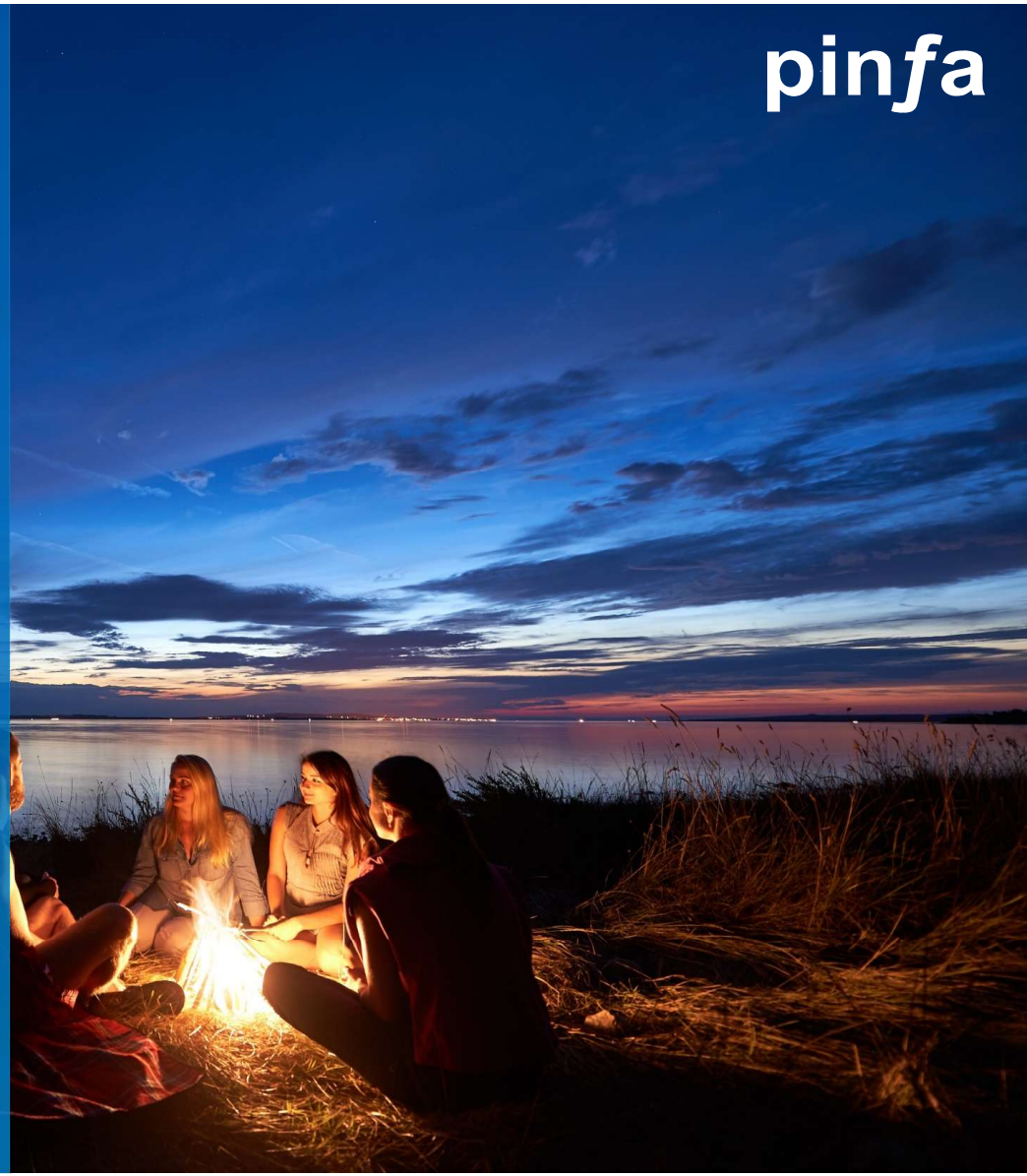
From compliance to circularity: future-proofing PIN flame retardants through sustainability, recycling and resource security

Thomas Futterer
pinfa chairman

AMI Fire Resistance in Plastics
3. November 2026



pinfa

Cefic sector group

Who is pinfa?



