Challenges and opportunities for recycled plastics in appliances

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Electro-Plast, Düsseldorf

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This Project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement N. 821087

PLAST2bCLEANED

Agenda

- Different recycling technologies on plastic waste

- The PLAST2bCLEANED process as a promising technology (of many)
    - project goal
    - process steps
    - results and scale-up

- Recycled plastics in appliances
    - application for HIPS
    - application for ABS

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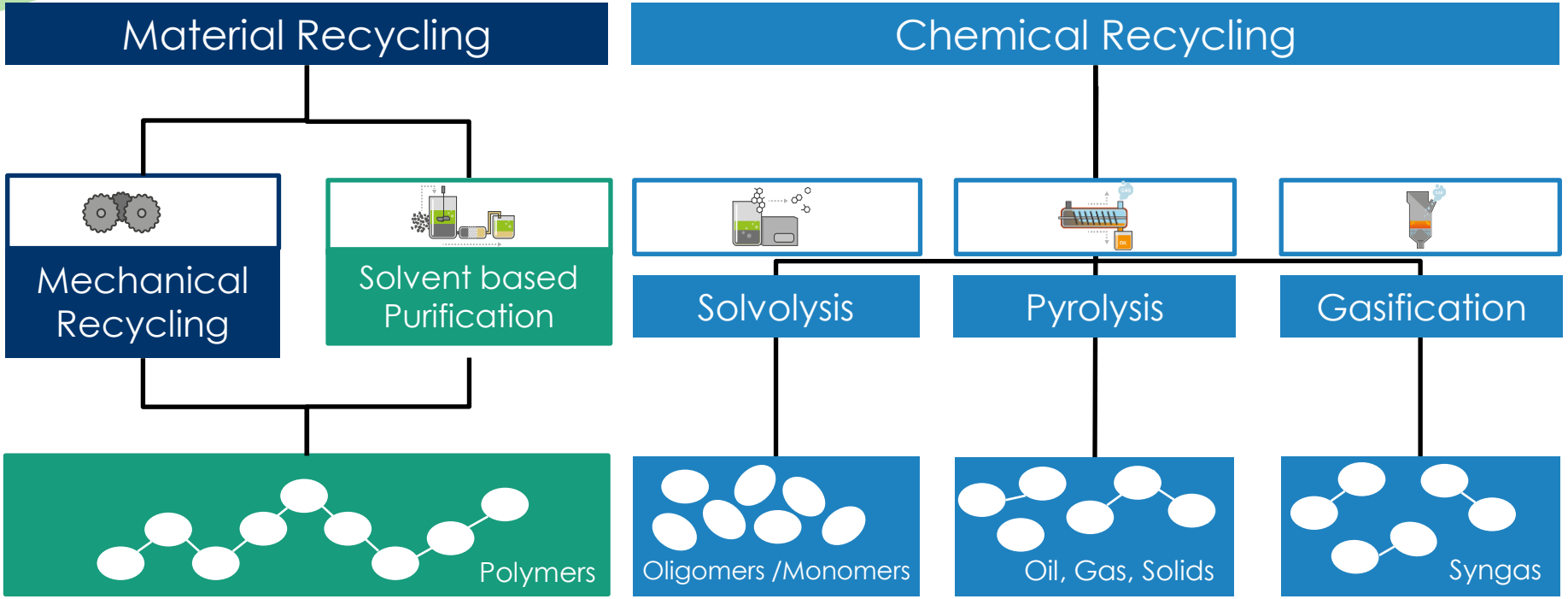
Overview of recycling technologies



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Objectives

PLAST2bCLEANED

The overall aim of PLAST2bCLEANED is to develop a human and environmentally safe recycling process for Waste Electrical and Electronic Equipment (WEEE) plastics in a technically feasible and economically viable manner.

1 **Development of a mechanical presorting technology**

2 **Closing 3 loops using dissolution under superheated conditions by separation of:**
- **(1) the polymer**
- **(2) the bromine**
- **(3) the antimony trioxide**

