prof. Kevin Van Geem and Prof. Juray De Wilde /  
8.12.2022

# Recycling of plastics?



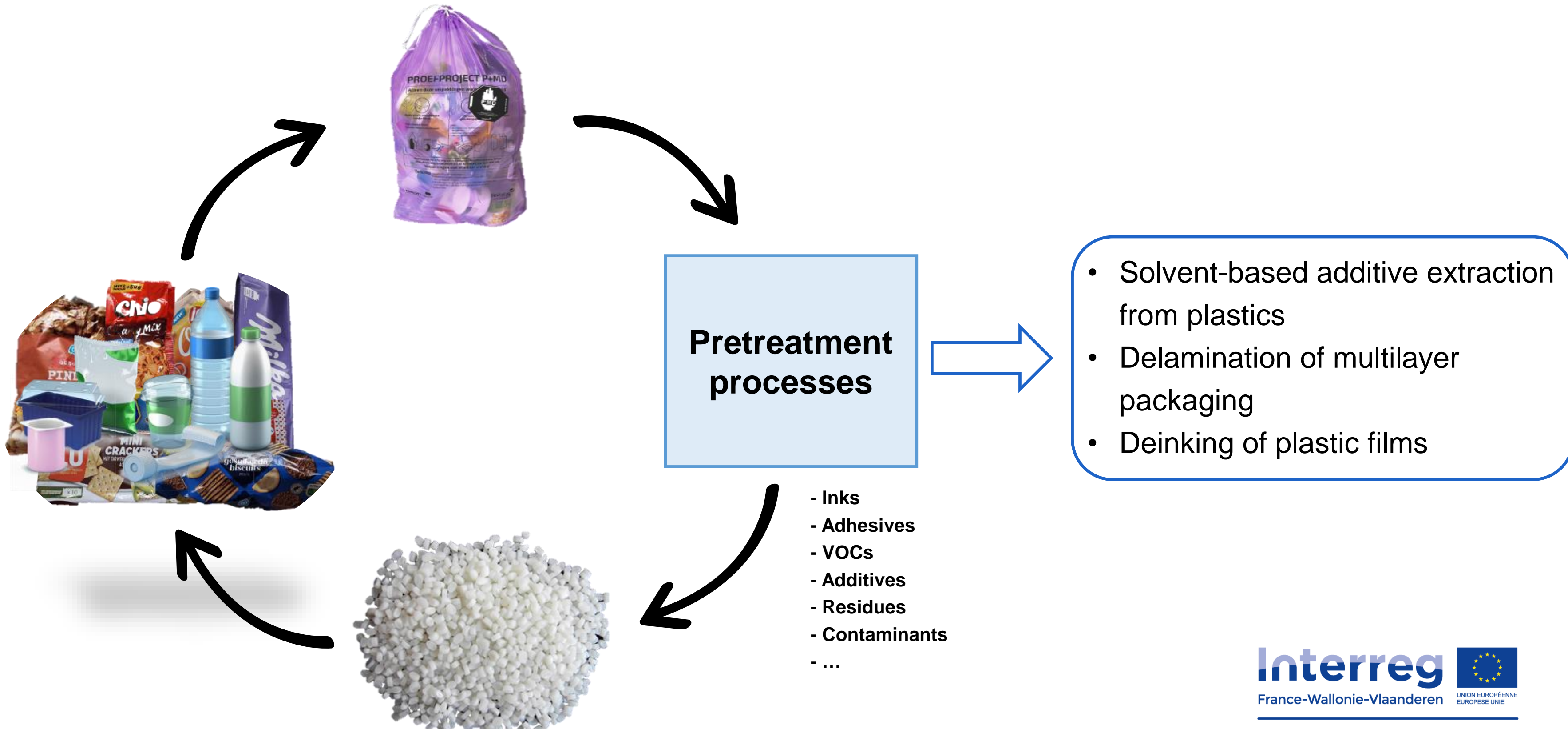




**PLASTICS ARE  
COMPLEX!**



# Towards closed-loop recycling



# Published papers on pretreatment of plastic waste

Waste Management 104 (2020) 148–182

Contents lists available at ScienceDirect

**Waste Management**

journal homepage: [www.elsevier.com/locate/wasman](http://www.elsevier.com/locate/wasman)

Challenges and opportunities of solvent-based additive extraction methods for plastic recycling

Sibel Ügdüler<sup>a</sup>, Kevin M. Van Geem<sup>b</sup>, Martijn Roosen<sup>a</sup>, Elisabeth I.P. Delbeke<sup>b</sup>, Steven De Meester<sup>a,\*</sup>

