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BIO-INGENIEURSWETENSCHAPPEN

LABORATORY FOR CIRCULAR PROCESS ENGINEERING
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Laboratory for Circular Process Engineering

ESR 9: SOLVENT TECHNIQUES FOR CLOSED-LOOP RECYCLING OF PLASTICS

Rita Kol / 10/09/2020

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ARISTOTLE UNIVERSITY OF THESSALONIKI

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ESR 9

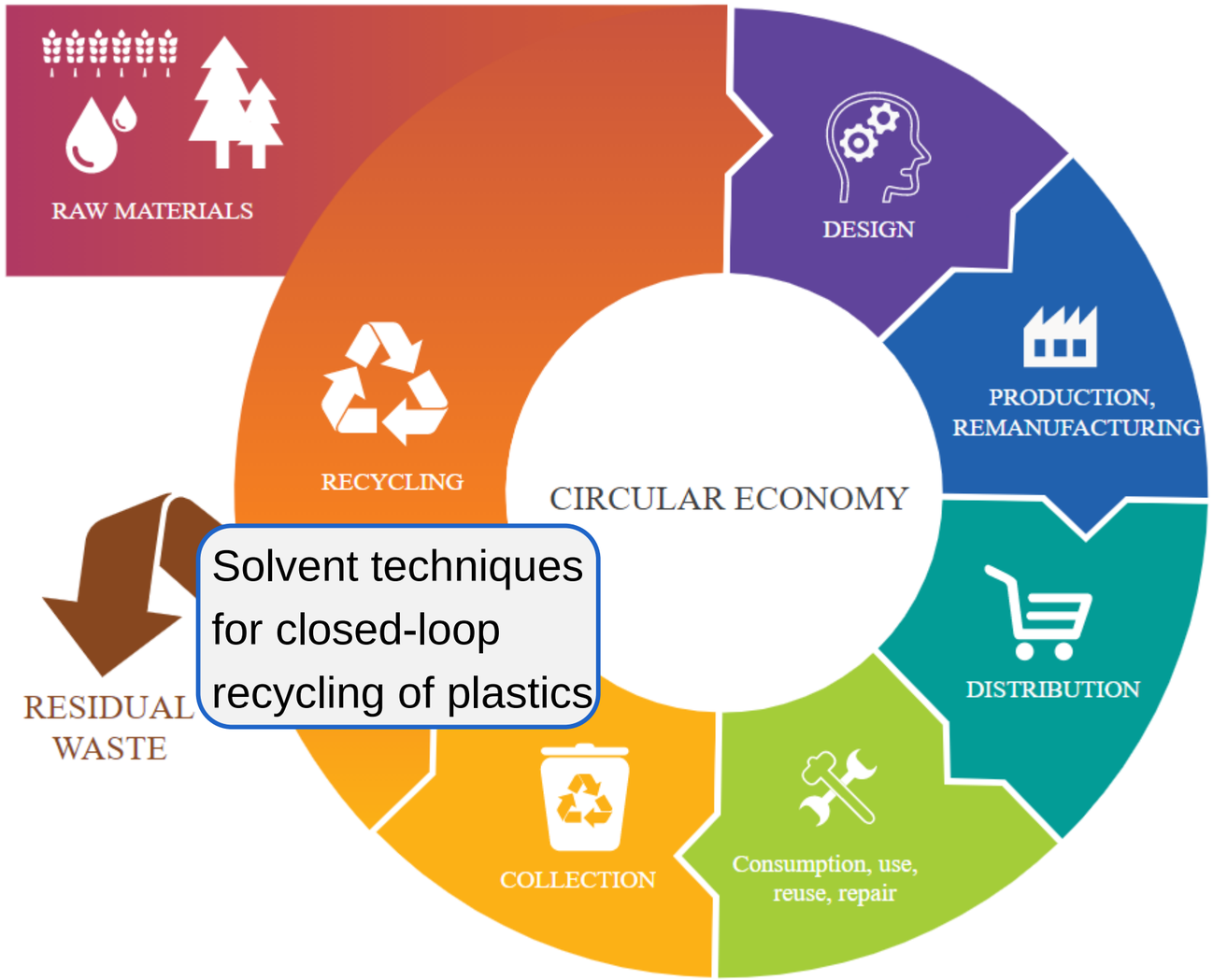

Fig. 1: Principles of the Circular Economy[1].