3 **Process integration and scale-up**

4 **Performance testing of process and products**

5 **System optimizing for sustainability and economic viability**

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Consortium

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Industry/SME

Recycling Company — Coolrec

Engineering company — JUCHHEIM

Polymer

Bromine fraction

Antimony fraction

Plastics producer — ELIX POLYMERS

Bromine recovery — ICL

Antimony recovery — Campine

End user — Electrolux

Chemical industry

Chemical industry

Dissemination and exploitation — Sustainable INNOVATIONS

Research Institutes

Coordinator — TNO

Fraunhofer ICT

Gaiker — MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

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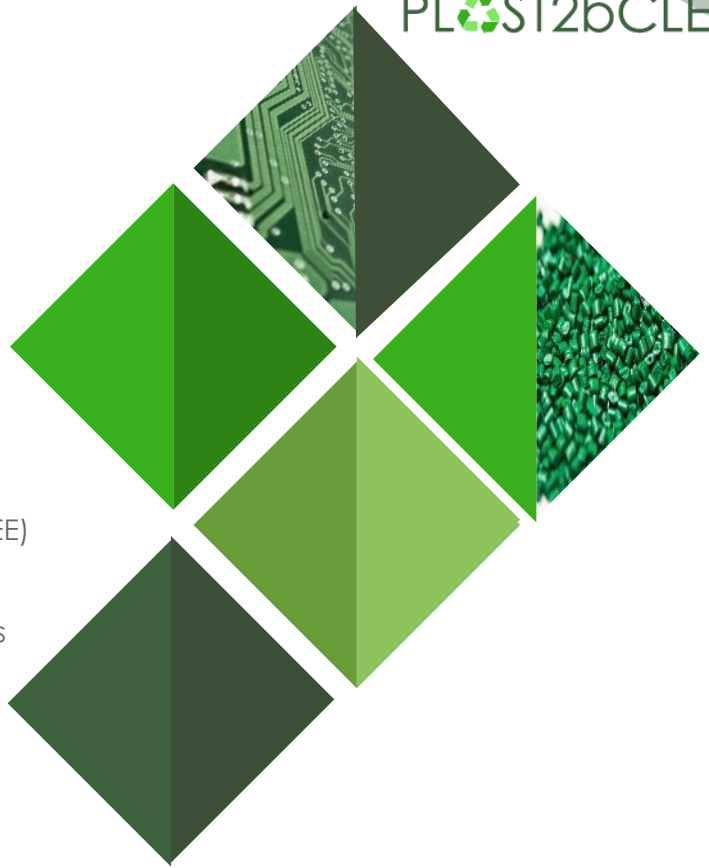
Overview of the project

The overall aim of PLAST2bCLEANED is to develop a human and environmentally safe recycling process for Waste Electrical and Electronic Equipment (WEEE) plastics in a technically feasible and economically viable manner.

Key technologies developed within the project are:

- Improved sorting of HIPS and ABS
- Dissolution of Waste Electrical and Electronic Equipment (WEEE) plastics in superheated solvents;
- Separation of additives to concentrate BFR and ATO fractions for recycling;
- Energy efficient recovery of solvent and of polymer.



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Improved sorting of HIPS and ABS

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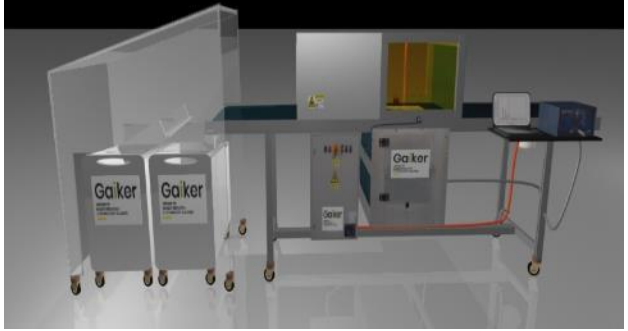
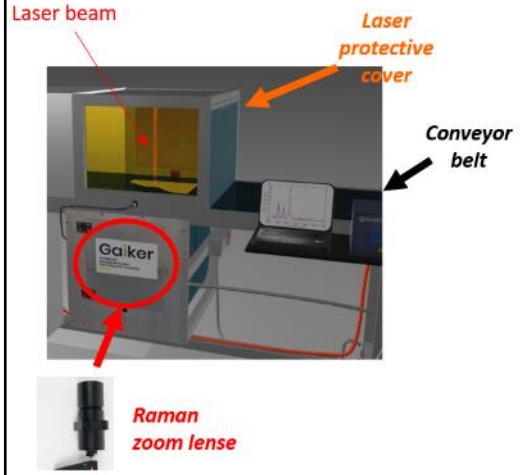
DESIGN, DEVELOPMENT AND TESTING OF THE RAMAN SORTING PROTOTYPE