pinfa

Phosphorus, Inorganic & Nitrogen Flame Retardants Association

- The **Phosphorus, Inorganic and Nitrogen Flame** Retardants **Association.**
- Has 28 members: **manufacturers and users** of the three major technologies of non-halogenated flame retardants.
- Established in 2009 as a Sector Group within **Cefic**, the European Chemical Industry Council.
- **pinfa-NA** and **pinfa China**, sister associations, established respectively in 2012 and 2018.
- Mutual membership with **INEMI**[1] and partnership with **GTFI**[2], **EAPFP**[3]**, EuroFSA**[4]

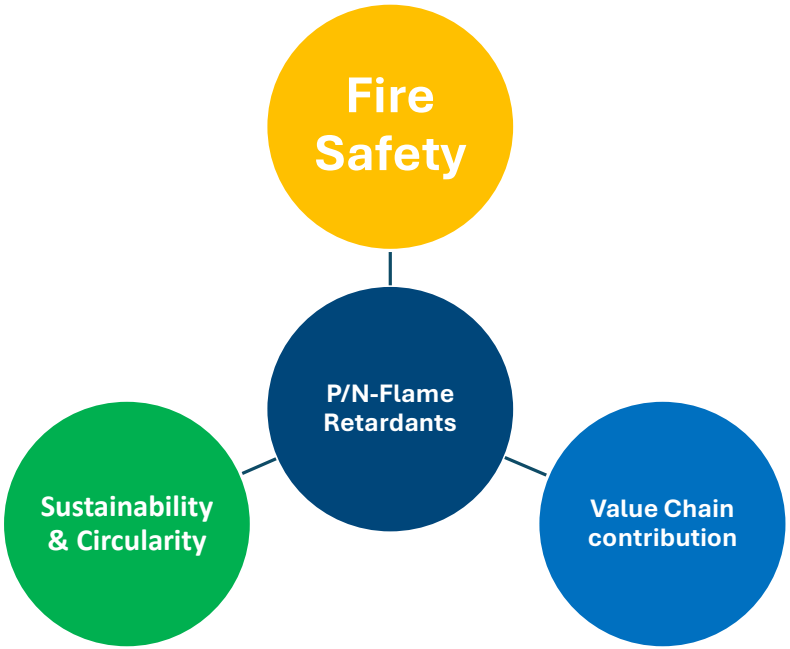
(1) International Electronics Manufacturing Initiative
(2) Groupement Technique Français contre l'Incendie
(3) European Association for Passive Fire Protection
(4) European Fire Safety Alliance

Pinfa Members: EU, China & North America



Fire Safety and Sustainability: Contradiction or Opportunity?

Future materials need to fulfil Fire safety, Sustainability and circular economy goals at the same time!





The challenge is not choosing between fire safety and sustainability/circularity. The challenge is delivering all.

Fire Safety and Sustainability: Contradiction or Opportunity?

Future materials need to fulfil Fire safety, Sustainability and circular economy goals at the same time!

Opportunities	Challenges
• **Energy transition** (EVs, batteries, renewable energy systems)	• Increasing **chemical regulation** and compliance requirements
• Renovation and **modernization of buildings** and infrastructure	• Growing dependence on **critical raw materials**
• Higher performance requirements for **modern materials** (also bio-based)	• Geopolitical and resource **security challenges**
• Need for more **resilient infrastructure** and buildings	• **Climate change** and increasing extreme weather events
• Advancing **Recycling Techniques**	• **Legacy substances limiting recycling streams**
• **Collaboration** across the value chain and fire safety community	

What is a sustainable Flame Retardant?

Hazards

- PBT: Persistence, Bioaccumulation, Toxicity
- CMR: Carcinogenicity, Mutagenicity, Reproductive Toxicity
- Endocrine effects, Mobility (new)

Life Cycle

- **Carbon footprint** (global warming potential) and other Product **Environmental Footprint** criteria
- Production (value chain): **impact on workers**
- Use Phase: **impact on consumers**
- End-of-life → Recycling properties