Objective 4: To develop efficient waste-to-resource recycling technologies

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CHALLENGES IN PLASTIC RECYCLING

Different types of plastic

Post-consumer plastic

Additives

Unknown composition

Multilayer structures

Glue

Food

Contaminants

Ink

Paper

Fig. 2: Representative image of plastic waste[2].

ADDITIVES IN PLASTIC RECYCLING

Additives are incorporated in plastics to improve physicochemical properties[3] :

- Additives
  - Functional additives (antioxidants, stabilizers, plasticizers, flame retardants, lubricants, antistatic agents, slip agents, foaming agents and biocides)
  - Fillers
  - Reinforcements
  - Colourants (colour pigments, dyes)

However

During recycling processes, they can cause[3,4] :

- Migration → Brominated flame retardants, phthalates
- Degradation → Metal containing additives
- Emission/Leaching → Toxic metals (Pb,Cd,Sb and Sn), VOCs, PAHs, among others
- Unwanted effects on recycled plastic → Colour pigments

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VOCs=volatile organic compounds, PAHs=Polycylic aromatic hydrocarbons

FROM OPEN TO CLOSED-LOOP RECYCLING

‘virgin-grade’ granulates

Closed-loop recycling
(up-cycling)

Plastic pretreatment

black granulates

Open loop recycling
(down-cycling)

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Fig. 3 – 7: Representative images are from [5-9].

POSITIONING SOLVENT-BASED RECYCLING/ PRETREATMENT

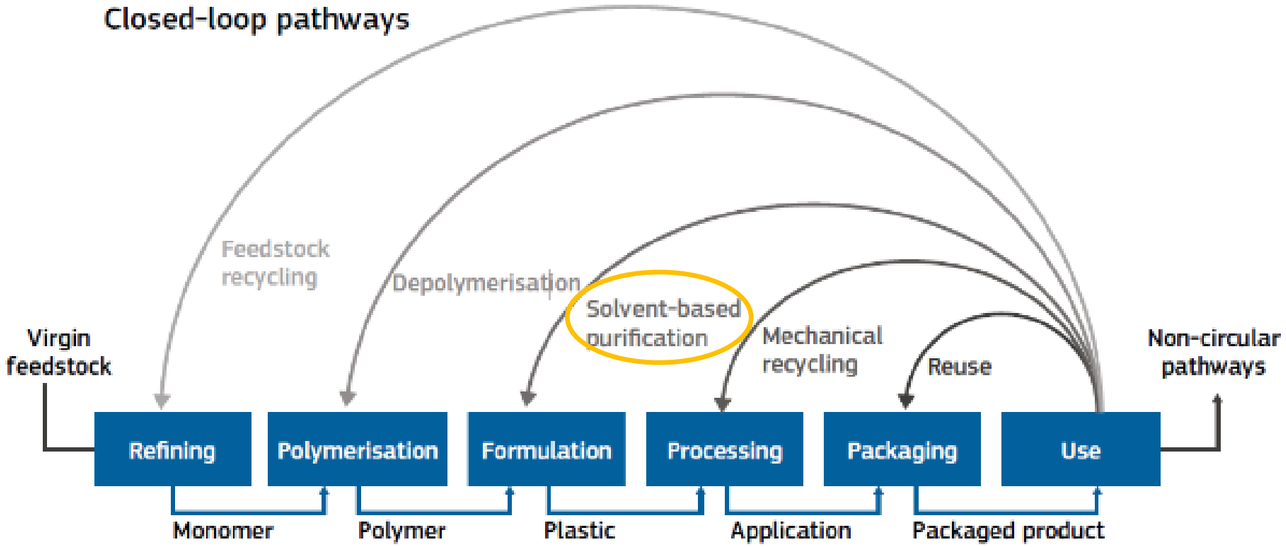

Fig. 8: Closed-loop pathways for plastic recycling (EuRIC)[10].

Plastic pretreatment can promote closed-loop recycling and up-cycling:

- Removal of additives and other contaminants such as (undesired) plastics, labels, organics and other impurities;
- Higher quality of recycled plastics (‘virgin-grade’ granulates);
- Potential increase of plastic waste input;
- Prevention of operational problems, such as corrosion.

DISSOLUTION/PRECIPITATION TECHNIQUE

Solvent-based pretreatment, which permits to remove e.g. additives from plastic waste.