✓ DESIGN



✓ COMPONENTS & TECHNICAL REQUIREMENTS

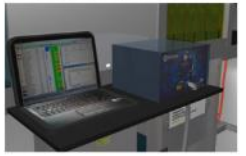
1) RAMAN MEASUREMENTS



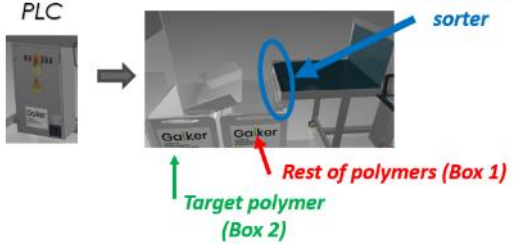
2) RAMAN SPECTRAL DATA ANALYSIS

Raman spectrometre

Software for on-line WEEE analysis & classification



3) WEEE SORTING



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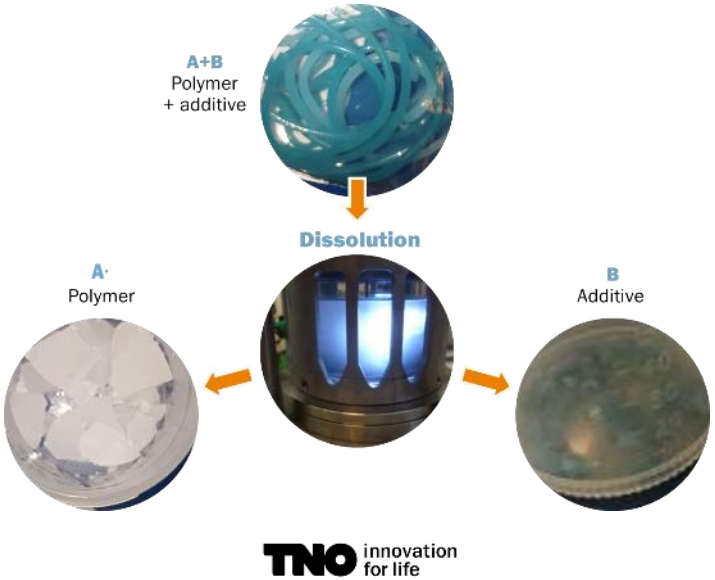
Dissolution process



Main characteristics

- Dissolve the polymer in the plastic
- Thus release additives
- Use a single low-boiling solvent
- Superheated above the boiling point
  - Pressurised system
- Remove additives from the polymer
- Recover polymer, additives and recycle solvent

Main benefits

- Energy efficient process
- Potential for high quality polymers: value retention
- Potential to also recover additives for recycling

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Density separation

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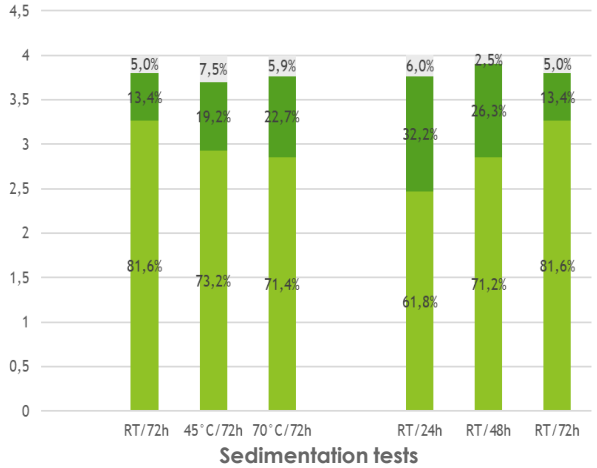
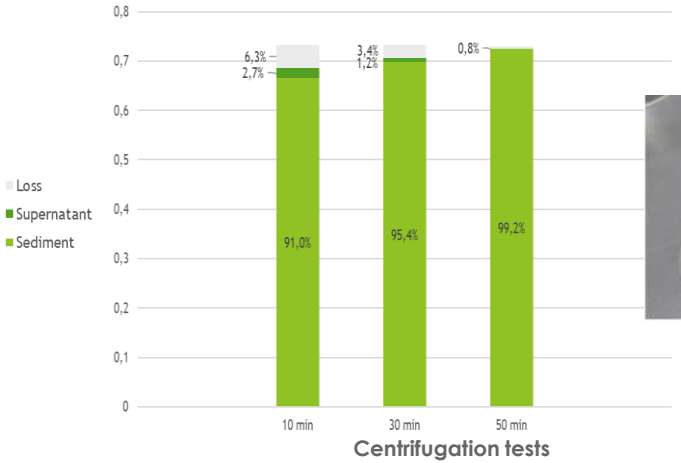
Removal of antimony trioxide by density separation

- Antimony recovery on reference samples
- Density separation tests along multiple approaches (sedimentation, centrifugation, decanter centrifuge)





Recovered ATO fraction
>90% ATO
<0,1% Br

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Membrane filtration

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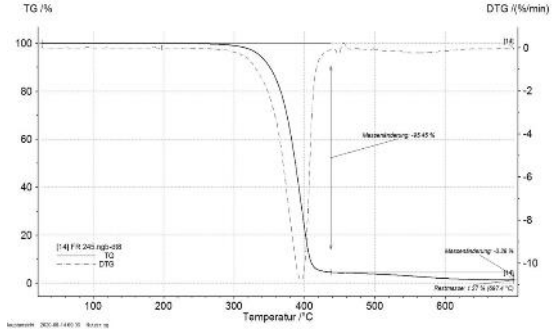
Removal of bromine flame retardants by filtration

