

Pinfa Sparks

Thursday 7th May 2026
14.00 – 14.45 CET

Closing the Loop: *Recycling Strategies for Flame Retardant Additives*

Presented by
Nacho Montesinos Beltrán
Chemical Recycling Technician
AIMPLAS

Cefic sector group 



Welcome & Introduction

Thomas FUTTERER & Esther AGYEMAN-BUDU



COMPETITION LAW

CHECKLIST FOR MEETINGS



Ensure strict performance in areas on:

Oversight / Supervision

- Have a Cefic/Sector Group Secretariat representative at each meeting
- Consult with appropriate counsel on all questions which might be related to competition law
- Limit meeting discussions to agenda topics
- Provide each attendee with a copy of this checklist, and have a copy available for reference at all meetings

Recordkeeping

- Have an agenda and minutes which accurately reflects the matters which occur
- Ensure the review of agendas, minutes and other important documents by appropriate staff or counsel, in advance of distribution
- Fully describe the purposes, structures and authorities of the groups

Vigilance

- Protest any discussion or meeting activities which appear to violate this checklist
- Ask for those activities to be stopped so that appropriate legal check can be made by counsel
- Dissociate yourself from any such discussion or activities and for the attendees, leave any meeting in which they continue (and have it minuted)

This checklist is for the conduct of Cefic-sponsored meetings. Prohibited discussion topics apply equally to social gatherings incidental to those meetings. The checklist is not exhaustive.

Contact: Quentin Silvestre, Senior Legal Advisor at qsi@cefic.be



in fact or appearance, discuss or exchange information not in conformity with competition law, including for example on:

Prices, including

- Individual company/industry prices changes, price differentials, discounts, allowances, credit terms, etc
- Individual company data on costs, production, capacity (other than nameplates capacities), inventories, sales, etc

Production, including

- Plans of individual companies concerning the design, production, distribution or marketing of particular products, including proposed territories or customers
- Changes in industry production capacity (other than nameplates capacities) or inventories, etc

Transportation rates

- Rates or rate policies for individual shipments, including basing point systems, zone prices, freight, etc

Market procedures, including

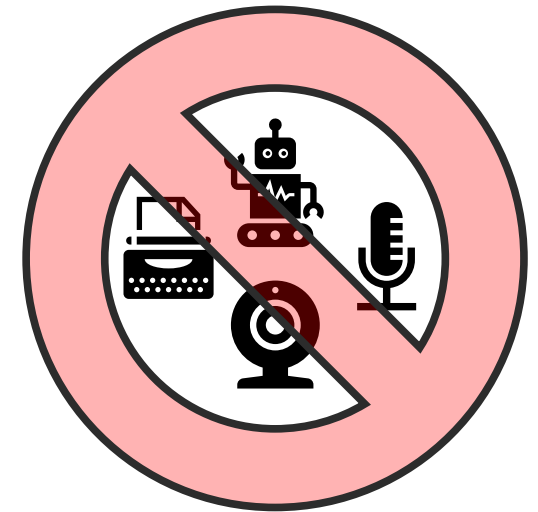
- Company bids on contracts for particular products; company procedures for responding to bid invitations
- Matters relating to actual or potential individual suppliers or customers that might have the effect of excluding them from any market or influencing the business conduct of firms towards them, etc
- Blacklist or boycott customers or suppliers



Housekeeping rules (1/2)

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pinfa Sparks # 2

Closing the Loop:

Recycling Strategies for Flame Retardant Additives

Speaker



Nacho MONTESINOS BELTRAN

Chemical Recycling Group
AIMPLAS

Moderated by



Thomas FUTTERER

Pinfa Chairman - Budenheim

Esther AGYEMAN-BUDU

Cefic Sector Group Manager



About us

Phosphorus, Inorganic and Nitrogen Flame retardants Association (pinfa)

- Established in **2009** as a Sector Group within **Cefic**, the European Chemical Industry Council.
- Represents **26 members**, including **manufacturers and users** of the three major technologies of non-halogenated flame retardants.
- **pinfa-NA** and **pinfa China**, sister associations, established respectively in 2012 and 2018.
- Maintains mutual membership with **INEMI**¹ and partnership with **EAPFP**² and **EuroFSA**³