**Green Chemistry**

ROYAL SOCIETY OF CHEMISTRY

PAPER

View Article Online  
View Journal

Check for updates

Cite this: DOI: 10.1039/d0gc00894j

**Towards closed-loop recycling of multilayer and coloured PET plastic waste by alkaline hydrolysis†**

Sibel Ügdüler,<sup>a</sup> Kevin M. Van Geem,<sup>b</sup> Ruben Denolf,<sup>a</sup> Martijn Roosen,<sup>a</sup> Nicolas Mys,<sup>a,c</sup> Kim Ragaert<sup>c</sup> and Steven De Meester<sup>a,\*</sup>

ChemSusChem

Full Papers  
doi.org/10.1002/cssc.202002877

Chemistry Europe  
European Chemical Societies Publishing

**Towards a Better Understanding of Delamination of Multilayer Flexible Packaging Films by Carboxylic Acids**

Sibel Ügdüler,<sup>[a]</sup> Tobias De Somer,<sup>[a]</sup> Kevin M. Van Geem,<sup>[b]</sup> Martijn Roosen,<sup>[a]</sup> Andreas Kulawig,<sup>[c]</sup> Ralf Leineweber,<sup>[c]</sup> and Steven De Meester<sup>\*,[a]</sup>

Contents lists available at ScienceDirect

**Science of the Total Environment**

journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)

Deodorization of post-consumer plastic waste fractions: A comparison of different washing media

Martijn Roosen<sup>a</sup>, Lies Harinck<sup>a</sup>, Sibel Ügdüler<sup>a,b</sup>, Tobias De Somer<sup>a,b</sup>, Amaury-Gauvain Hucks<sup>a</sup>, Tiago G.A. Belé<sup>c</sup>, Andrea Buettner<sup>c,d</sup>, Kim Ragaert<sup>e</sup>, Kevin M. Van Geem<sup>b</sup>, Ann Dumoulin<sup>a</sup>, Steven De Meester<sup>a,\*</sup>

## Chapter

## Recent Advances in Pre-Treatment of Plastic Packaging Waste

Rita Kol, Martijn Roosen, Sibel Ügdüler, Kevin M. Van Geem, Kim Ragaert, Dimitris S. Achilias and Steven De Meester

Contents lists available at ScienceDirect

**Waste Management**

journal homepage: [www.elsevier.com/locate/wasman](http://www.elsevier.com/locate/wasman)

Towards a better understanding of odor removal from post-consumer plastic film waste: A kinetic study on deodorization efficiencies with different washing media

Martijn Roosen<sup>a</sup>, Tobias De Somer<sup>a,b</sup>, Ruben Demets<sup>a,c</sup>, Sibel Ügdüler<sup>a</sup>, Valérie Meesseman<sup>a,d</sup>, Bart Van Gorp<sup>e</sup>, Kim Ragaert<sup>c</sup>, Kevin M. Van Geem<sup>b</sup>, Christophe Walgraeve<sup>f</sup>, Ann Dumoulin<sup>a</sup>, Steven De Meester<sup>a,\*</sup>

Contents lists available at ScienceDirect

**Resources, Conservation & Recycling**

journal homepage: [www.elsevier.com/locate/resconrec](http://www.elsevier.com/locate/resconrec)

Full length article

**Analysis of the kinetics, energy balance and carbon footprint of the delamination of multilayer flexible packaging films via carboxylic acids**

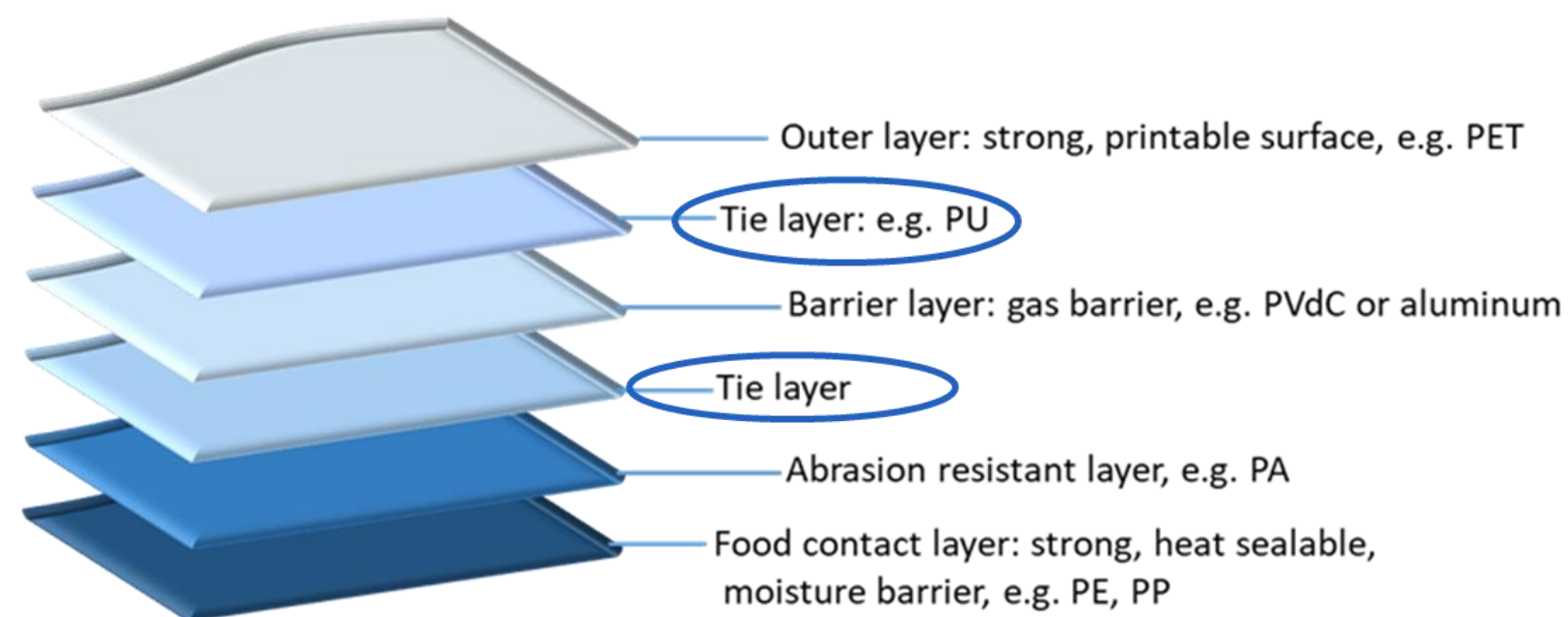
Sibel Ügdüler<sup>a</sup>, Tobias De Somer<sup>a</sup>, Kevin M. Van Geem<sup>b</sup>, Juray De Wilde<sup>c</sup>, Martijn Roosen<sup>a</sup>, Bram Deprez<sup>a</sup>, Steven De Meester<sup>a,\*</sup>