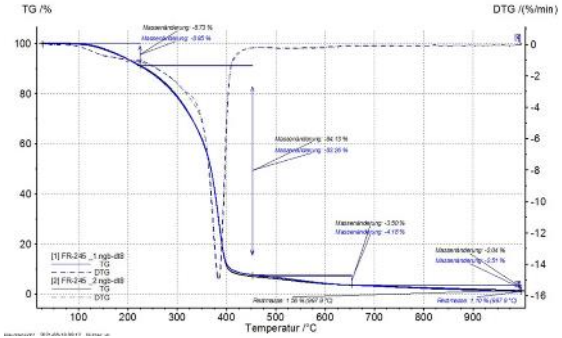
- After 2h filtration 80-90% Br could be removed from the dissolution mix via permeate
  - BFR recovery by solvent evaporation
  - BFR recovery by active carbon

- Recovered bromine fraction
  - Average 469.000 ppm Br content
  - <LoD Sb
  - TGA shows solvent and polymer impurities



TGA of pure FR-245

Recovered bromine fraction



TGA of recovered BFR fraction

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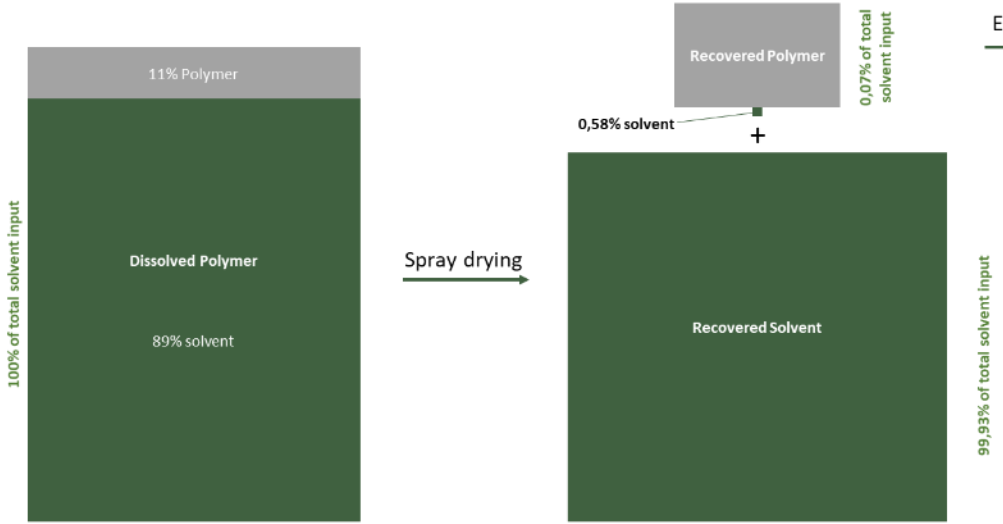
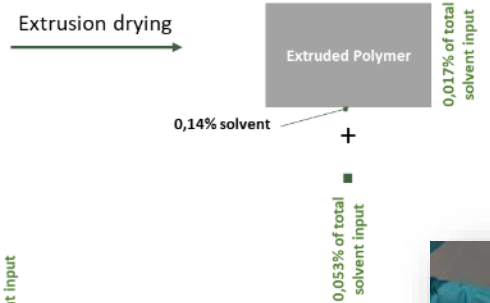
Spray drying

Recovery of rABS / rHIPS and solvent

Spray drying in one step removes >99,93% of solvent, then extrusion drying is necessary to achieve specifications (<1.000ppm)





Recovered polymer from spray drier

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Transfer from reference substrate to real waste

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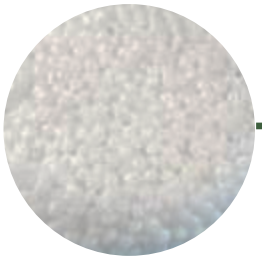

Reference Substrate

1. Dissolution

ΔT, t

2. Density separation

ATO & insol. BFR

3. Hot filtration

Soluble brominated flame retardants

4. Spray Drying

Recycled polymer

Sorted waste plastic

ΔT, t

ATO sediment fraction

Soluble brominated flame retardants

Recycled polymer

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Transfer from reference substrate to real waste

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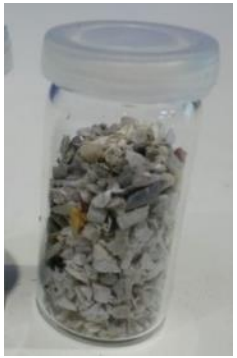

Intermediate results

ABS white/black → **Coarse filtration** → **Settling tank/centrifuge** → **Membrane filtration** → **Spray Drying**

