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SOLVENT-BASED TECHNIQUES FOR RECYCLING OF PLASTICS

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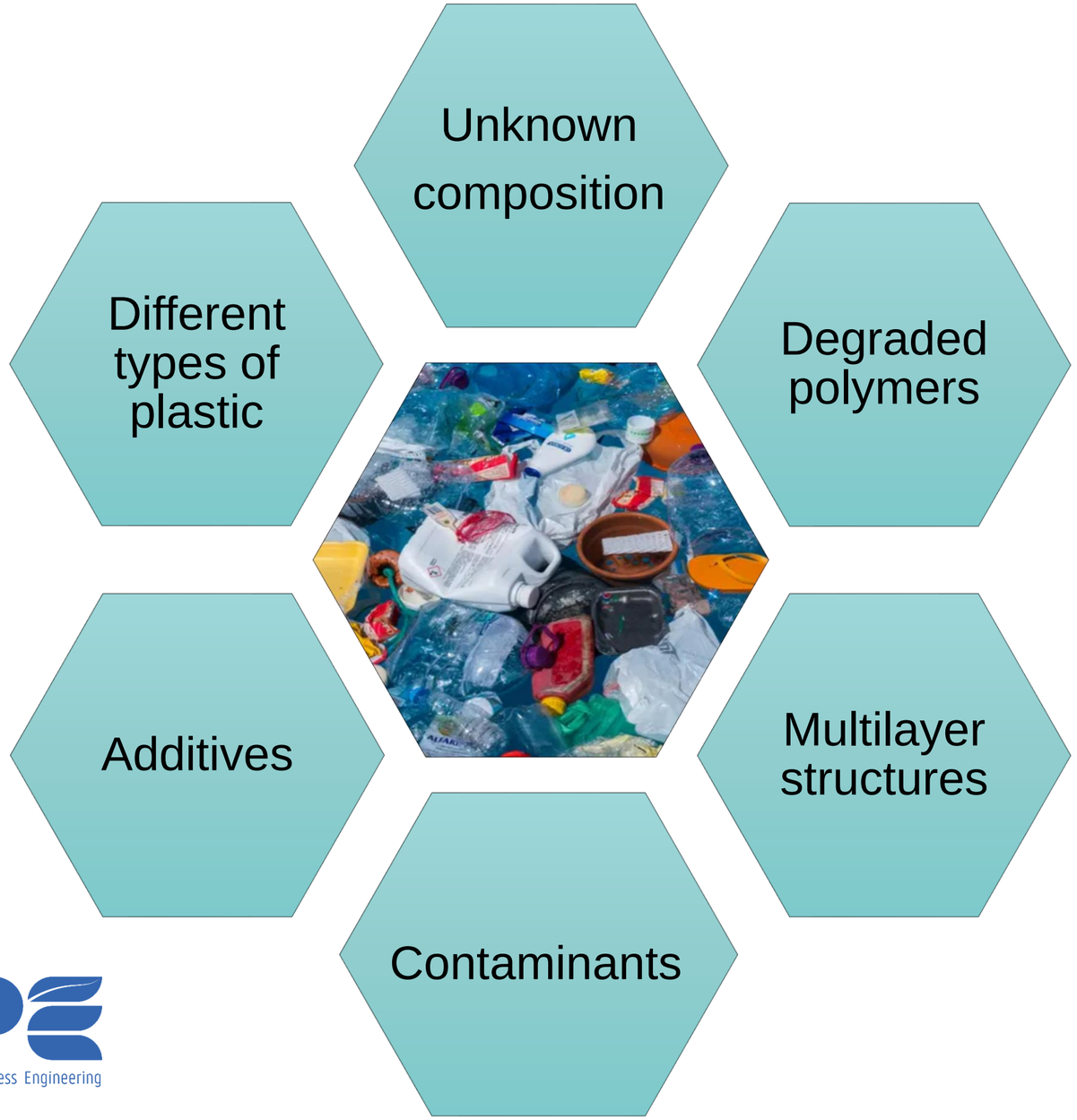
CHALLENGES IN PLASTIC RECYCLING



