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LCPE Laboratory for Circular Process Engineering

THE POTENTIAL OF SOLVENT-BASED RECYCLING TO ACHIEVE CLEAN RECYCLED POLYMERS

Rita Kol - CAPTURE Event – 24th August 2022

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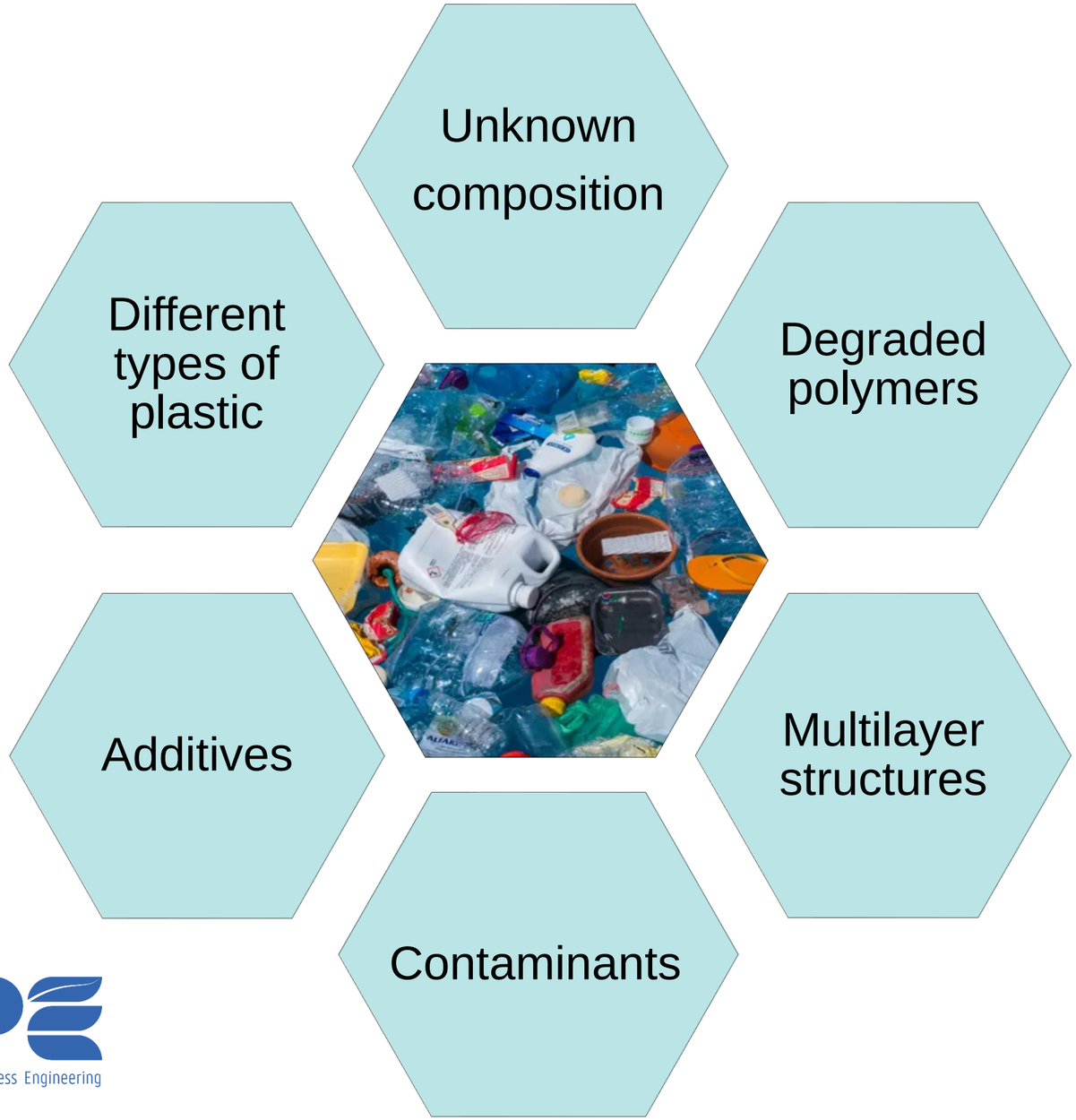
ARISTOTLE UNIVERSITY OF THESSALONIKI