(1) International Electronics Manufacturing Initiative

(2) European Association for Passive Fire Protection

(3) European Fire Safety Alliance

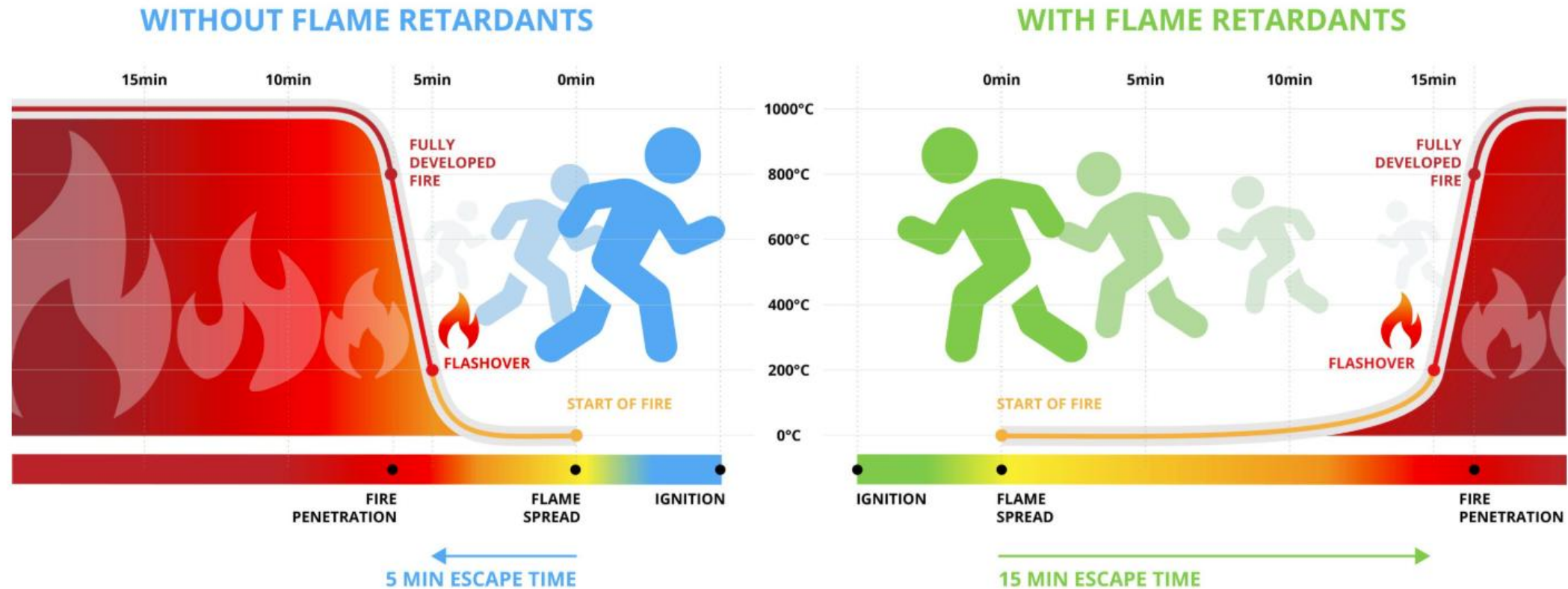


What are PIN Flame Retardants (PIN FRs)?

- PIN flame retardants are **phosphorus-, inorganic- and nitrogen-based** technologies designed to enhance fire safety in materials such as plastics, textiles, foams, and electronics.
- They contribute to fire protection by:
 - **Reducing flammability and slowing ignition**, helping materials resist or delay catching fire.
 - **Interfering with the burning process**, for example through char formation, heat shielding, or stabilising the polymer during exposure to heat.
 - **Limiting heat release and flame spread**, supporting improved fire performance across multiple applications.



How PIN FRs Support Increased Escape Time in Fires



- PIN flame retardants slow down fire development, helping to delay ignition, reduce heat release and limit flame spread.
- This slower progression can extend the available time for people to escape, which is critical for overall fire safety.



Pinfa members

Europe, China & North America



Meet the pinfa Europe team



Thomas Futterer
Chair



Adrian Beard
Vice-Chair



Zahra Fahimi
Vice-Chair



Sander Kroon
Vice-Chair



Esther Agyeman-budu
Sector Group
Manager



Elena Leonardi
Sector Group
Manager



Hannane Haddouch
Assistant



Myriam Goffin
Communications



Chris Thornton
Communications



pinfa members' shared vision



Vision: continuously improving the environmental and health profile of their flame-retardant products, offering innovative solutions for sustainable fire safety.



Commitment: to maintain high fire safety standards across the world, standards which minimize the risk of fire to the general public.



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pinfa Sparks # 2

Closing the Loop: *Recycling Strategies for Flame Retardant Additives*

Speaker



Nacho MONTESINOS BELTRAN

Chemical Recycling Group
AIMPLAS

- Research technician in chemical recycling at AIMPLAS, specialized in the valorization of complex plastic waste and advanced recycling processes.
 - Experience in technologies such as pyrolysis, selective dissolution, and solvolysis for recovering high value-added materials and products.
 - Involved in circular economy, recycling, and decarbonization projects focused on developing innovative recycling solutions for difficult-to-recycle waste streams.
 - AIMPLAS is a leading technology center in plastics innovation, sustainability, and the development of mechanical, physical, and chemical recycling technologies.
-



Closing the Loop: *Recycling Strategies for Flame Retardant Additives*

Nacho Montesinos Beltran
Chemical Recycling Technician
Chemical Recycling Group
AIMPLAS



INNOVATION WITH PURPOSE
Closing the Loop: Recycling Strategies for
Flame Retardant Additives



What is AIMPLAS?

A technology centre with more than 35 years' experience in the **plastic sector.**





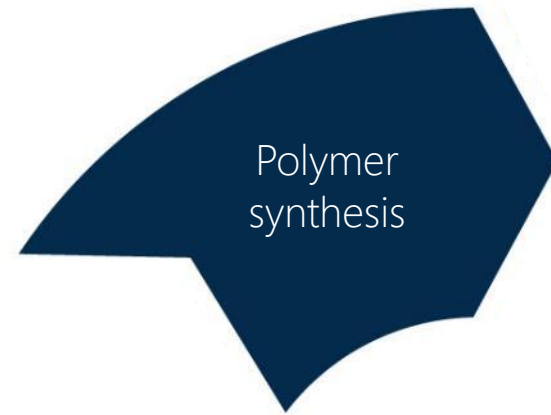
1. I+D+i



2. Technological Services



3. Training and Workshops



Polymer synthesis

Raw materials

Recovery of plastic waste



Compounding

End users

Manufacturing / Processing

Expertise across the entire plastics value chain

Content



- 1. Context**
2. Recycling Technologies
3. Strategies

1. Context

1. PLASTIC WASTE IS BECOMING INCREASINGLY COMPLEX

Mixed polymers, multi-layer structures and diverse additive formulations make recycling more challenging.



COLLECTION & SORTING

CLOSING THE LOOP: RECYCLING STRATEGIES FOR FLAME RETARDANT ADDITIVES

ADVANCED
RECYCLING
TECHNOLOGIES

3. CURRENT RECYCLING SYSTEMS ARE NOT DESIGNED FOR ADDITIVE RECOVERY

Additives are lost, diluted or end up as contaminants—limiting material quality and circularity.



! Additives are not recovered. Value and performance are lost. Safety can be compromised.

2. FUNCTIONAL ADDITIVES ARE ESSENTIAL FOR PERFORMANCE

Flame retardant additives enhance fire safety and enable advanced performance across applications.



FIRE SAFETY PERFORMANCE DURABILITY

The right additives. The right performance. The right protection.