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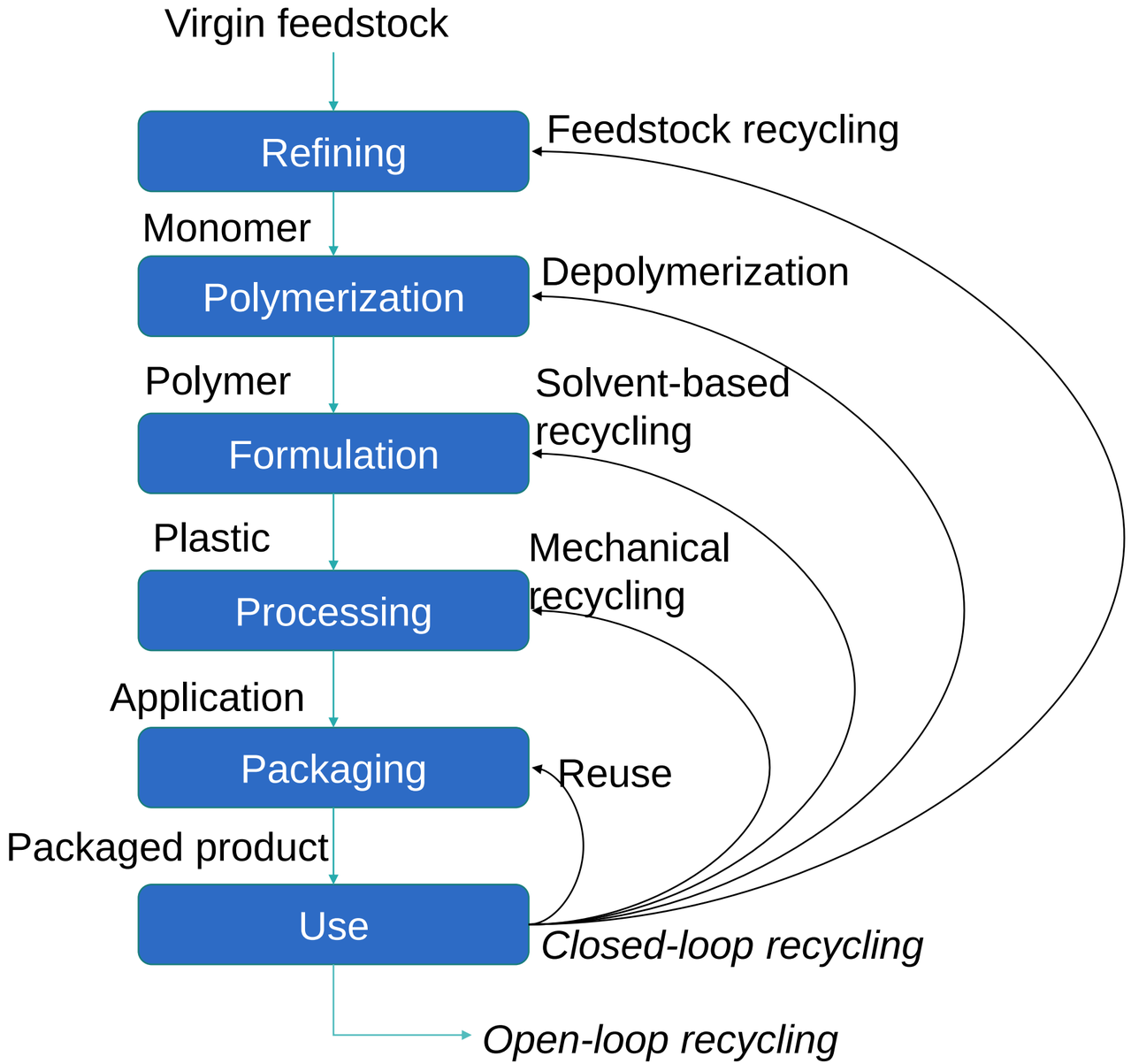
SOLVENT-BASED RECYCLING

Solvent-based recycling (physical recycling):