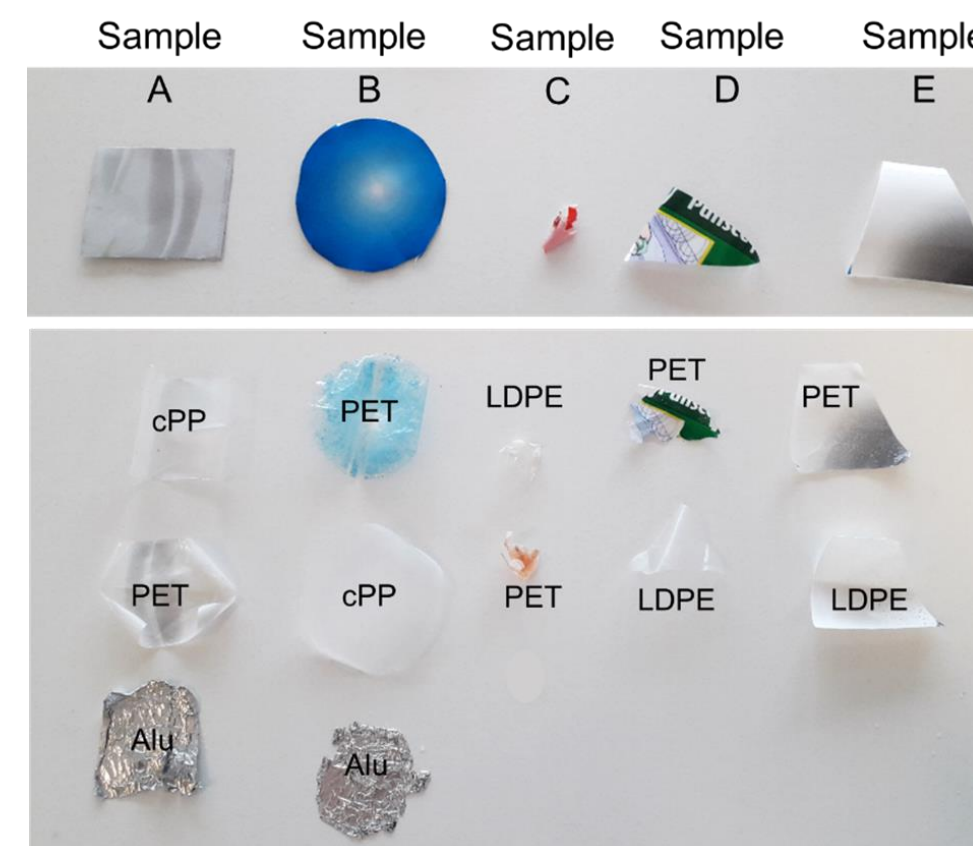
# Delamination of multilayer flexible packaging

- 35 kg plastic packaging per inhabitant (2019)
- Less than 20% recycling (Plastics Europe)
- European target of 55% plastic packaging recycling by 2030