- Coarse filtration: ~8% mass loss; ~2% mass loss
- Settling tank/centrifuge: 97% Sb end in sediment; 98% Sb and 77% of Ti end up in sediment
- Membrane filtration: 82 - 89% Br reduction; 65 – 70% Br reduction

Residual solvent **0,07%**	Residual solvent **0,13%**

rABS cyclone
Br 7.322 ppm (-89%)
Sb 216ppm (-99%)

rABS tower
Br 12.187 ppm (-82%)
Sb 284ppm (-98%)

Colouring contaminants significantly removed !

rABS cyclone
Br 19.750 ppm (-65%)
Sb 765ppm (-96%)
Ti 6.651 ppm (-66%)

rABS tower
Br 17.002 ppm (-70%)
Sb 714 ppm (-97%)
Ti 7.311 ppm (-57%)

Residual solvent **0,41%**	Residual solvent **0,24%**

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Process development and Scale-up

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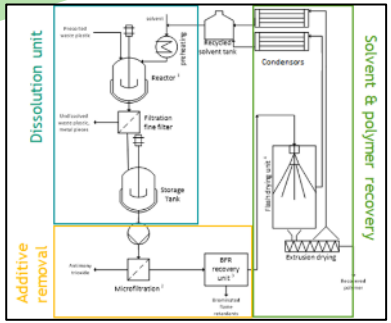
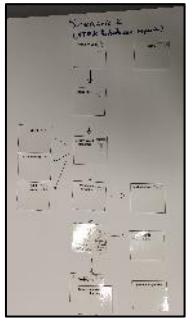
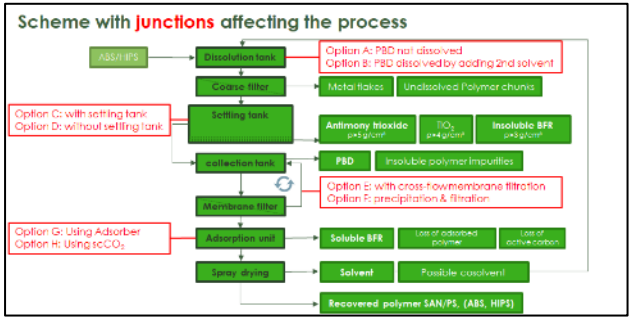
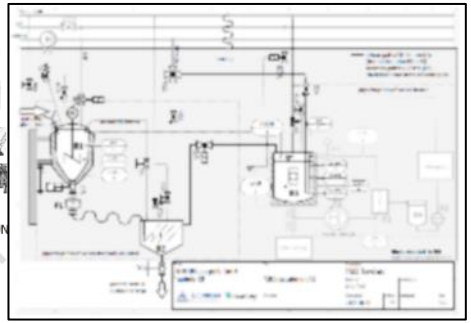
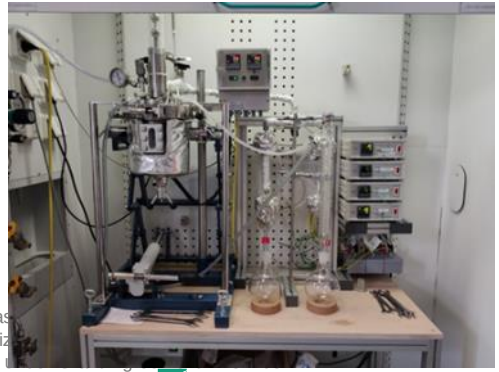


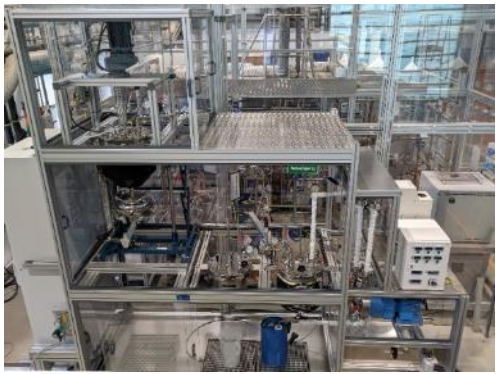






May 2019 — 2020 — 2021 — 2022 — 2023





TNO innovation for life

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Process development and Scale-up

Process development and Scale-up

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How does recycling technology affect application?