C-PlaNeT CIRCULAR PLASTICS NETWORK FOR TRAINING

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 859885

CHALLENGES IN PLASTIC RECYCLING



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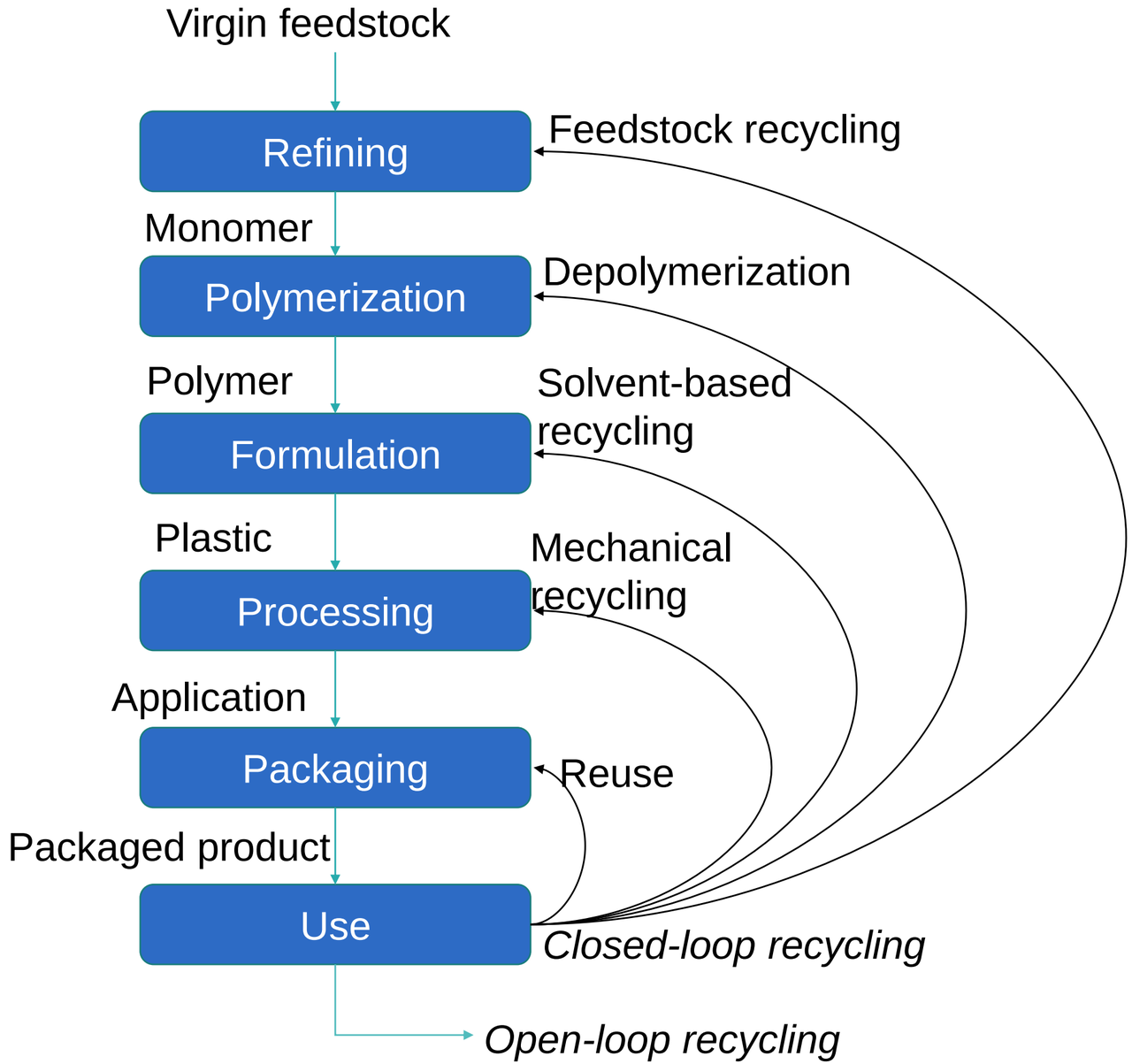
SOLVENT-BASED RECYCLING

Solvent-based recycling (physical recycling):