Composition of the polymer is not changed ≠ chemical recycling



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SOLVENT-BASED TECHNIQUES

Solid-liquid extraction

- Shake-flask
- Soxhlet

- Low investment
- Time, solvent consuming

- Ultrasonic extraction
- Microwave assisted extraction
- Supercritical fluids extraction
- Accelerated solvent extraction

- Reduced solvent usage
- Shorter extraction times
- High investment

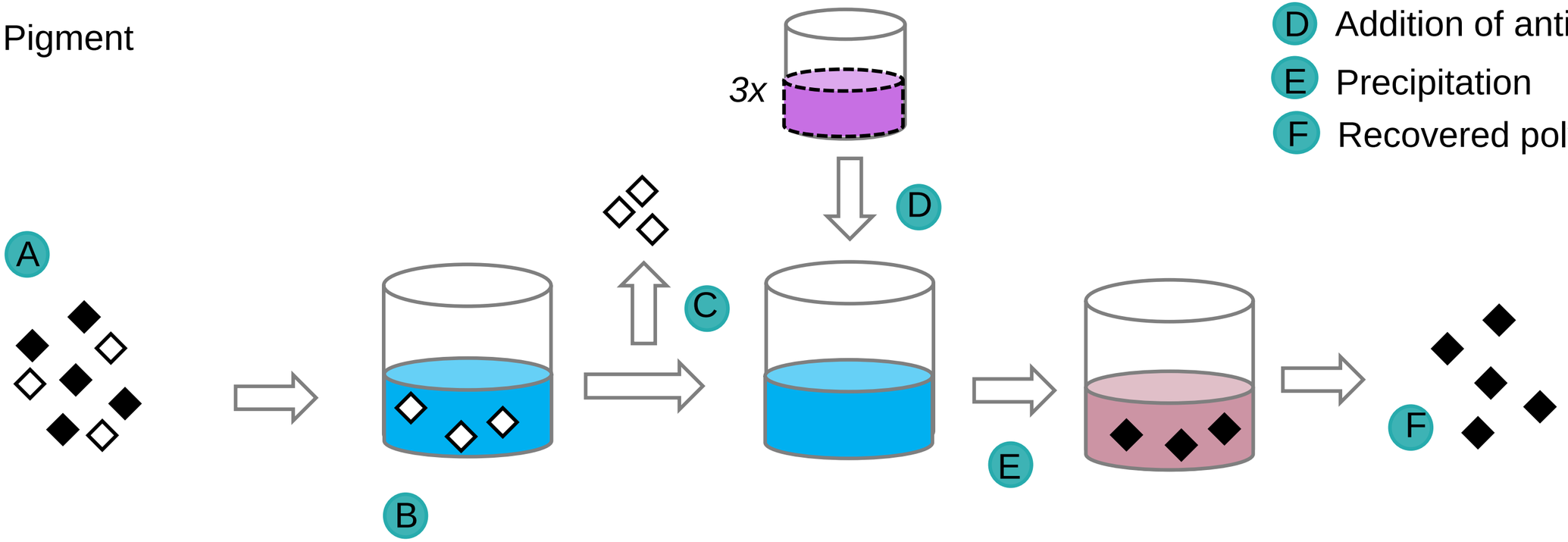
Dissolution-precipitation

CreaSolv® (PE,PP multilayer)
Newcycling® (PE multilayer)
PureCycle Technologies℠ (PP)
Polyloop® (PVC)