## ❖ Delamination through dissolution of tie layers

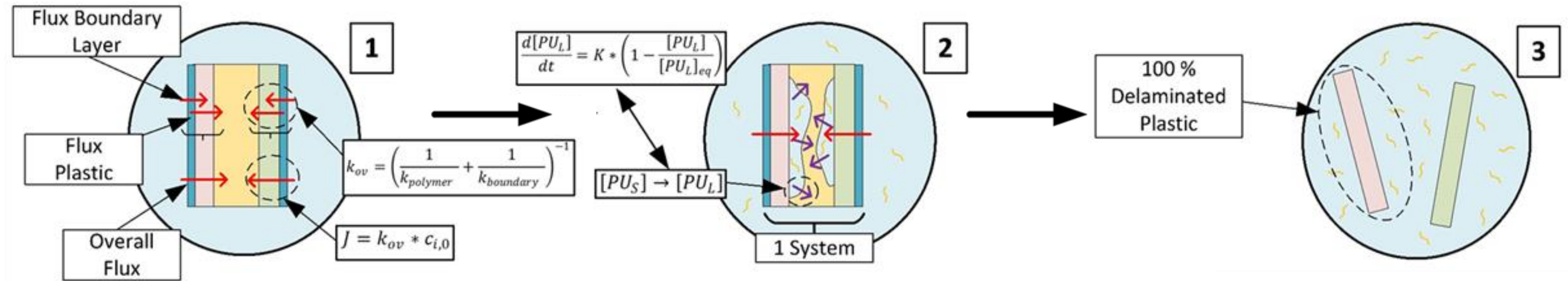


- Recovery of polymer layers without any dissolution/degradation
- Lower amount of reagent
- Dissolution of broader range of tie layers with carboxylic acids



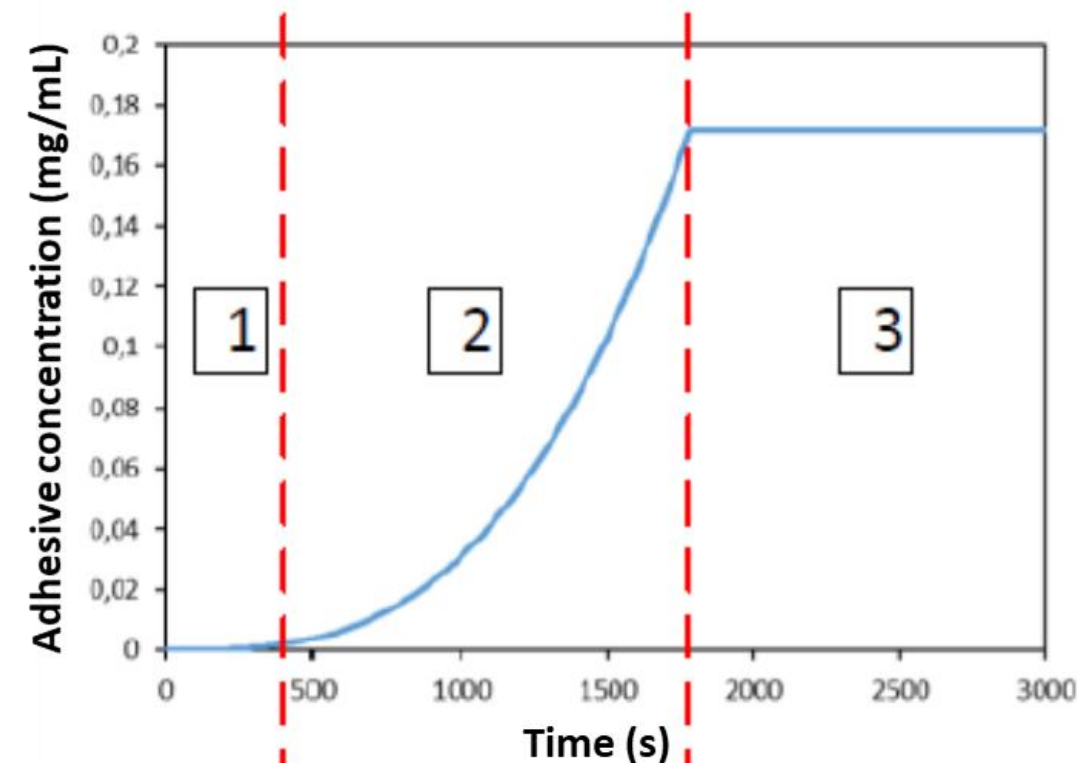
# Delamination of multilayer plastic films

- ❑ Fundamental model was developed based on Fick's first law of diffusion and first-order dissolution kinetics of PU adhesives