Composition of the polymer is not changed ≠ chemical recycling



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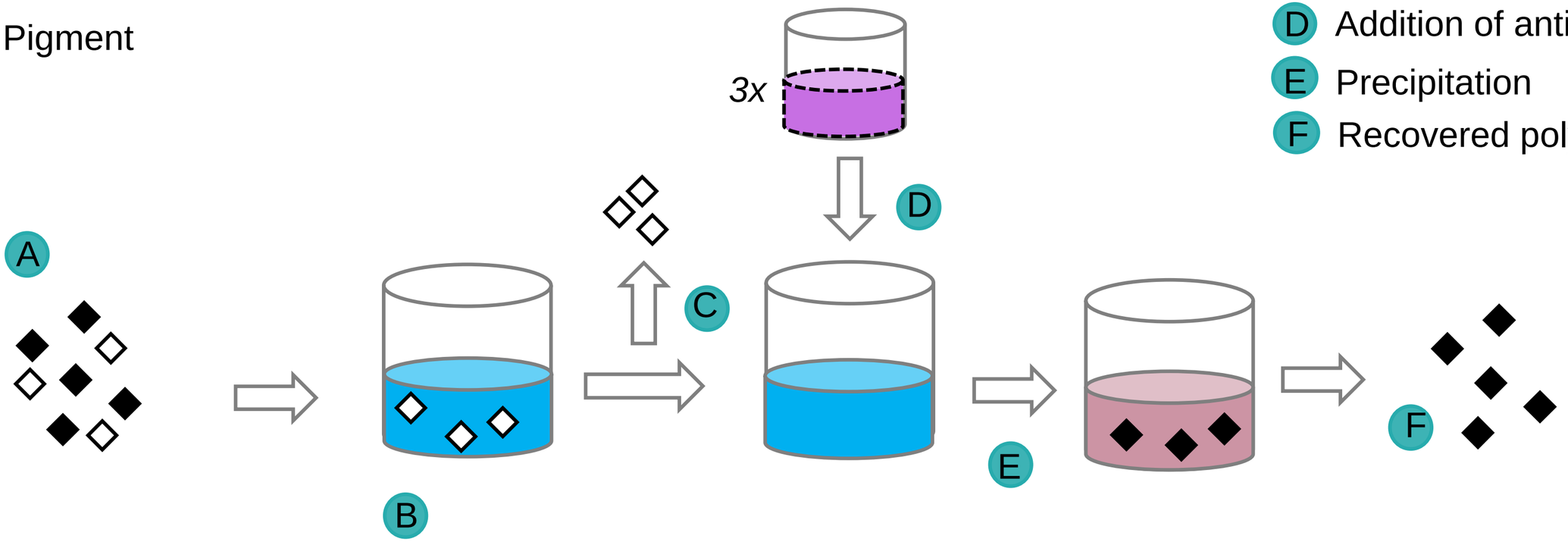
DISSOLUTION-PRECIPITATION TECHNIQUE

Solvent
Antisolvent
Polymer
Pigment

A Colored plastic
B Dissolution
C Filtration/Centrifugation
D Addition of antisolvent
E Precipitation
F Recovered polymer



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SELECTIVE DISSOLUTION

Separation of different polymers

- ❑ Changing solvents
- ❑ Temperature
  - Xylene @25°C for PS
  - Xylene @85°C for LDPE
  - Xylene @150°C for HDPE

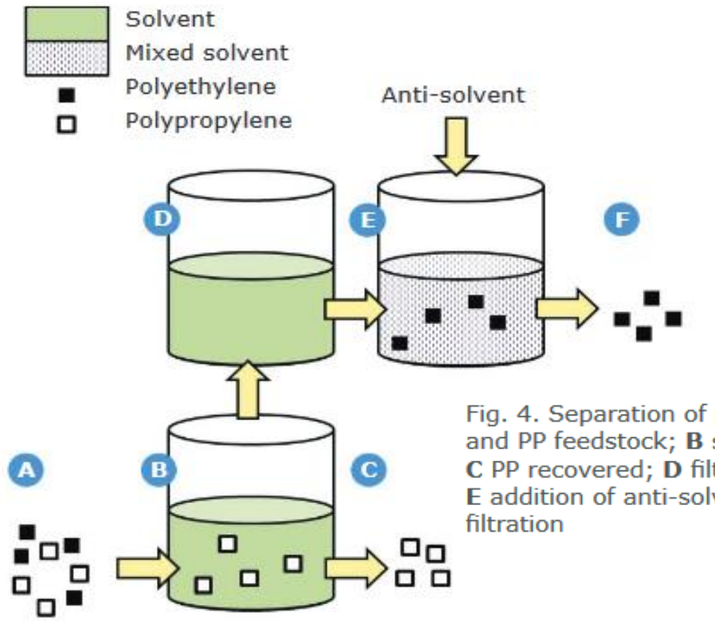

Fig. 4. Separation of polyolefins; **A** mixed PE and PP feedstock; **B** selective dissolution of PE; **C** PP recovered; **D** filtration to give a PE solution; **E** addition of anti-solvent; **F** isolation of PE by filtration