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

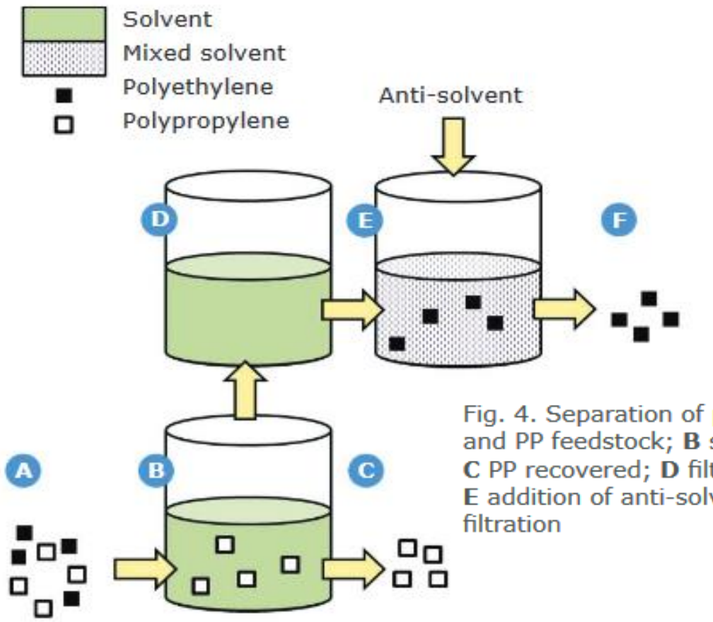

Fig. 4. Separation of polyolefins; **A** mixed PE and PP feedstock; **B** selective dissolution of PE; **C** PP recovered; **D** filtration to give a PE solution; **E** addition of anti-solvent; **F** isolation of PE by filtration

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

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DISSOLUTION-PRECIPITATION TECHNIQUE

Economical balance: amount of solvent

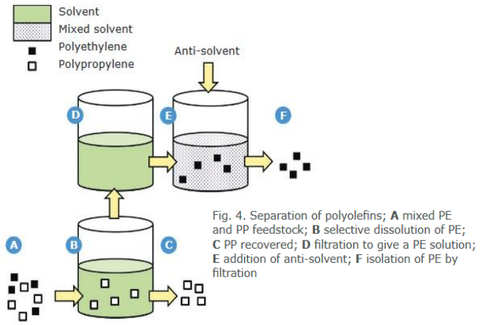

Fig. 4. Separation of polyolefins; **A** mixed PE and PP feedstock; **B** selective dissolution of PE; **C** PP recovered; **D** filtration to give a PE solution; **E** addition of anti-solvent; **F** isolation of PE by filtration

Diluted solutions

✓ Less viscous solutions

✗ High amount of antisolvent (typical ratio: 3:1)
Higher costs (also for S/AS treatment)
Lower polymer output

Concentrated solutions

✓ Low amount of antisolvent
Higher polymer output

✗ More viscous solutions

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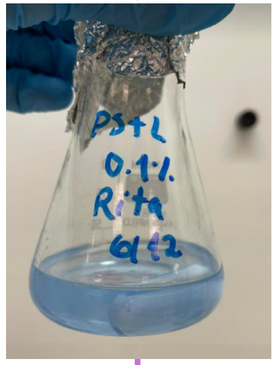
DISSOLUTION OF MUSHROOM TRAY

Dissolution

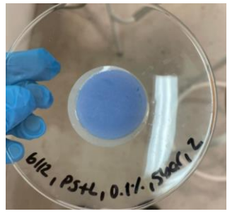
Food-contacting packaging (polystyrene)



Antisolvent + Recovery of polymer

Pressurized filtration set-up

Dead-end configuration



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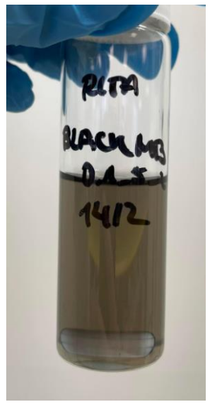
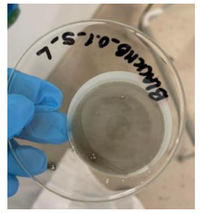
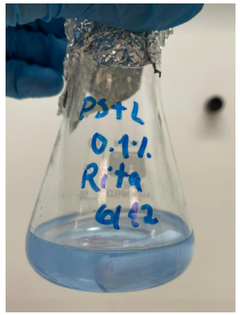
BLUE VS BLACK MUSHROOM TRAY