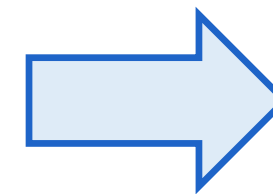
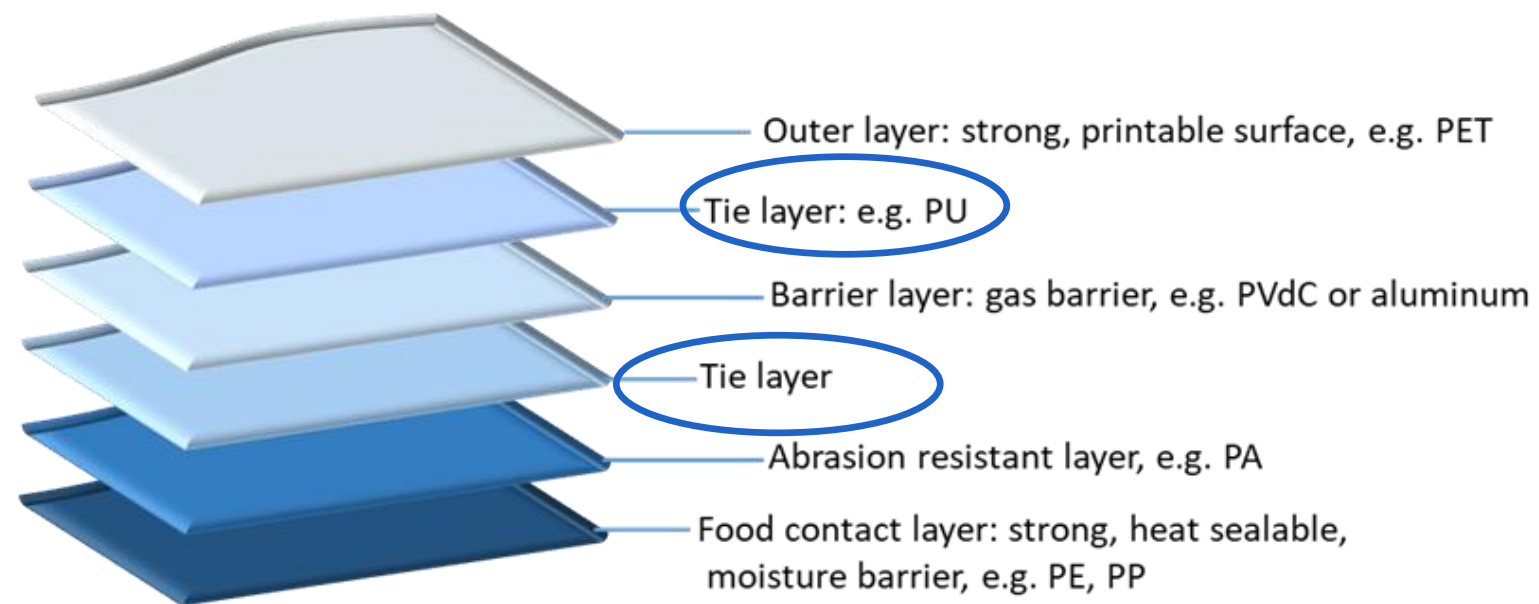
- Legend**
- Boundary layer
  - Plastic 1
  - Plastic 2
  - Adhesive
  - Alu
  - Acid
  - → Diffusion process
  - → Dissolution process
  - Dissolved PU

These figures illustrate the delamination process, the thickness of the various layers does not correspond to reality.





# Delamination of multilayer flexible packagings



Delamination of multilayers by dissolution of tie layers with formic acid

Optimization of delamination conditions

Recovery of the medium

Life cycle assessment



Kinetic studies based on CCI:

- Temperature
- Stirring rate
- Solid/liquid ratio
- Particle size



ASPEN model for mass and energy balance



Carbon footprint of the delamination process for two different multilayer structures

# Printed plastic films

- The composition of inks



## **Solvent 50-70%**

- Dissolve resins
- Keep ink liquid to support ink transfer
- Viscosity control
- Drying speed



## **Resins 20-30%**

- Binder for pigment stabilization
- Film former



## **Pigments 6-30%**

- Color



## **Additives 1-10%**

- Improving specific properties like adhesion, slip, scratch resistance, etc.

- ☐ Various types of polymer resins depending on the application
- ☐ Different synthesis routes
  - ☐ Water-based
  - ☐ Solvent-based
  - ☐ Oil-based
  - ☐ UV-based
- ☐ Presence of coatings, lacquers



# Deinking of printed plastic films

Chips pack.

Bread pack

Beverage pack.

Detergent pack.

Pampers

Fish pack.

Cheese pack.

Chips pack.

Bread pack

Beverage pack.

Detergent pack.








Pampers

Fish pack.

Candy pack.

Toothpaste pack.

Cheese pack.