REINTEGRATION
INTO NEW
MATERIALS

ADDITIVE
RECOVERY &
PURIFICATION

From waste to resource.
Performance. Safety. Sustainability.

SAFE. EFFECTIVE. CIRCULAR.
Maintaining flame safety while
building a circular future.

THE SOLUTION: CLOSING THE LOOP

Innovative technologies enable the recovery of flame retardant additives and their reintegration into high-quality, safe, and sustainable materials.



CLOSING THE LOOP TODAY
FOR A SAFER TOMORROW



1. Context

FROM SINGLE POLYMERS TO MULTI-COMPONENT SYSTEMS

Multi-layer materials, composites, additives
(Additives can account for up to 10–30 wt% in engineering plastics)

PRESENCE OF CRITICAL FUNCTIONAL ADDITIVES

- FLAME RETARDANTS**
Enable compliance with fire safety regulations
- STABILIZERS**
Protect polymers from degradation and extend service life
- FILLERS**
Improve mechanical, thermal and dimensional performance

WASTE STREAMS: HIGHLY HETEROGENEOUS & POORLY CHARACTERIZED

MULTI-MATERIAL **MULTI-LAYER** **COMPOSITES** **UNKNOWN ADDITIVE CONTENT**

ADDITIONS ARE:

- TECHNICALLY COMPLEX**
- COST-INTENSIVE**
- OFTEN CRITICAL RAW MATERIALS**

1. Context

CURRENT RECYCLING = LOSS OF FUNCTIONALITY



MECHANICAL RECYCLING:
Does not preserve additive performance



CHEMICAL DEGRADATION:
FRs often decomposed or transformed



RESULT: LOSS OF



FLAME
RETARDANCY



MATERIAL
CERTIFICATION



ECONOMIC
VALUE



**WE ARE LOSING FUNCTIONALITY
AND CHEMICAL VALUE**



GLOBAL CONSUMPTION OF FRs:
>2.5 MILLION TONNES/YEAR

TYPES OF FLAME RETARDANTS



HALOGENATED
(Br, Cl)



PHOSPHORUS-BASED



INORGANIC
(ATH, MDH)

**WE ARE LOSING
FUNCTIONALITY
AND CHEMICAL VALUE**



Loss of
flame retardancy



Loss of
material certification



Loss of
economic value



**WE NEED TO RECOVER,
PRESERVE AND REINTEGRATE
FUNCTIONAL ADDITIVES**

to close the loop and enable a
circular & safe future

- ✓ Preserve performance and safety
- ✓ Recover critical raw materials
- ✓ Create value in a circular economy

1. Context

WHY CONVENTIONAL RECYCLING FAILS FOR FRs



Conventional recycling was not designed for additive circularity. | The result: **loss of functionality** and **chemical value**.



1. MECHANICAL RECYCLING: LIMITATIONS

PROCESS:

Grinding → melting → reprocessing



KEY ISSUES:



No selective separation
Additives remain in matrix

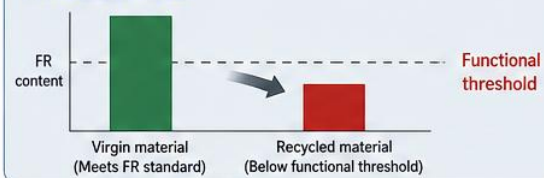


Dilution effect
Loss of additive concentration



Mixing with virgin or other waste streams
Decrease in FR concentration

TYPICAL EXAMPLE:



RESULT:

Material does not meet fire safety regulations.



2. THERMAL DEGRADATION

PROCESSING INDUCES ADDITIVE BREAKDOWN.

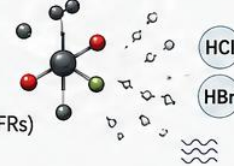
REPROCESSING TEMPERATURES:

180–300 °C
(depending on the polymer)



CONSEQUENCES:

Decomposition of FRs



RELEASE OF:

- HCl / HBr (in halogenated FRs)
- Volatiles

EXAMPLE:

Brominated FRs → debromination



IMPACT:

- Loss of flame retardant performance
- Release of corrosive and hazardous gases
- Loss of value and regulatory compliance



3. MATERIAL INCOMPATIBILITY

POLYMER DEGRADATION + ADDITIVE MISMATCH



Chain scission



Cross-contamination



Interaction between additives

EFFECTS:



Reduced mechanical properties
(strength, impact resistance, etc.)



Reduced thermal stability
(earlier degradation, lower service life)



Loss of performance and reliability
(fails to meet specifications)



RESULT:

The material no longer meets performance requirements and safety standards.



CONVENTIONAL RECYCLING WAS NOT DESIGNED FOR ADDITIVE CIRCULARITY.



WE NEED NEW STRATEGIES TO RECOVER, PRESERVE AND REINTEGRATE FRs.



1. Context

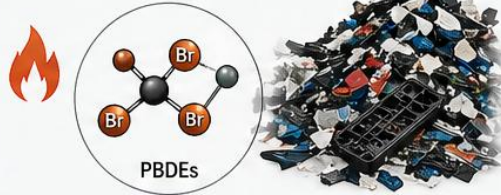
WHY CONVENTIONAL RECYCLING FAILS FOR FRs



REGULATORY BARRIERS A CRITICAL LIMITATION

LEGACY ADDITIVES:

Brominated FRs (PBDEs, etc.)



RESTRICTIONS:



REACH

Registration, Evaluation, Authorisation and Restriction of Chemicals

Many brominated FRs are restricted or require authorization



STOCKHOLM CONVENTION

Global treaty to protect human health and the environment from Persistent Organic Pollutants (POPs)

PBDEs are listed and phased out



These restrictions limit the use, trade and recycling of legacy FRs.

COMPLIANCE RISKS AND MARKET ACCESS IMPACTED.