- For solvent-based purification technology, dryness of recyclate is of primary importance
- Size distribution of polymer does not change when using solvent based-technology
- As solubility of polybutadiene in ABS is lower than SAN, the recovered ABS/HIPS can have a lower polybutadiene component.
- The recovered ABS verifiably lacks thermal stabilizers, which need to be replenished
- Testing the recycled material in defined application, which will be ready by October 2023

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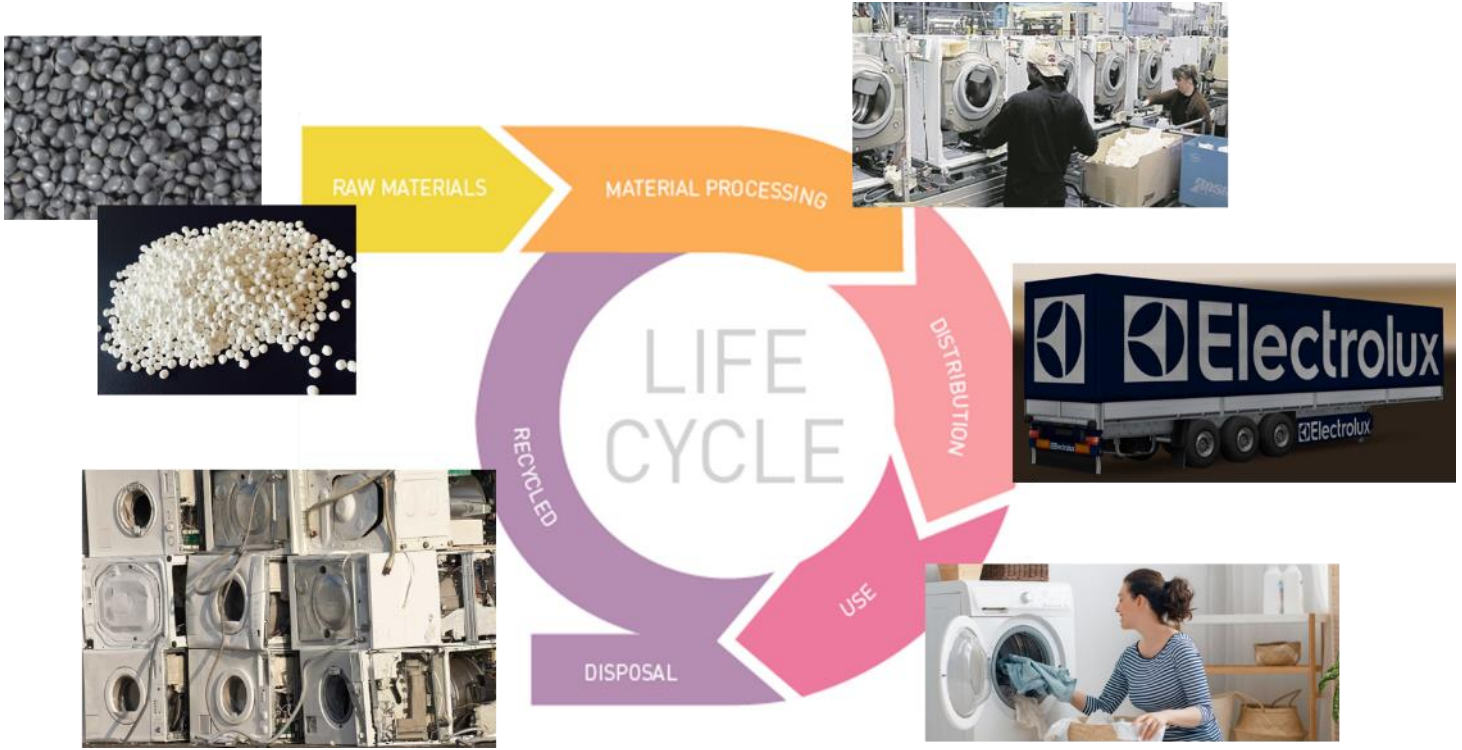
Recycled plastics in appliances

The virtuous cycle



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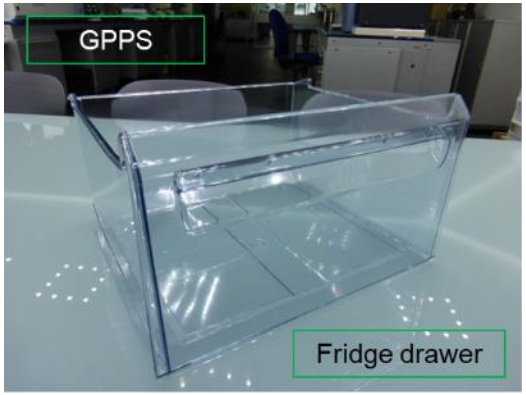
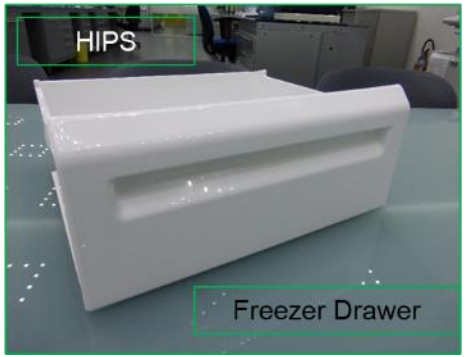
Recycled plastics in appliances