Other

- Critical raw materials
- Fires: Smoke formation / toxicity
- Social impact



Europe is very active on chemical regulation

Example: restriction of non-polymeric brominated FRs

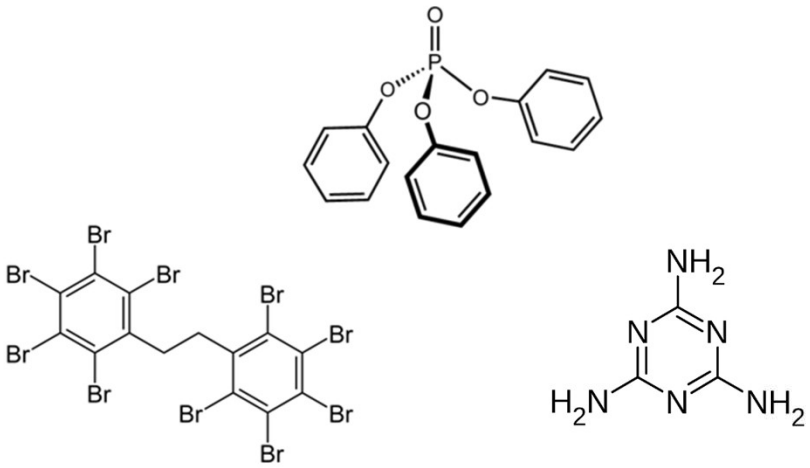
EU is going through a double twin transition: Climate neutrality, **Chemicals Strategy for Sustainability**, Circularity and Digitalization

- **Restriction report** on non-polymeric additive aromatic brominated flame retardants.
  - Plan to be submitted by ECHA December 2026
- Comprehensive **investigation report** on organophosphorus flame retardants and potential alternatives to certain aromatic brominated flame retardants.
  - Plan to be submitted by ECHA December 2027
- Pilot Project on **EU Substitution Centres**
  → HEFESTOS https://www.hefestoshub.com/

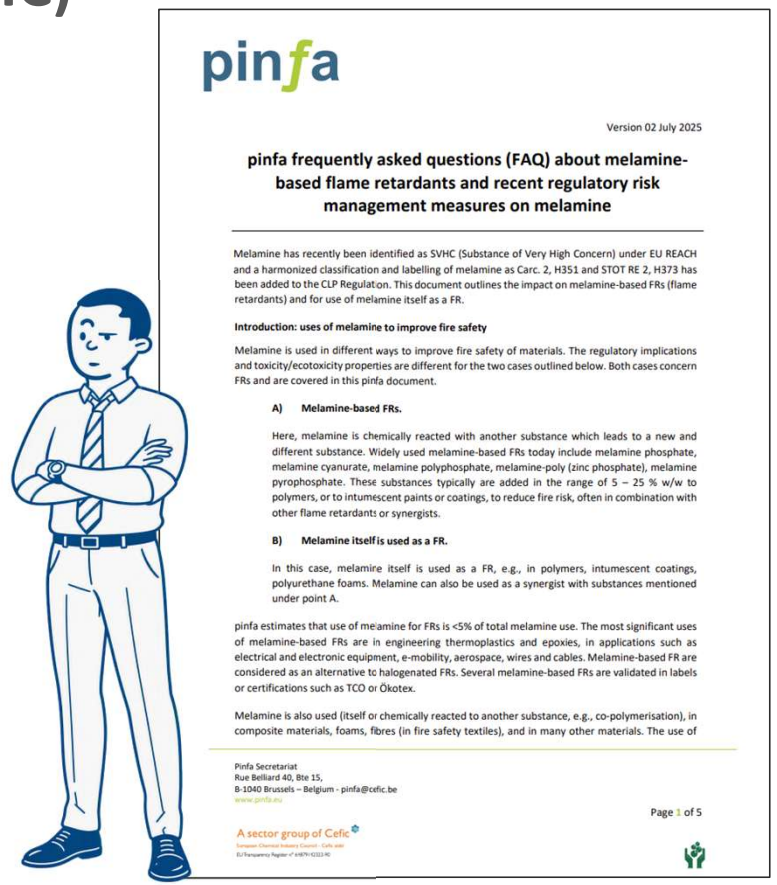


Substances of Very High Concern (SVHC)

- Decabromo diphenylethane (DBDEP)
- Triphenylphosphate (TPP)
- Melamine



➢ https://chem.echa.europa.eu/obligation-lists/candidateList



pinfa

Version 02 July 2025

pinfa frequently asked questions (FAQ) about melamine-based flame retardants and recent regulatory risk management measures on melamine

Melamine has recently been identified as SVHC (Substance of Very High Concern) under EU REACH and a harmonized classification and labelling of melamine as Carc. 2, H351 and STOT RE 2, H373 has been added to the CLP Regulation. This document outlines the impact on melamine-based FRs (flame retardants) and for use of melamine itself as a FR.