Principle:

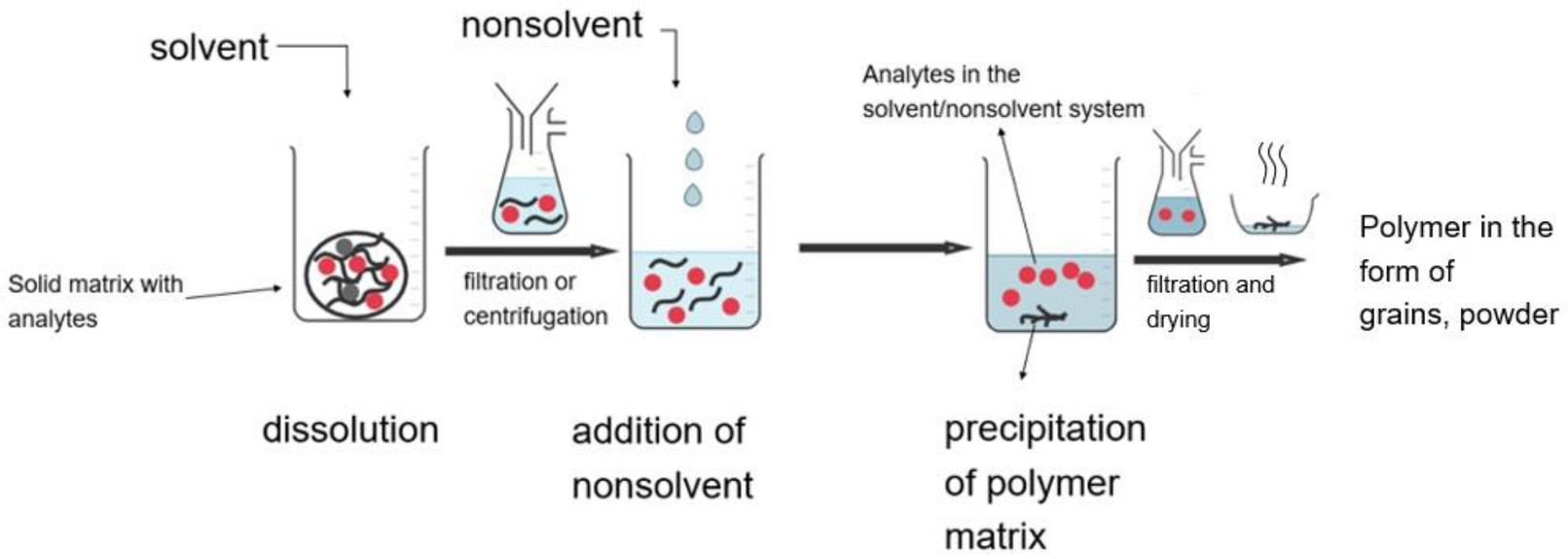

Fig. 9: Principle of the dissolution/Precipitation technique for the removal of e.g. additives, adapted from [11] and [12,13].

EXAMPLE: VINYLOOP

Designed to recycle PVC cables and films waste:

Decanter centrifuge to remove additives

Filtration step to remove additives

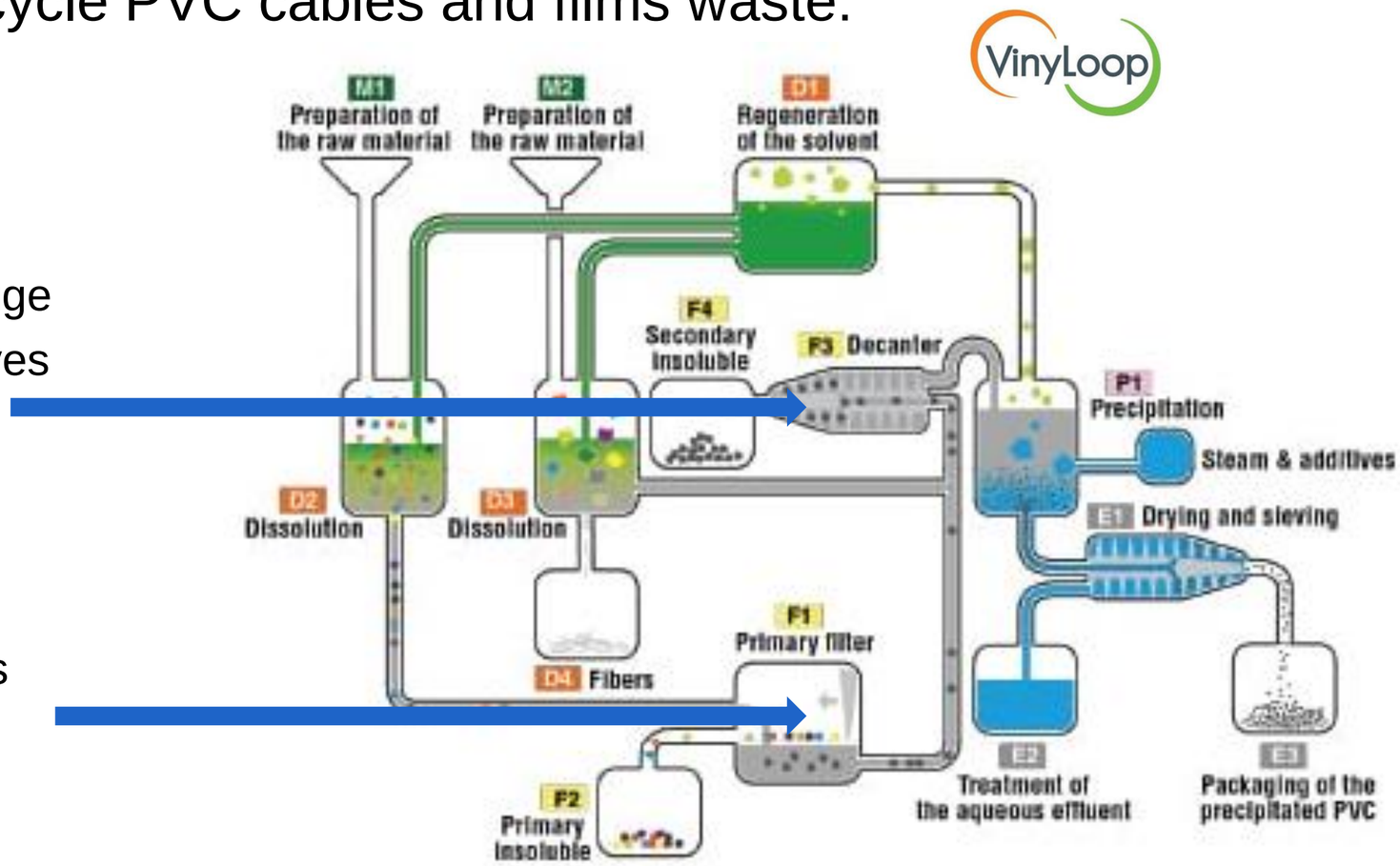

Fig. 10: Vinyloop process [14].

Vinyloop pilot plant closed because additives (such as phthalates) were not sucessfully removed (cost-effective).

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ADDITIVES SEPARATION

In the centrifugation/filtration steps → Viscosity of polymer solutions is important (amongst others)

Example: Sedimentation centrifuges

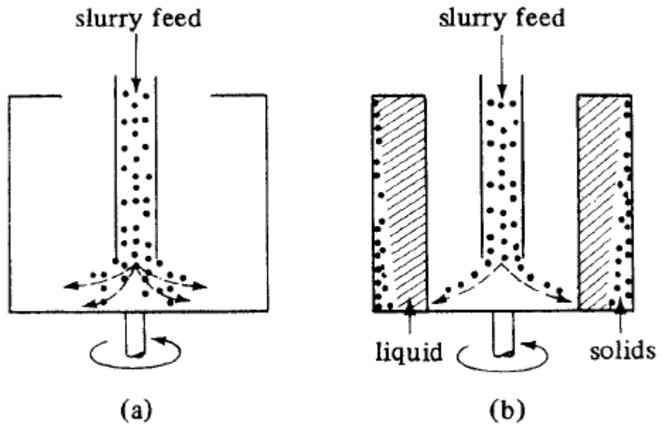

Fig. 11: Scheme of centrifugal separation: (a) feed entering, (b) settling of solids.

sedimentation velocity (v_s):

$$v_s = r\omega^2 \frac{(\rho_p - \rho_l) {d_p}^2}{18\mu}$$

v_s sedimentation velocity (m/s)
ω angular velocity (s^{-1})
r is the angular radius (m)
ρ_p and ρ_l are the particle's and solution's density (kgm^{-3})
d_p is the particle size (m)
μ is the viscosity of the solution (Pa.s)

→**Currently:** modelling viscosity to understand problems during additives separation

CONCLUSION

Focus: Removal of contaminants of plastic waste with solvent based pretreatment and understand physicochemical phenomena during this process (e.g. viscosity)

Objective: Optimize chemical pretreatment to remove contaminants from plastics before recycling → promote closed-loop recycling and up-cycling

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