Figure from J. Sherwood (2020) Closed-loop recycling of polymers using solvents. Johnson Matthey Technology Review. pp. 4-15

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OVERVIEW OF (OPERATIONAL) PLANTS

Technology	Principle	Current state and capacity	Current application	Source
VinyLoop® & Texyloop®	Dissolution and precipitation of flexible PVC	Italy: pilot scale at 10.000 tons/year (closed in 2018)	Recycling of flexible PVC.	(VinylPlus)
Polyloop®	Dissolution and precipitation of PVC	Mobile (container) solution, treating 300 kg in 3h intervals	Recycling of PVC composite materials, continuing from Texyloop®	(Polyloop, 2020), (Ferrari, 2021)
CreaSolv® Technology, PolyStyreneLoop	Dissolution and precipitation of EPS	The Netherlands: capacity of 3300 tons/year	Removal of banned, legacy flame retardant HBCDD.	(Polystyreneloop, 2022)
CreaSolv® Technology, Lober	Dissolution and precipitation of PE and PP from multilayer laminates	Germany: pilot scale at 5 m^3 per day, with 15x industrial up-scaling in a second phase	Separation of multilayer laminates	(CreaCycle, 2018)
PureCycle Technologies℠, P&G	Dissolution and precipitation of PP	The United States: industrial-scale demonstration plant at 119 million pounds (≈ 54.000 tons) per year by 2021	Removal of colour, odour and other contaminants.	(PureCycle Technologies, 2019)
Newcycling®, APK AG	Dissolution and precipitation of PE multilayer films	Germany: pilot scale at 8.000 tons/year	Separation of multilayer films (PE/PA). Additional separation of PP, PET, PS, PLA and aluminium fractions possible.	(Niaounakis, 2020), (Wohnig, 2018), (Coker, 2019)

DISSOLUTION-PRECIPITATION TECHNIQUE

Economical balance: amount of solvent

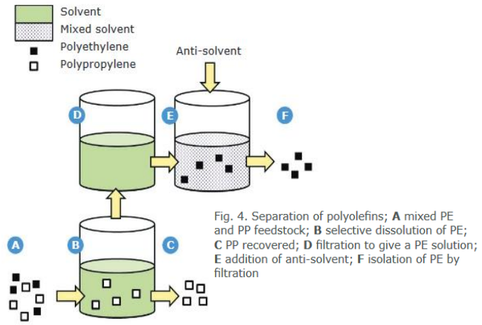

Fig. 4. Separation of polyolefins; **A** mixed PE and PP feedstock; **B** selective dissolution of PE; **C** PP recovered; **D** filtration to give a PE solution; **E** addition of anti-solvent; **F** isolation of PE by filtration

High amounts of solvents

- ✓ Less viscous solutions
- ✗ High amount of antisolvent (typical ratio: 3:1)
- ✗ Higher costs (e.g. S/AS treatment)

Low amounts of solvents

- ✓ Low amount of antisolvent
- ✓ Lower costs (e.g. S/AS treatment)
- ✗ More viscous solutions