Original samples

Trial 1

Trial 2

Trial 3

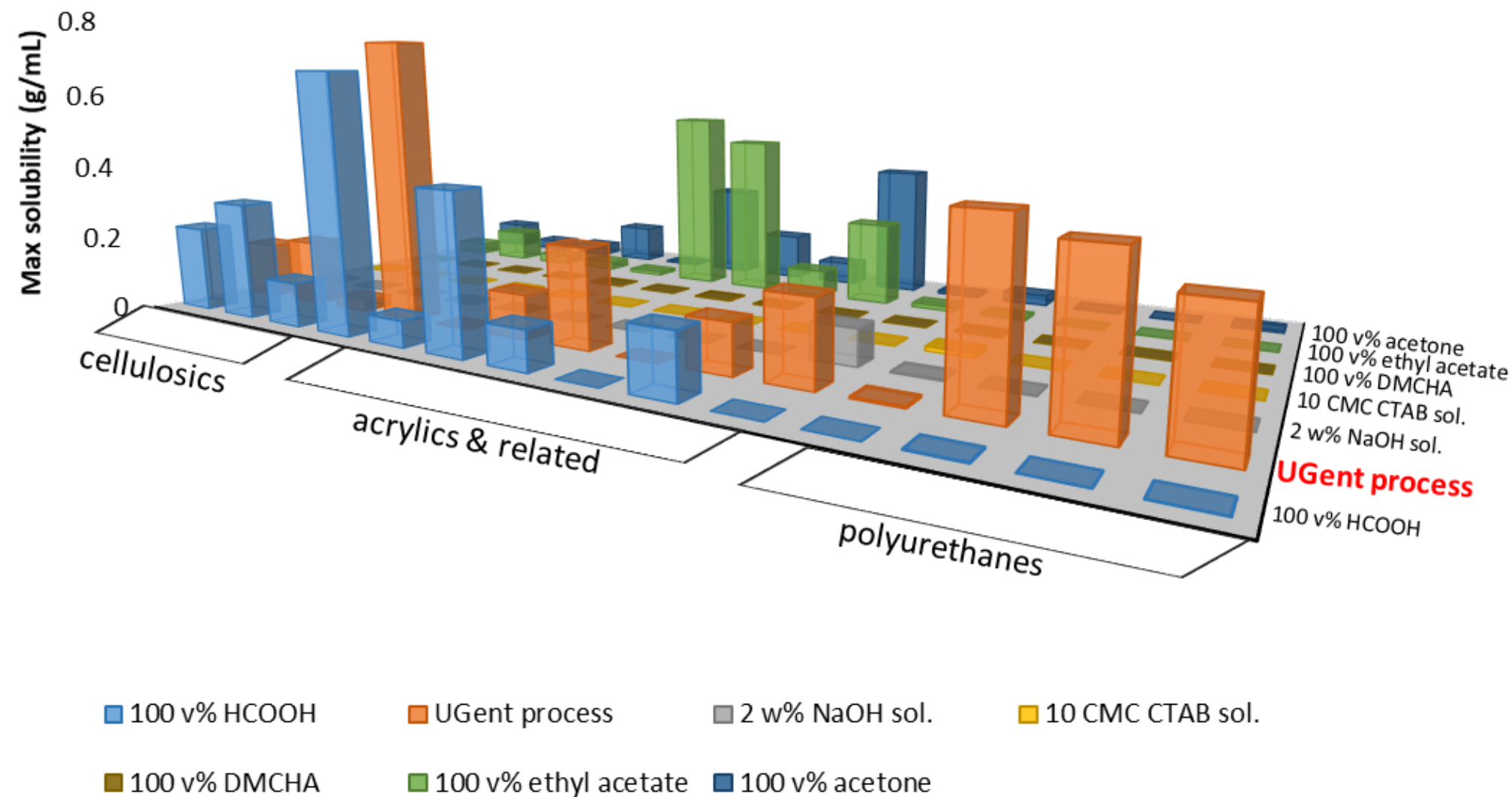
Trial 4

Trial 5

UGent process

# Comparison of maximum solubility

- Max solubility of each polymer resin in different medium, at RT



We aim:

- To understand and improve delamination procedures
- To gain knowledge on which polymer resins are more suitable to obtain more efficient deinking/delamination process
- To improve design for recycling