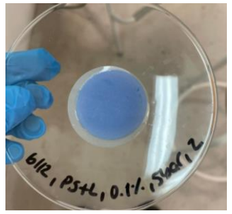
Membrane



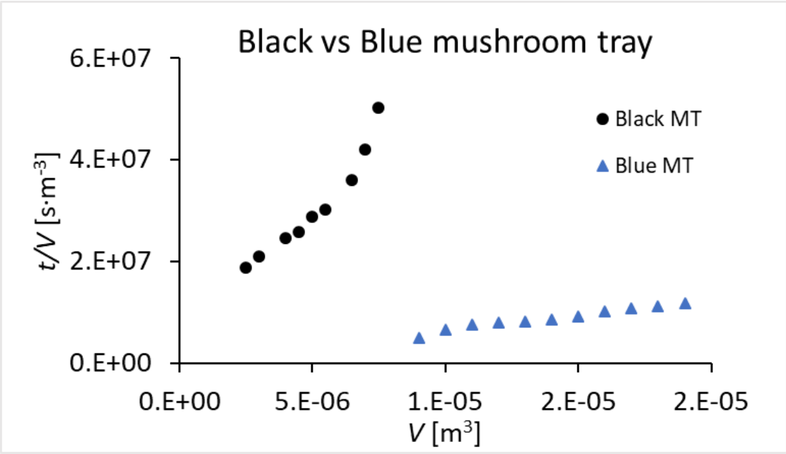
96% turbidity reduction

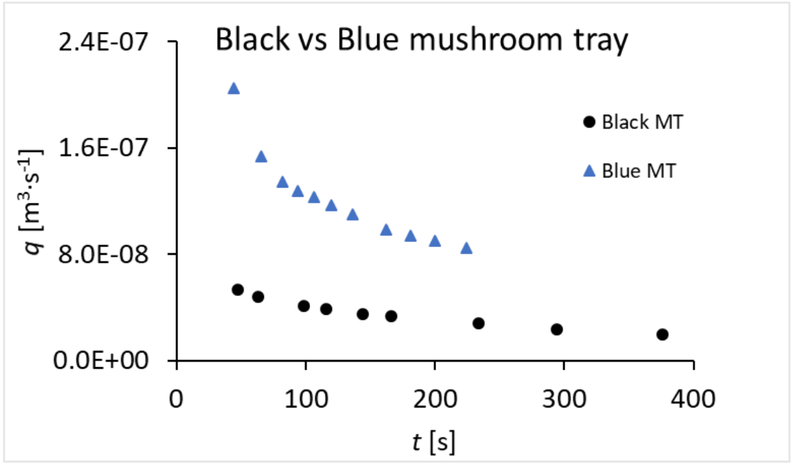


Membrane



97% turbidity reduction

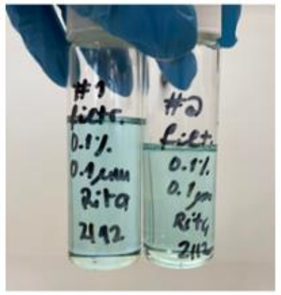




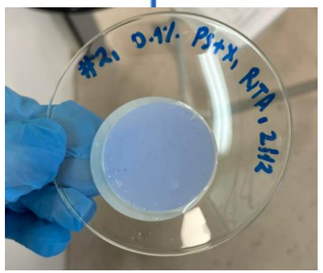
- M_w
- Pigment
- % of rubber (HIPS)