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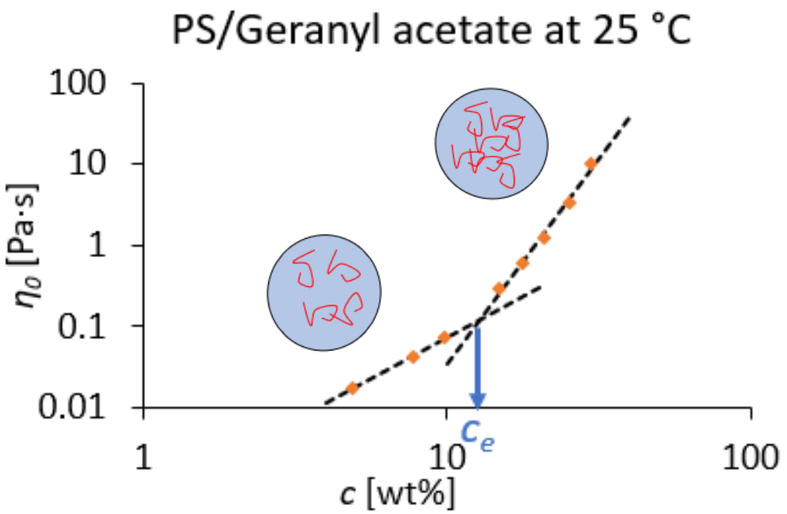
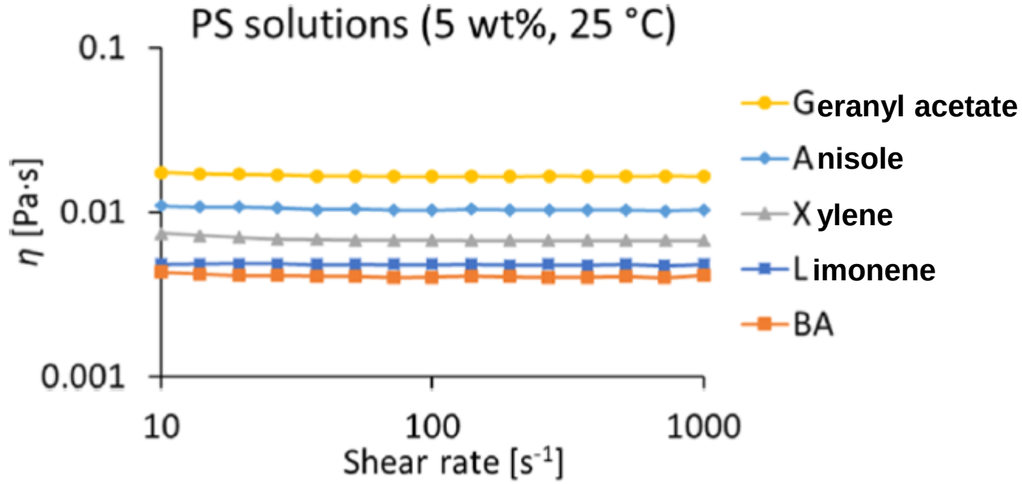
CONCENTRATION RANGE

Literature: 5 – 20 wt%

Experimental results: c_e = 13 – 15 wt%





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c_e – entanglement concentration

I&EC research
Industrial & Engineering Chemistry Research
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Article

Toward More Universal Prediction of Polymer Solution Viscosity for Solvent-Based Recycling

Rita Kol, Pieter Nachtergaele, Tobias De Somer, Dagmar R. D'hooge, Dimitris S. Achilias, and Steven De Meester*

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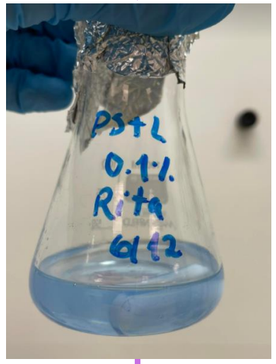
REMOVAL OF COLOURANTS FROM PLASTIC WASTE

MUSHROOM TRAYS

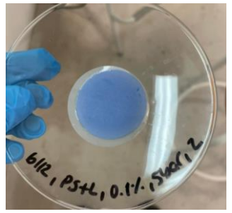
Dissolution

Food-contacting packaging (polystyrene)



Antisolvent + Recovery of polymer

Pressurized filtration set-up



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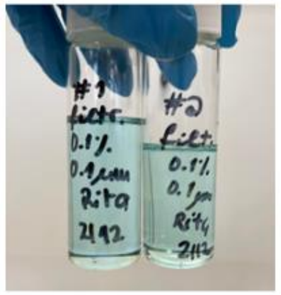
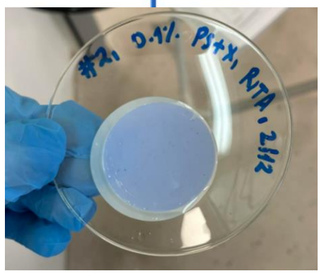
SOLVENT INFLUENCE