Examples of components made of Polystyrene (HIPS and GPPS)





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Recycled plastics in appliances

Polystyrene grades: challenges & opportunities

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CHALLENGES

- Produce food grades (HIPS and GPPS)
- Produce clear grades of recycled GPPS
- Reduce GPPS content in rHIPS
- Develop improved sorting methods
- Improve ESCR
- Reduce production costs

OPPORTUNITIES

- Strongly reduce carbon footprint for appliances (especially fridges)
- Exploit selected scrap sources already available (i.e. refrigerators only)
- Use the multilayered sheets to achieve food grade components
- Use rec PS grades in appliances other than refrigerators

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Recycled plastics in appliances

Examples of components made of ABS

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Recycled plastics in appliances

ABS grades: challenges & opportunities

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CHALLENGES

- Improve colour sorting for white coloured applications
- Create dedicated collection systems (close loops)
- Improve sorting methods for WEEE scraps (main source of rABS)
- Reduce production costs

OPPORTUNITIES

- Increase the use of rec ABS in appliances
- Avoid material regrading thanks to the good properties of rec ABS
- Adopt drop-in solutions (no change to the existing tools)
- Use colour-unsorted materials for components to be painted

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Recycled plastics in appliances

Applications targeted in Plast2bCleaned project

1 external door frame (made out of 0.495 kg ABS) of a washing machine with overall running time of 220 washing cycles per year and an expected lifespan of 10 years (7,000 running hours)".

1 inner liner (made out of 4.6 kg HIPS) of a household refrigerator's cabinet with overall running hours of 78,840 hours and an expected lifespan of 9 years"

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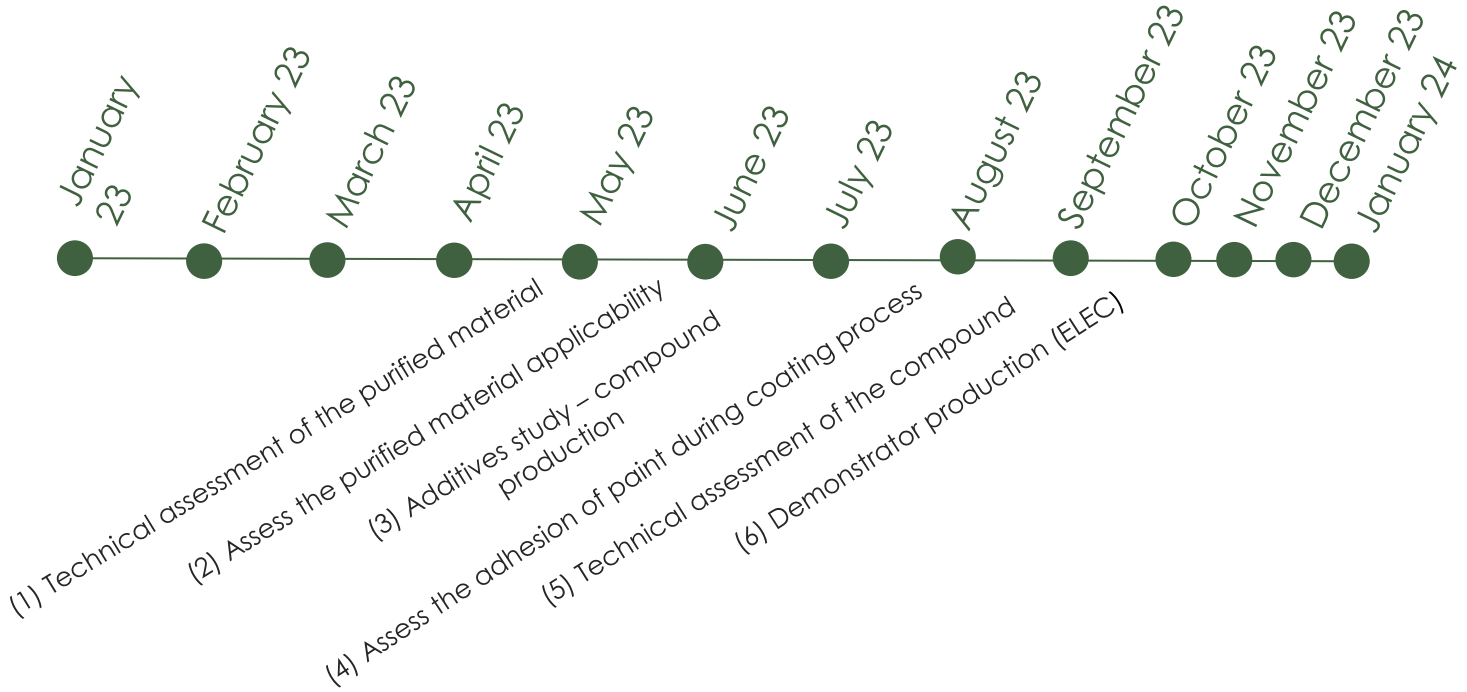
Recycled plastics in appliances