INFLUENCE OF SOLVENT

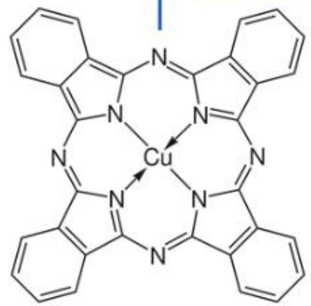
Membrane



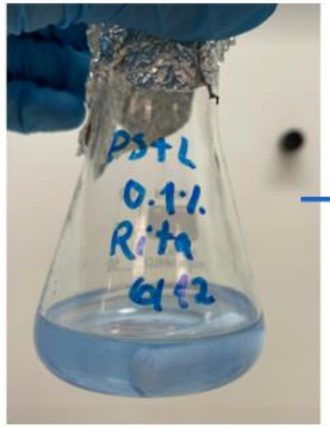
Remaining pigment



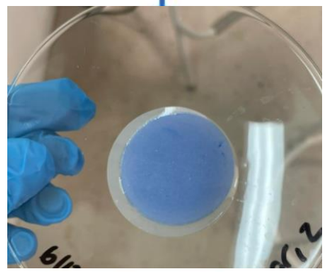
Additive some solubility in xylene



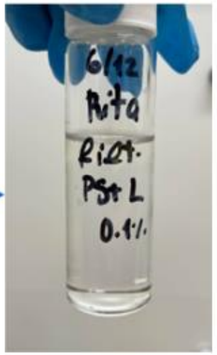
Pigment blue 15:3



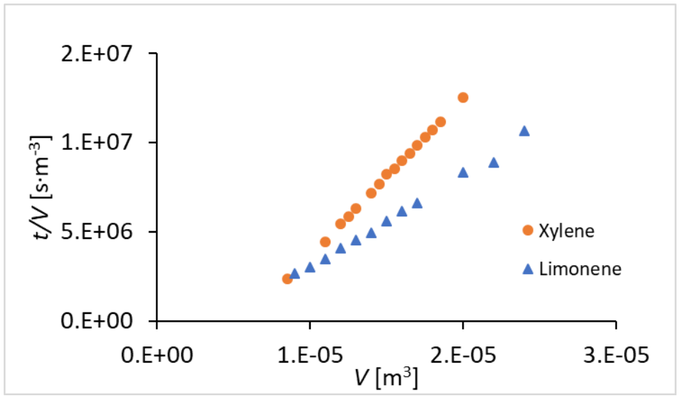
Membrane

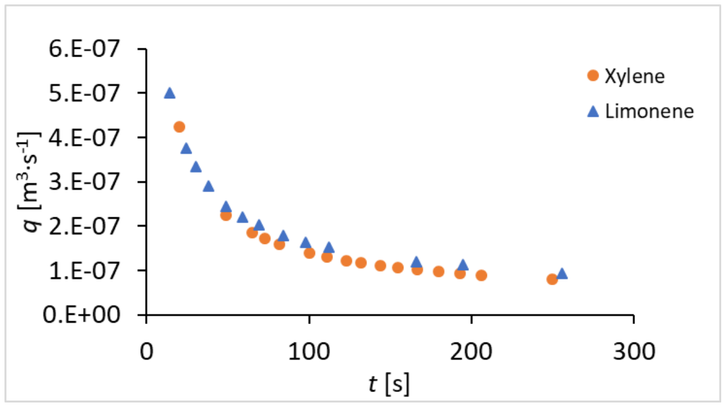


Additive hardly any solubility in limonene

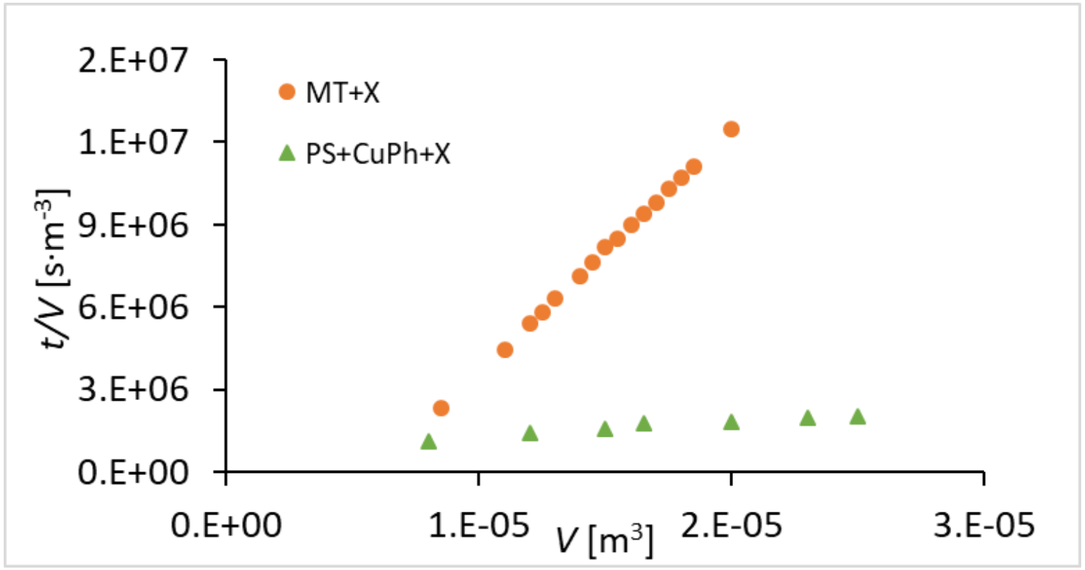


Clean polymer

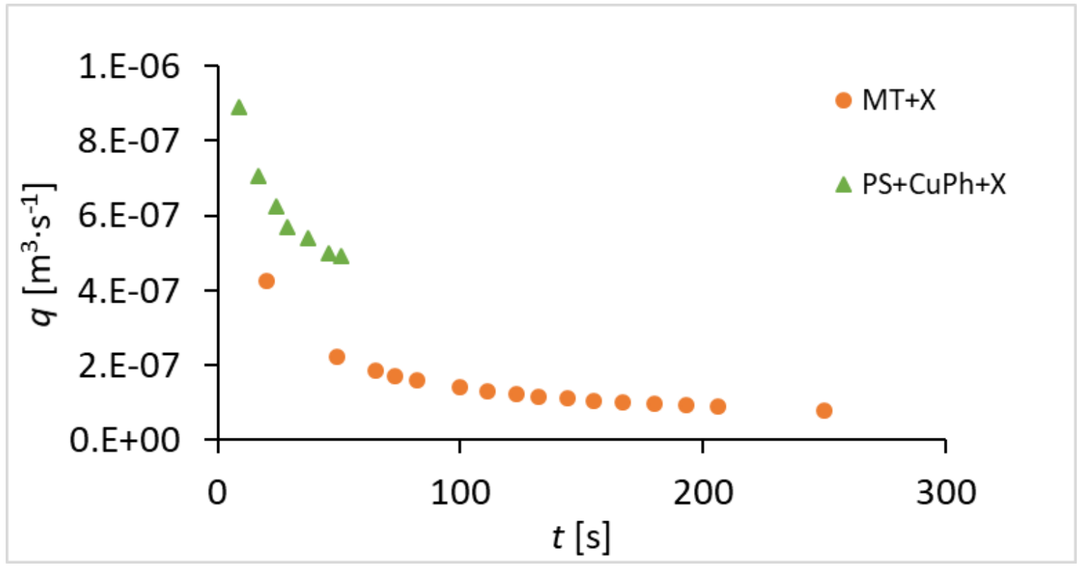




MODEL SOLUTION VS WASTE



Waste → higher resistance



Waste → lower flow rate

- Waste: M_w, HIPS (rubber part), additives
- Low concentrations → optimization needed

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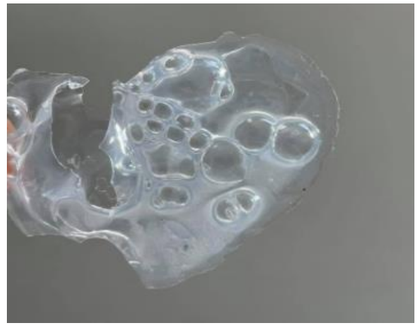
POLYMER RECOVERY

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

- Solvent-based recycling promising route for plastic recycling.
- Filterability is influenced by: concentration, polymer, additives.
- Solvent choice plays an important role.
- Currently optimizing a process for the removal of colourants from polystyrene-based waste.
- Assess recovered polymer properties.

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Chapter Intechopen, 2021

Recent Advances in Pre-Treatment of Plastic Packaging Waste

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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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REFERENCES

Slides 3,4,6,7,8,9: adapted from R. Kol, *Solvent techniques for closed loop recycling of plastics*, Microteaching, C-PlaNet EU H2020 project (2021), https://doi.org/10.5281/zenodo.5710332

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