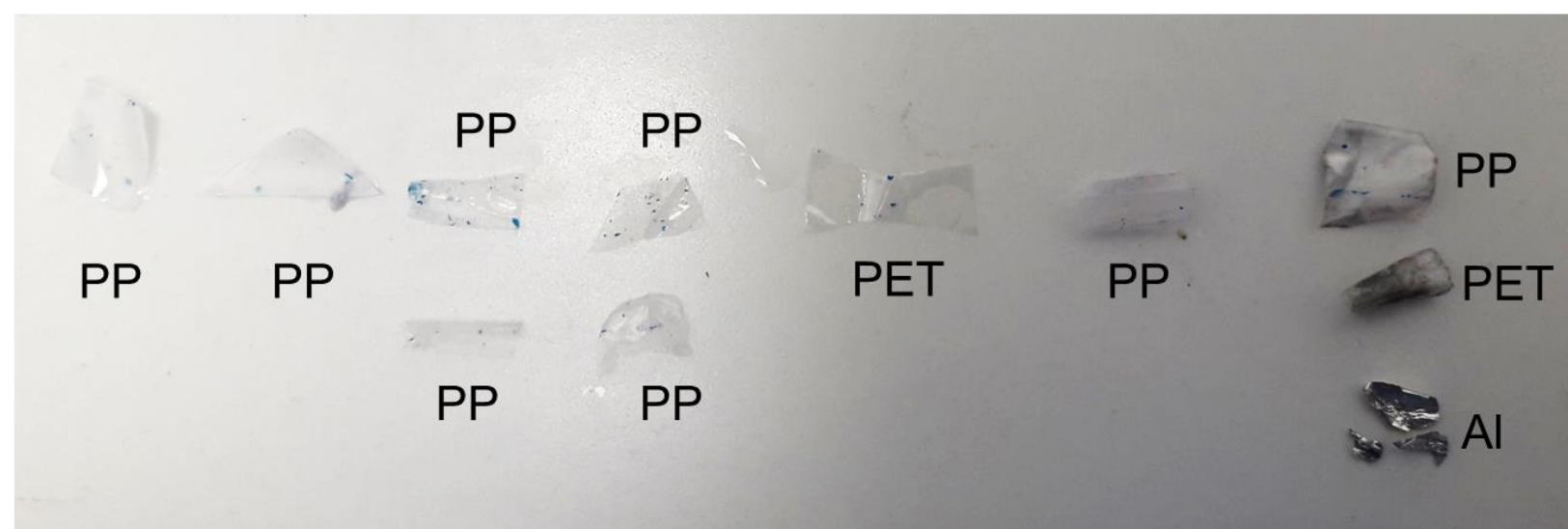
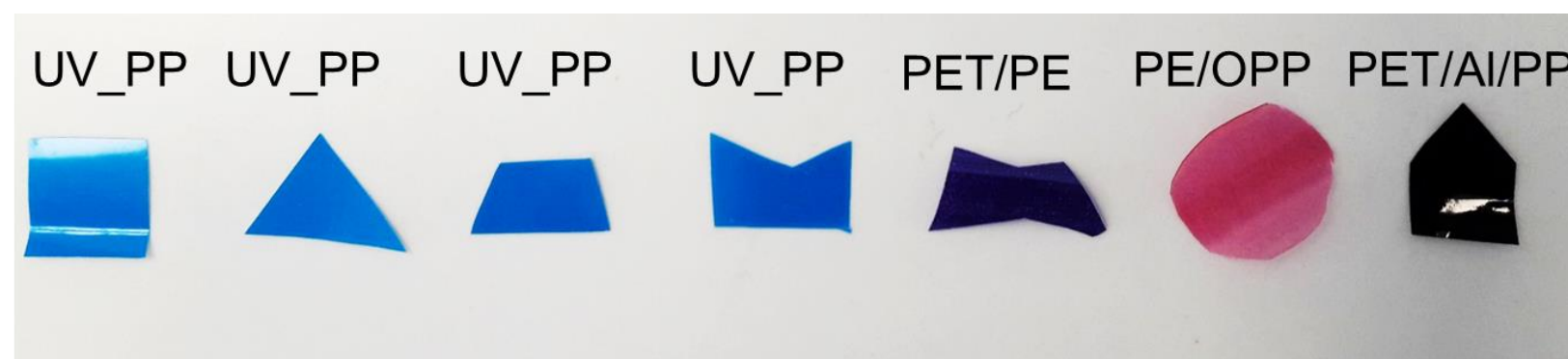
CTAB: Cetrimonium bromide  
DMCHA: N,N-dimethylcyclohexylamine