Applications demonstrators will be ready in October 2023



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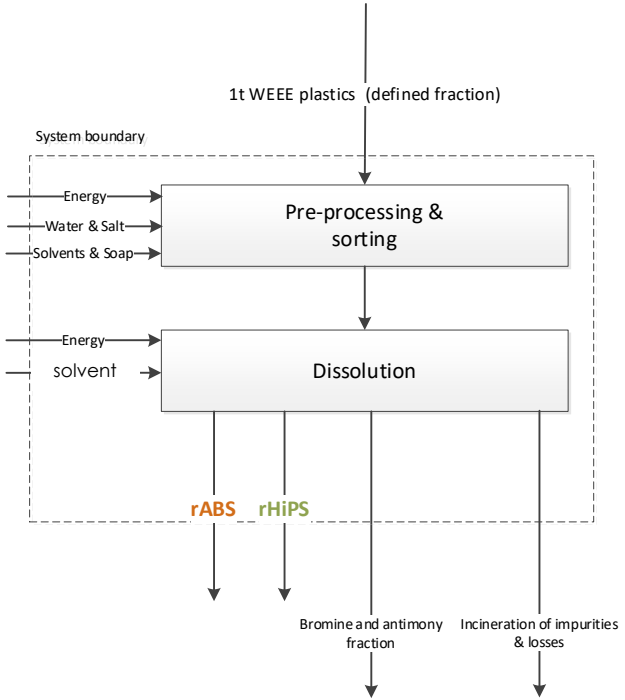
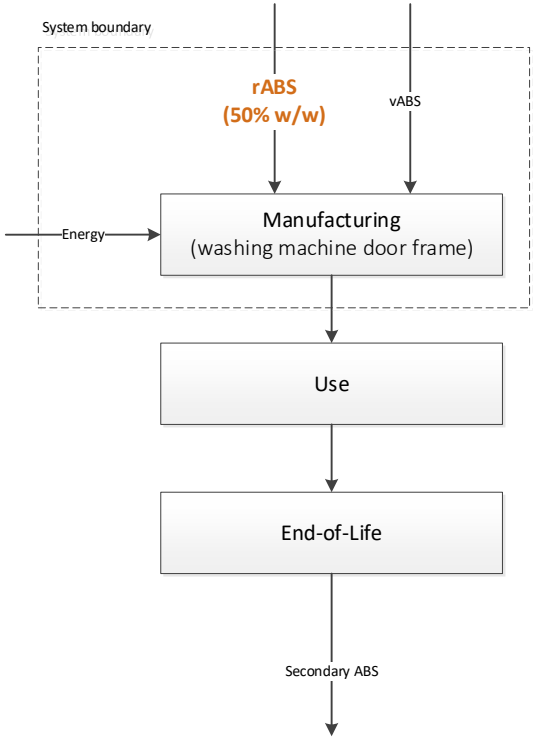
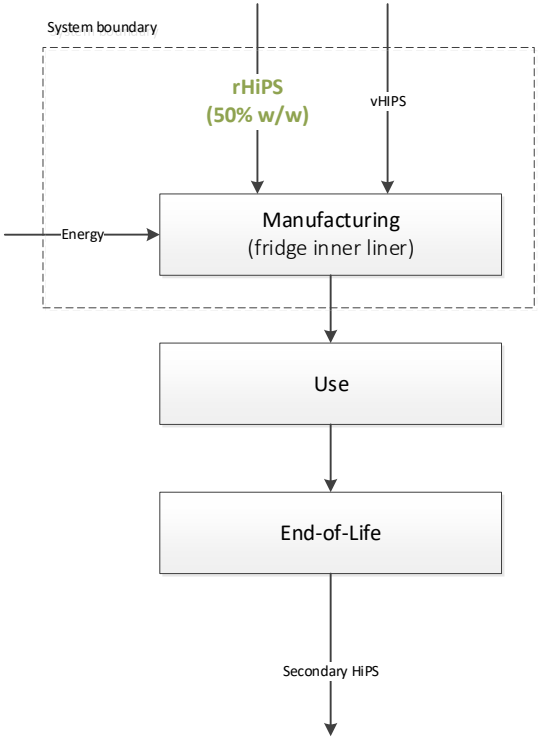
Recycled plastics in appliances

Defined product system







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THANK YOU FOR YOUR ATTENTION

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For further information about recycled plastics in appliances:

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