**THE CHALLENGE IS NOT JUST RECYCLING PLASTICS,
BUT RECOVERING AND PRESERVING FUNCTIONALITY.**



FINAL CONCLUSION

MECHANICAL RECYCLING IS INSUFFICIENT



✗ DOES NOT ENABLE ADDITIVE CIRCULARITY

Additives are not recovered or reused.



✗ LEADS TO DOWNCYCLING

Loss of additive concentration and performance.



✓ ONLY PRESERVES MATERIAL (PARTIALLY)

The polymer backbone may be retained, but functionality is lost.



BOTTOM LINE

FUNCTIONALITY AND CHEMICAL VALUE
ARE LOST IN CONVENTIONAL RECYCLING.



NEED FOR ALTERNATIVE APPROACHES



SELECTIVE SEPARATION

Isolate polymers and additives using advanced physical, dissolution or separation technologies.



CHEMICAL RECOVERY

Recover additives through solvolysis, depolymerization or selective chemical processes.



FUNCTIONAL VALUE RETENTION

Regain and reintegrate functional additives to formulate new materials with performance compliance.



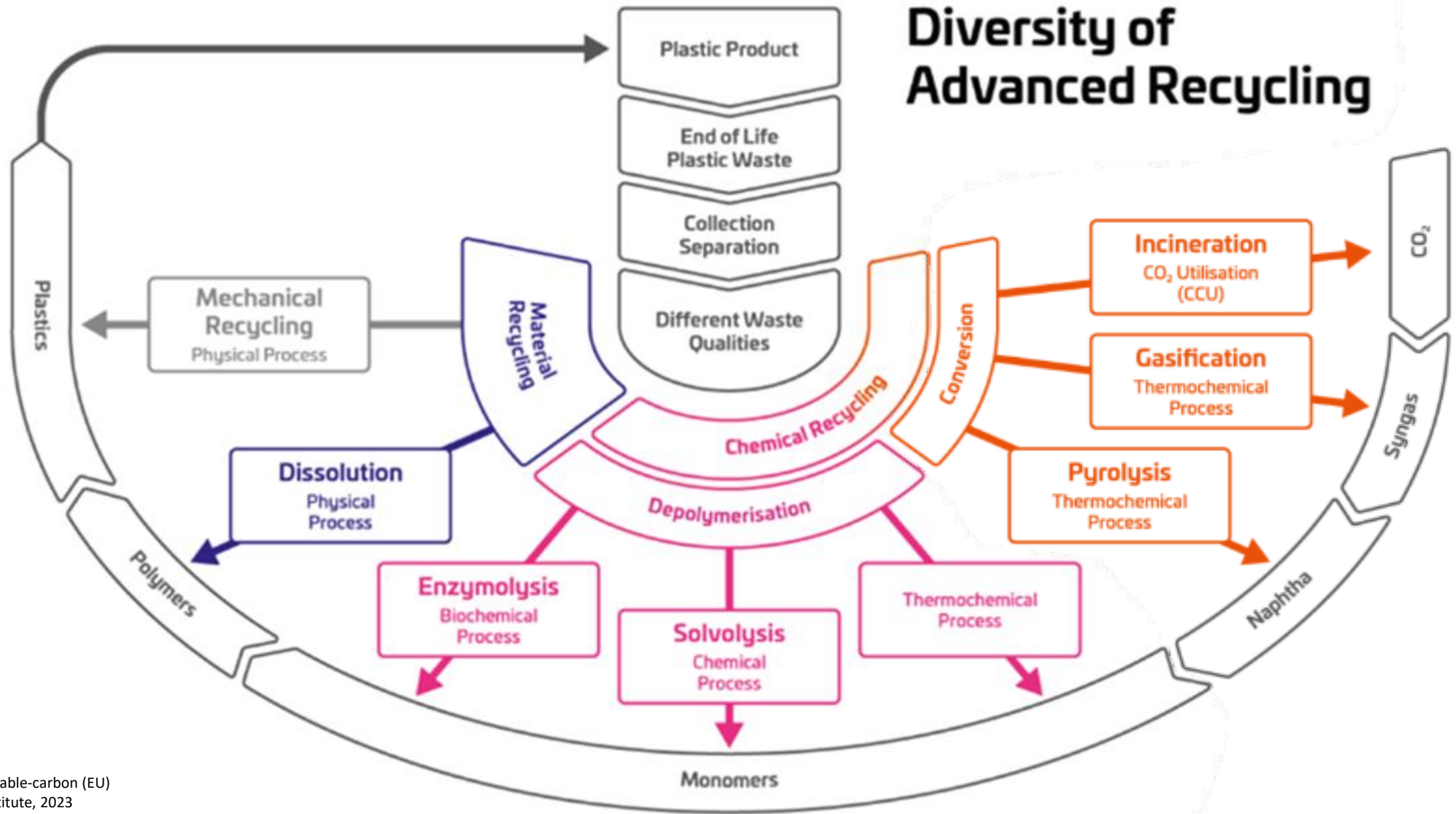
**TO CLOSE THE LOOP FOR FRs,
WE MUST GO BEYOND MECHANICAL RECYCLING:
RECOVER. PRESERVE. REINTEGRATE.**