# Deinking

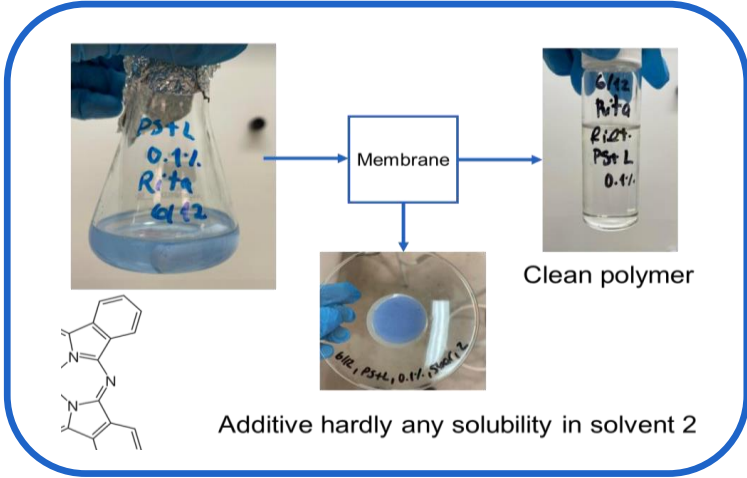
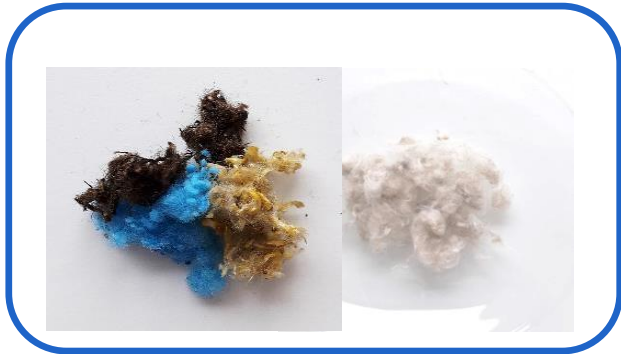
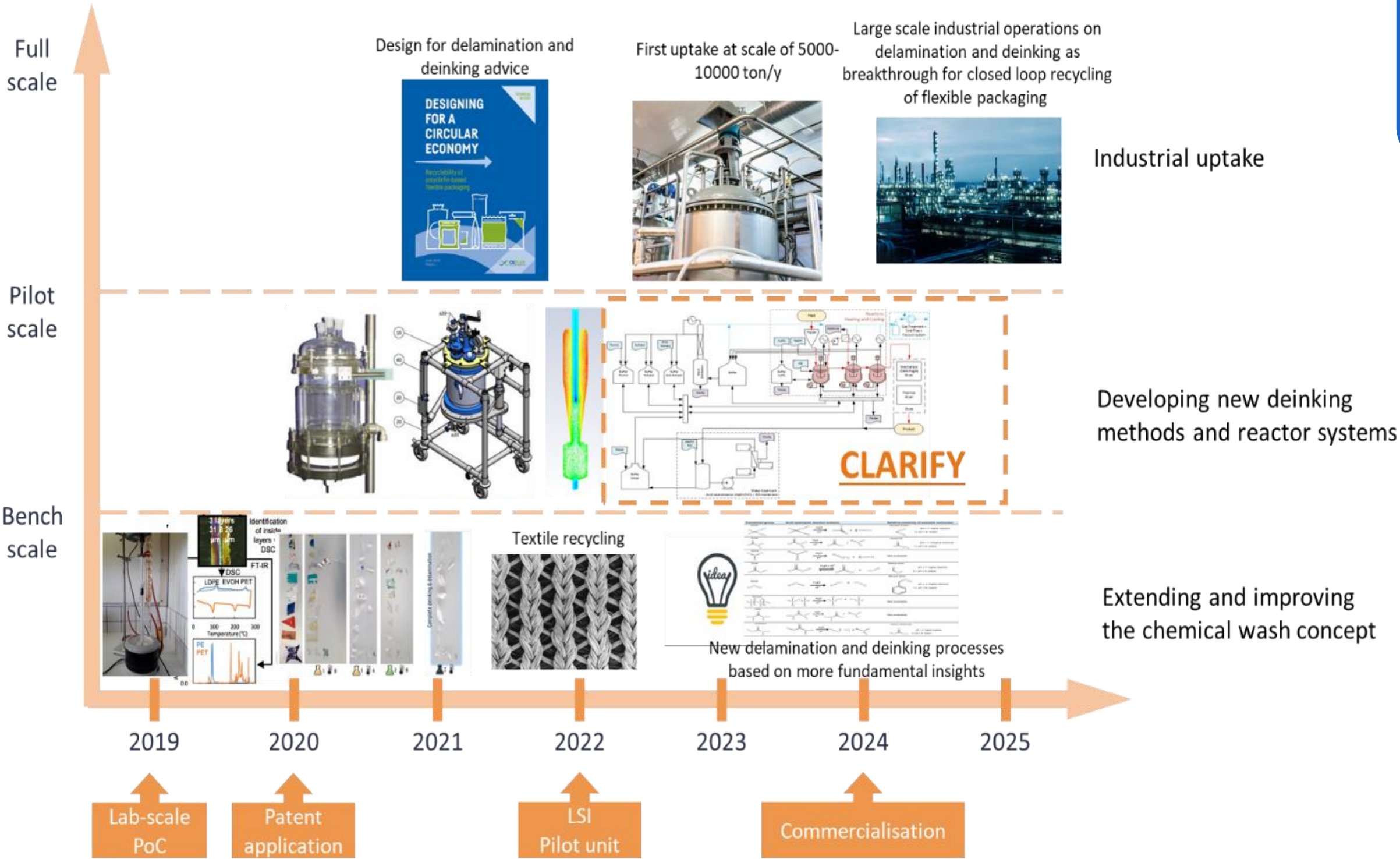
## ❑ New deinking route (patent is filed)

- Single step delamination and deinking of plastic packagings
- Removal of different types of inks, including UV-based inks
- Single reagent
- Recovery of polyolefins and heteropolymers e.g. PET





# Pilot plant





# Acknowledgements



**PSYCHE**



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Met steun van het Europees Fonds voor Regionale Ontwikkeling



# THANK YOU FOR YOUR ATTENTION!

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