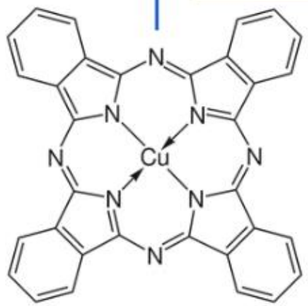
Membrane



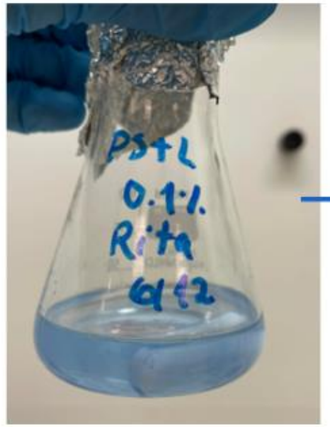
Remaining pigment



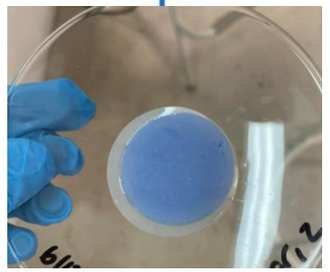
Additive some solubility in xylene



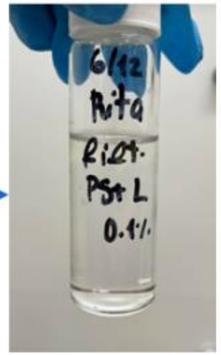
Pigment blue 15:3



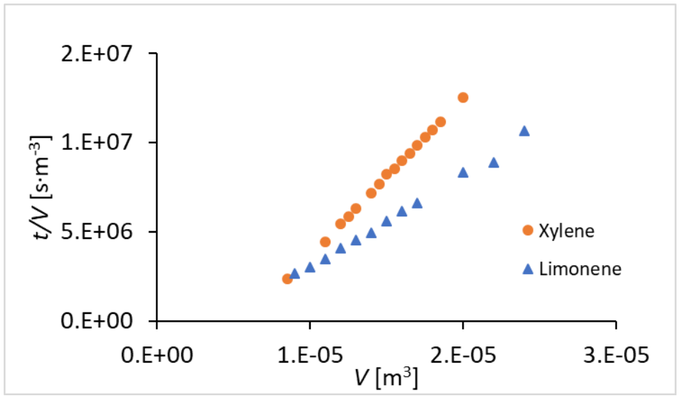
Membrane

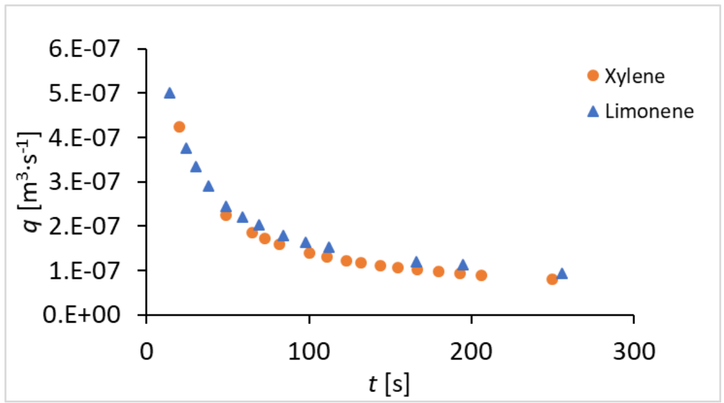


Additive hardly any solubility in limonene



Clean polymer

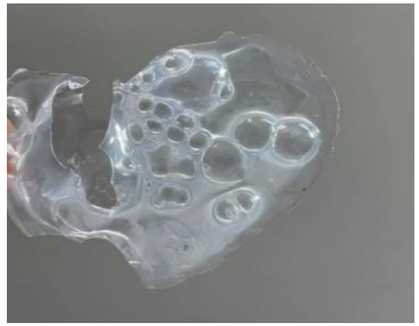




POLYMER RECOVERY

Addition of antisolvent

Method 1



Brittle film

Method 2

Powder

- AS/S ratio
- AS/S combination
- Temperature
- Solid-liquid separation process

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CONCLUSIONS & NEXT STEPS

- Solvent-based recycling promising route for plastic recycling.
- Solvent choice plays an important role.
- Currently: optimizing a process for the removal of colourants from plastic waste.
- Assess polymer properties.
- Work with other polymers.

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Chapter Intechopen, 2021

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

ChemSusChem
Chemistry–Sustainability–Energy–Materials

Chemistry Europe
European Chemical Societies Publishing

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State-Of-The-Art Quantification of Polymer Solution Viscosity for Plastic Waste Recycling

Rita Kol, Tobias De Somer, Prof. Dagmar R. D'hooge, Fabian Knappich, Prof. Kim Ragaert, Prof. Dimitris S. Achilias, Prof. Steven De Meester

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