Content



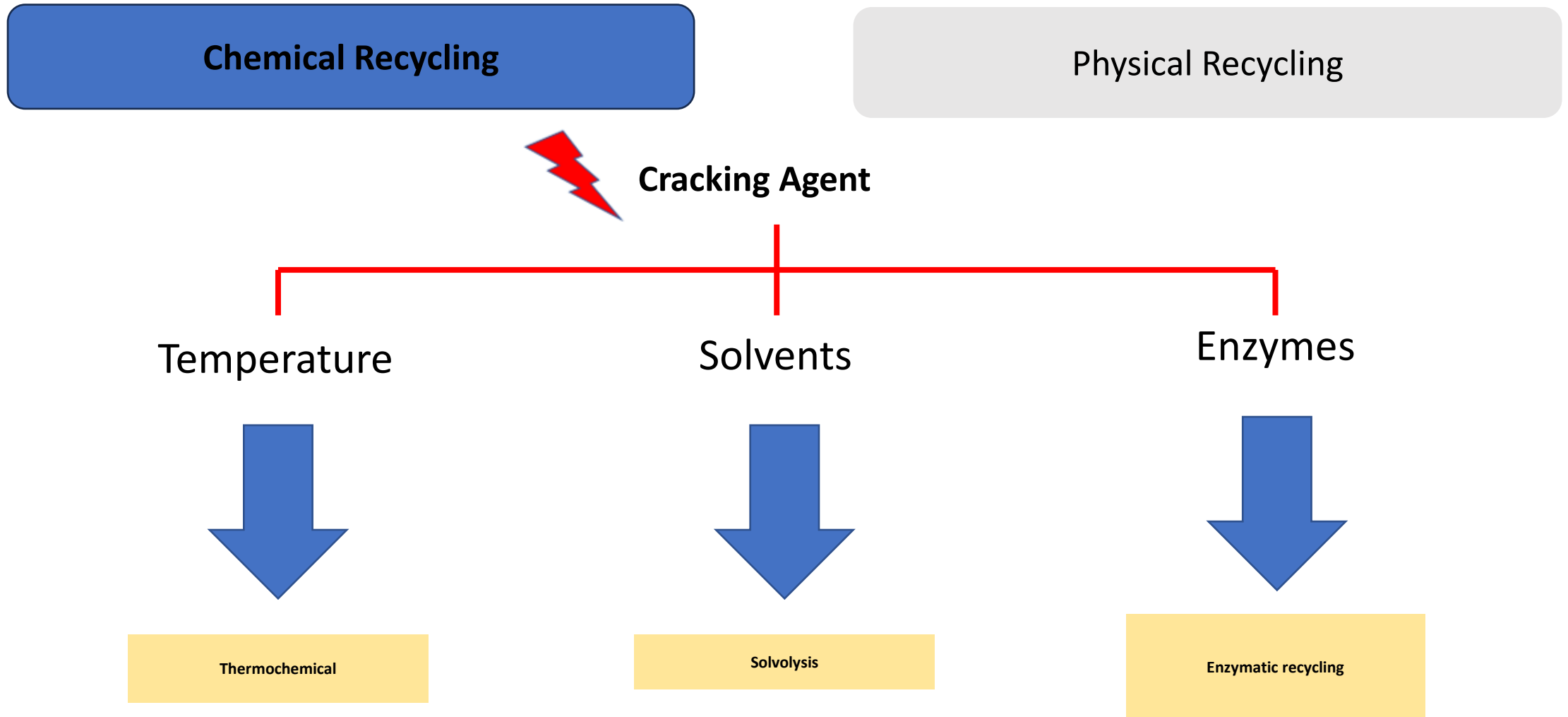
1. Context
- 2. Recycling Technologies**
3. Strategies

Recycling technologies



Source: Renewable-carbon (EU)
Nova-Institute, 2023

Recycling technologies

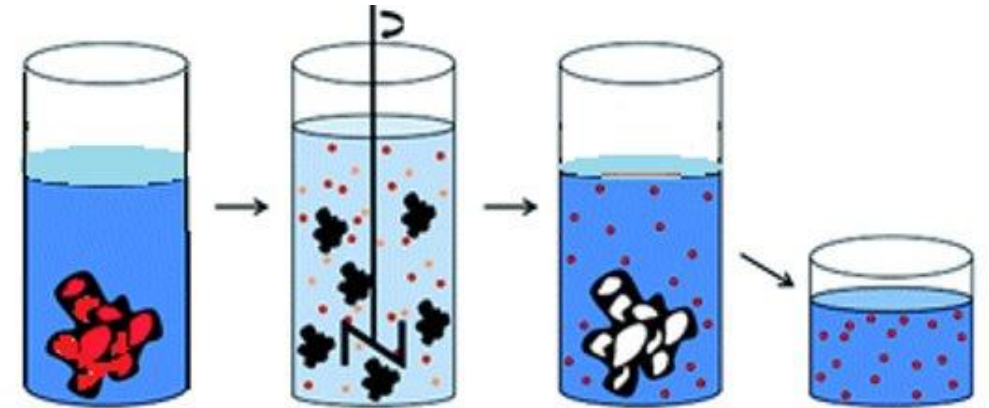


Recycling Technologies

Chemical Recycling

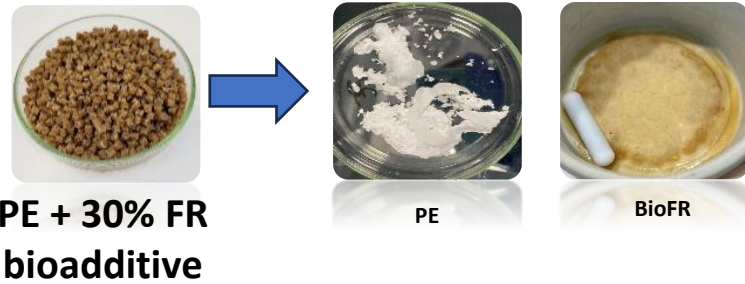
Physical Recycling

- Unlike chemical recycling, the **polymer chains aren't broken**.
- It's based on the **dissolution/precipitation method**.
- Through the action of solvents (supercritical or subcritical conditions), the following is achieved:
 - Dissolution the polymers or adhesives (multilayer materials).
 - Extraction of an additive of interest (e.g. flame retardants).
 - Elimination of inherited substances, impurities, etc.

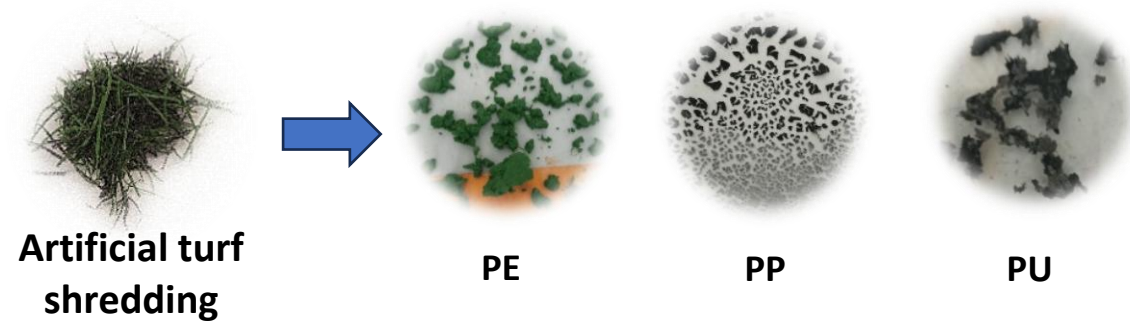


Recycling technologies

1. Recovery of additives or removal of inherited substances



3. Polymer Separation of complex waste



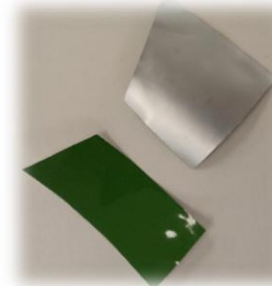
2. De-inking process:

- Elimination of inks and dyes from textile and plastic waste.
- Use of green solvents.
- Extraction at moderate temperatures and short times (through MW and ultrasonic methods)

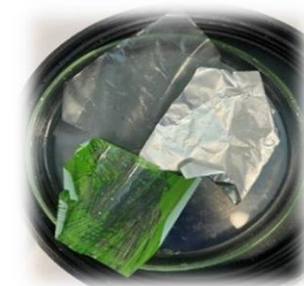


4. Delamination process

- Dissolution and extraction of adhesives.
- Delamination of multilayer materials.
- Needed for mechanical separation techniques.
- Reuse of solvents in subsequent cycles.



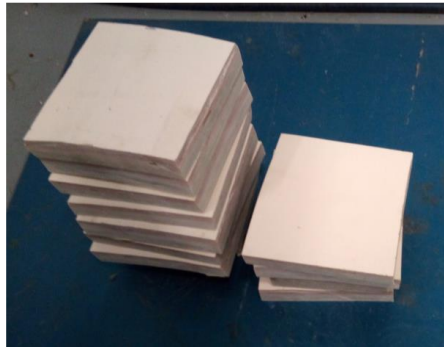
Multilayer



PET, PP, Aluminum

Recycling technologies

Resin/fiber Thermosetting Composites



Wind Blade Residues
(Glass fiber reinforced polyester resin)

THERMAL
CRACKING



Pyrolysis example:

- Char + Fibers.
- Pyrolytic Liquids.
- Gas.

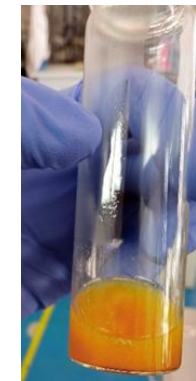
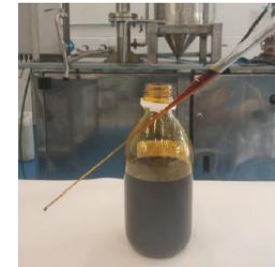
SOLVOLYSIS



- Fibers.
- Reaction crude.



Clean rGF



Content



1. Context
2. Recycling Technologies
3. **Strategies**



THE REALITY



There is no dedicated recycling route for flame retardants



No industrial process specifically designed to recover FRs

CURRENT TECHNOLOGIES ARE:



POLYMER-CENTRIC
Focus on the bulk material (polymer)



NOT ADDITIVE-CENTRIC
Additives are not targeted or recovered

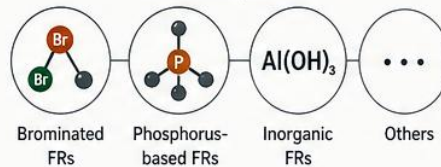


FLAME RETARDANTS ARE:

Embedded in complex matrices



Chemically diverse



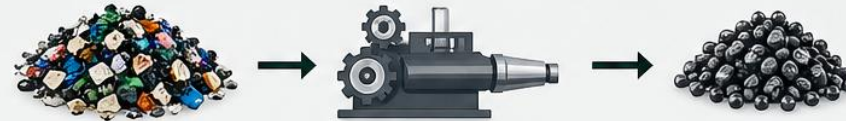
CURRENT RECYCLING SYSTEMS ARE NOT DESIGNED TO RECOVER FUNCTIONAL ADDITIVES LIKE FLAME RETARDANTS.



KEY PARADIGM SHIFT

From process-driven to chemistry-driven recycling

CONVENTIONAL APPROACH
"Apply a recycling technology"



One-size-fits-all
Technology applied without deep understanding of the system

PROPOSED APPROACH

"Understand the system, then select the strategy"



1. UNDERSTAND THE SYSTEM
Analyze composition, additives, interactions, and matrix



2. SELECT THE STRATEGY
Choose the most suitable chemistry-driven approach



3. RECOVER VALUE
Target additives and preserve functionality



4. PRESERVE PERFORMANCE
Maintain safety, regulatory compliance and functionality



RECYCLING MUST BE:



CASE-SPECIFIC



CHEMISTRY-DRIVEN

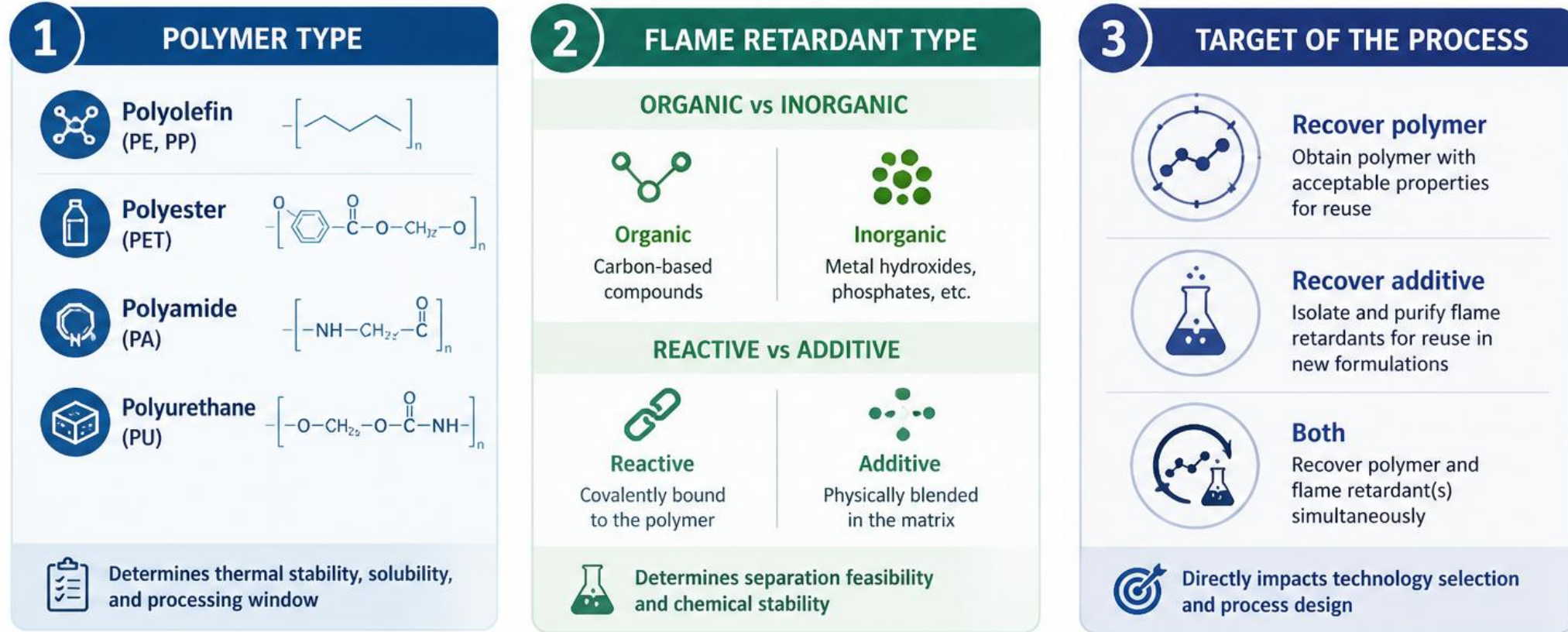


TO CLOSE THE LOOP FOR FLAME RETARDANTS, WE MUST MOVE FROM PROCESS-CENTRIC TO CHEMISTRY-CENTRIC THINKING.

Strategies

KEY PARAMETERS TO EVALUATE

Before selecting any recycling route



RECYCLING STRATEGY MUST BE TAILORED TO THE SYSTEM



No one-size-fits-all solution



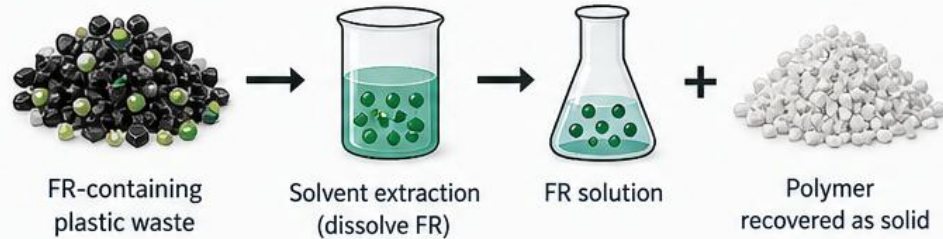
Chemistry-driven decision

Strategies

STRATEGY 1: DISSOLVE THE ADDITIVE

If the additive is selectively soluble

✓ APPROACH



✓ APPLICABLE WHEN:



⚠ LIMITATIONS

- Solvent selection critical
- Co-extraction of other additives

EXAMPLE

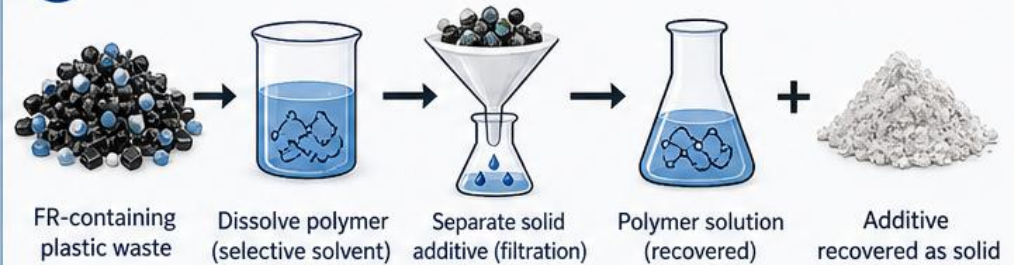


GOAL:
Recover FR in solution and polymer as solid for reuse

STRATEGY 2: DISSOLVE THE POLYMER

If the polymer is soluble and FR is not

✓ APPROACH



✓ MAY BE INTERESTING FOR:



INORGANIC FRs:
• ATH ($\text{Al}(\text{OH})_3$)
• MDH ($\text{Mg}(\text{OH})_2$)

✓ ADVANTAGE

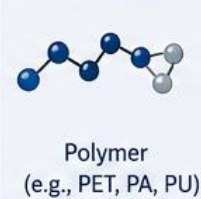


Potentially intact recovery of the additive

⚠ LIMITATIONS

- Solvent selectivity
- Solvent cost and recovery

EXAMPLE



GOAL:
Recover additive as solid and polymer in solution for reuse

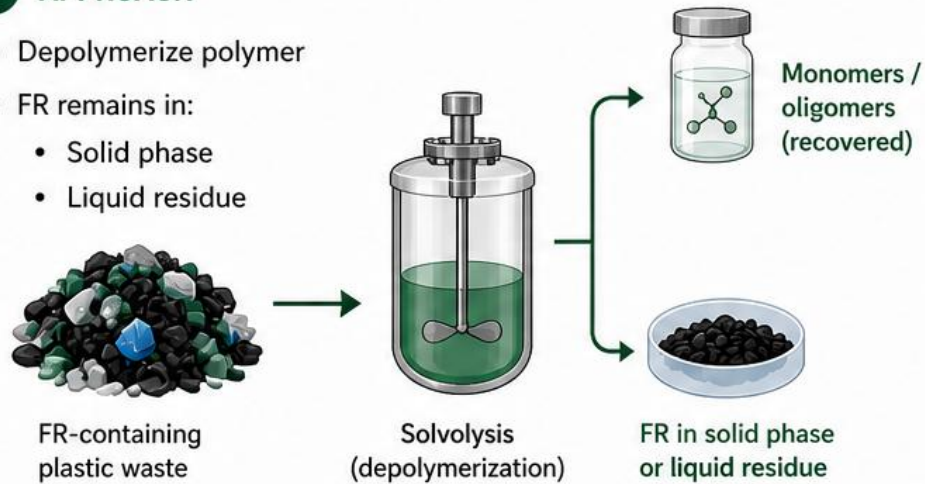
Strategies

STRATEGY 3: SELECTIVE DEPOLYMERIZATION (SOLVOLYSIS)


If the polymer can be chemically broken down

✓ APPROACH

- Depolymerize polymer
- FR remains in:
 - Solid phase
 - Liquid residue



✓ APPLICABLE TO

-  PET
-  PU
-  Polyamidas

! KEY RISKS

- Degradation of FR
- Secondary reactions



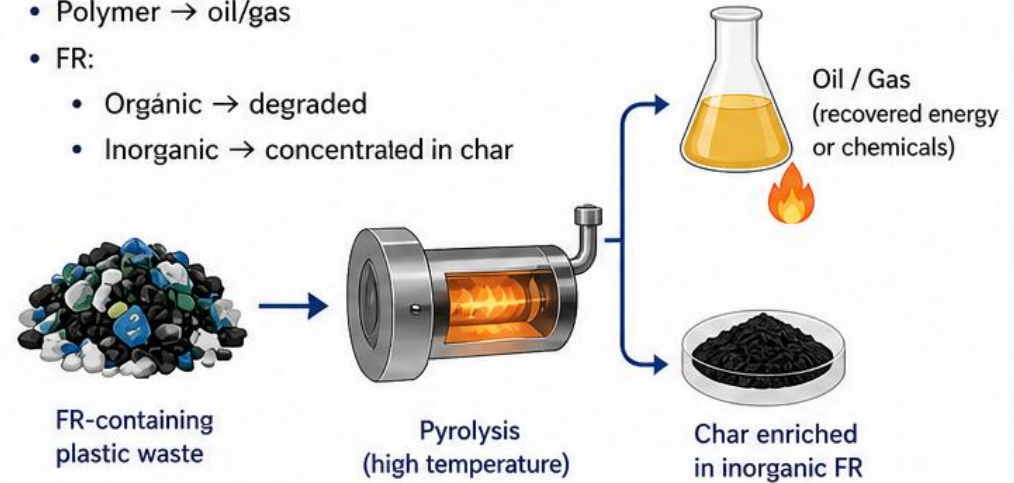
GOAL: Recover high-value monomers while retaining the flame retardant (FR).

STRATEGY 4: THERMAL ROUTES (PYROLYSIS)

When selective separation is not feasible

✓ RESULT

- Polymer → oil/gas
- FR:
 - Organic → degraded
 - Inorganic → concentrated in char



✓ OPPORTUNITY



Recovery of mineral fraction (inorganic)

! LIMITATION

- No functional recovery of organic FR



GOAL: Energy recovery and potential recovery of inorganic flame retardants.

Strategies



WHAT NOT TO DO

Applying technologies without chemical understanding

EXAMPLES:



Pyrolysis of systems with halogenated FRs without control



Solvolysis without evaluating additive stability



Dissolution without selectivity



RESULT:



Contamination



Loss of value



Non-viable processes



KEY INSIGHT

Recycling strategy must be designed, not selected



NO UNIVERSAL SOLUTION EXISTS



EACH WASTE STREAM REQUIRES:



CHEMICAL CHARACTERIZATION

Understand composition, additives, and interactions



TAILORED PROCESS DESIGN

Design the most suitable strategy for each case



THE RIGHT STRATEGY PRESERVES FUNCTIONALITY, VALUE, AND CIRCULARITY

THANK YOU VERY MUCH FOR YOUR ATTENTION.
ANY QUESTIONS OR COMMENTS?
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Questions & Answers

Thomas FUTTERER & Esther AGYEMAN-BUDU



Survey

Esther AGYEMAN-BUDU



What did you think about the webinar?



A promotional banner for a webinar. The top left features the 'pinfa | sparks' logo in white on a dark blue background. The top right has a green bar with the text 'FREE WEBINAR', 'Thursday 7 May 2026', and '14.00 - 14.45 CET'. The main title 'Closing the loop : Recycling Strategies for Flame Retardant Additives' is centered in white. Below the title is a circular portrait of Nacho Montesinos Beltrán, a man with short dark hair and a beard, wearing a dark shirt. Underneath the portrait, his name and title 'Nacho Montesinos Beltrán Chemical Recycling Technician AIMPLAS' are written in orange. At the bottom right, it says 'A sector group of Cefic' with a small blue flower icon.



More questions?
pinfa@cefic.be

...stay tuned for our
next pinfa Sparks

About Cefic

Cefic, the European Chemical Industry Council, is the forum of large, medium and small chemical companies across Europe, accounting for 1.2 million jobs and 13% of world chemicals production.

On behalf of its members, Cefic's experts share industry insights and trends, and offer views and input to the EU agenda. Cefic also provides members with services, like guidance and trainings on regulatory and technical matters, while also contributing to the advancement of scientific knowledge.

Cefic sector group 



Thank you!