Introduction: uses of melamine to improve fire safety

Melamine is used in different ways to improve fire safety of materials. The regulatory implications and toxicity/ecotoxicity properties are different for the two cases outlined below. Both cases concern FRs and are covered in this pinfa document.

A) Melamine-based FRs.

Here, melamine is chemically reacted with another substance which leads to a new and different substance. Widely used melamine-based FRs today include melamine phosphate, melamine cyanurate, melamine polyphosphate, melamine-poly (zinc phosphate), melamine pyrophosphate. These substances typically are added in the range of 5 – 25 % w/w to polymers, or to intumescent paints or coatings, to reduce fire risk, often in combination with other flame retardants or synergists.

B) Melamine itself is used as a FR.

In this case, melamine itself is used as a FR, e.g., in polymers, intumescent coatings, polyurethane foams. Melamine can also be used as a synergist with substances mentioned under point A.

pinfa estimates that use of melamine for FRs is <5% of total melamine use. The most significant uses of melamine-based FRs are in engineering thermoplastics and epoxies, in applications such as electrical and electronic equipment, e-mobility, aerospace, wires and cables. Melamine-based FR are considered as an alternative to halogenated FRs. Several melamine-based FRs are validated in labels or certifications such as TCO or Ökotex.

Melamine is also used (itself or chemically reacted to another substance, e.g., co-polymerisation), in composite materials, foams, fibres (in fire safety textiles), and in many other materials. The use of

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A sector group of Cefic

➢ *pinfa frequently asked questions (FAQ) about melamine-based flame retardants and recent regulatory risk management measures on melamine:* pinfa-Melamine-based-FRs_QA.pdf

From Regulatory Scrutiny to Sustainable Alternatives

Contributing to the development of lower-hazard solutions for future applications.



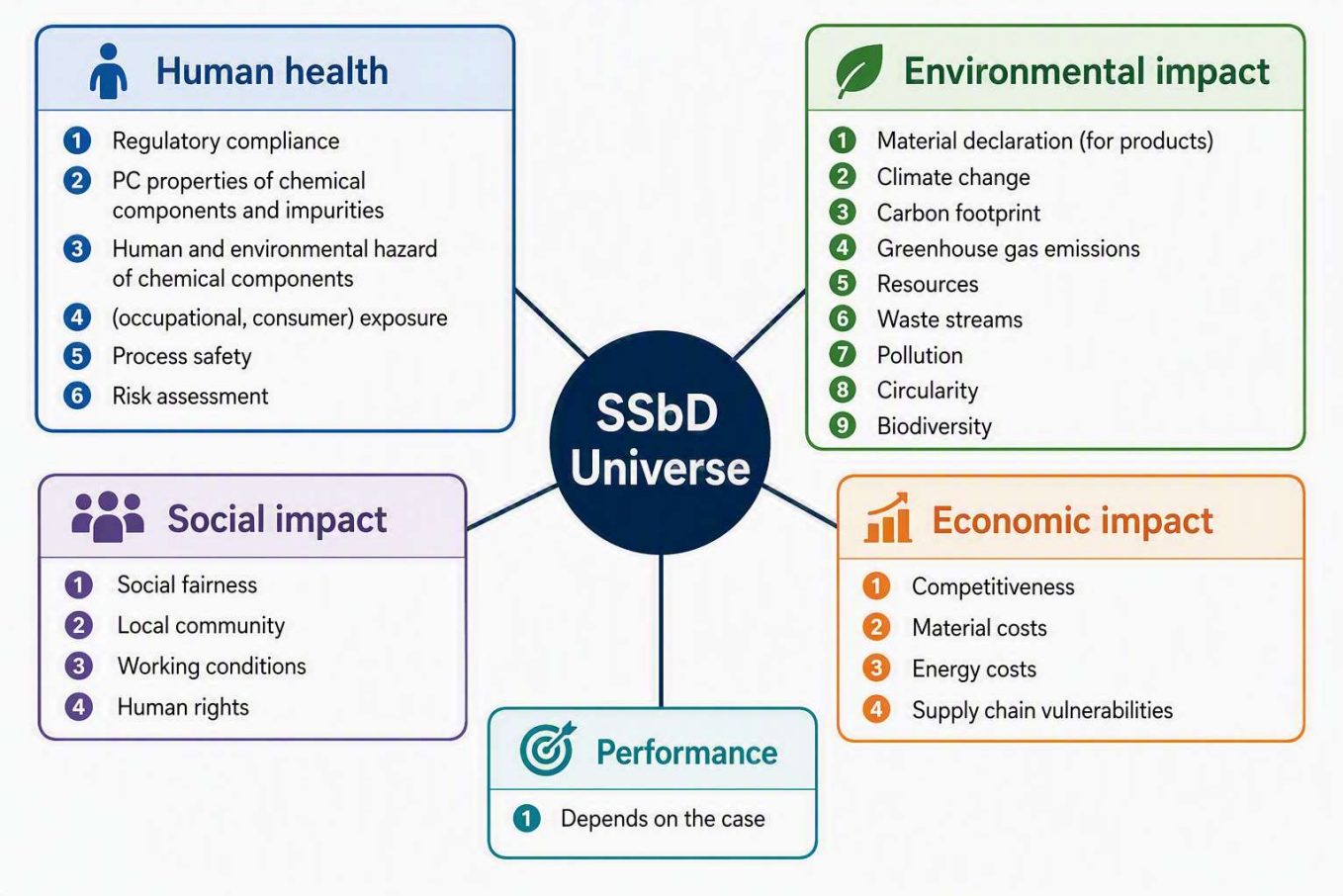
"Thus, based on the current information, groups of low or unlikely hazards can be identified such as:

- *Non-cyclic alkyl aryl esters of phosphoric acid,*
- *Other hydrogenphosphonates and alkyl phosphonates, their salts and esters, and*
- *Dibenzo oxaphosphorine oxide derivatives (DOPO derivatives)*
- *Hydrocarbyl phosphinates"*

***Inorganic phosphates, polyphosphates, phosphinates, phosphonates and phosphorus and its inorganic salts** have been assessed with **low hazard and no further EU regulatory risk management need**."*

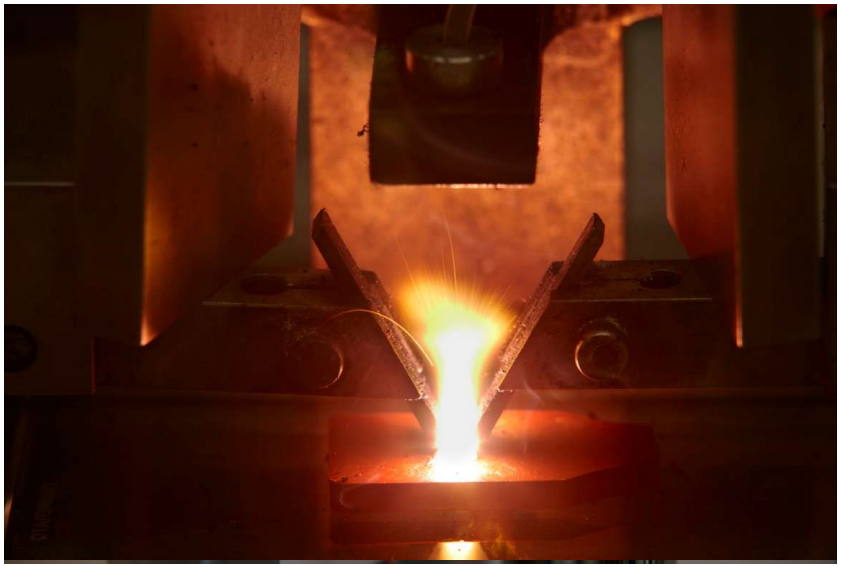
ECHA Flame Retardants Strategy 2023-03

Safe and Sustainable by Design Framework (SSbD) Indicators and criteria



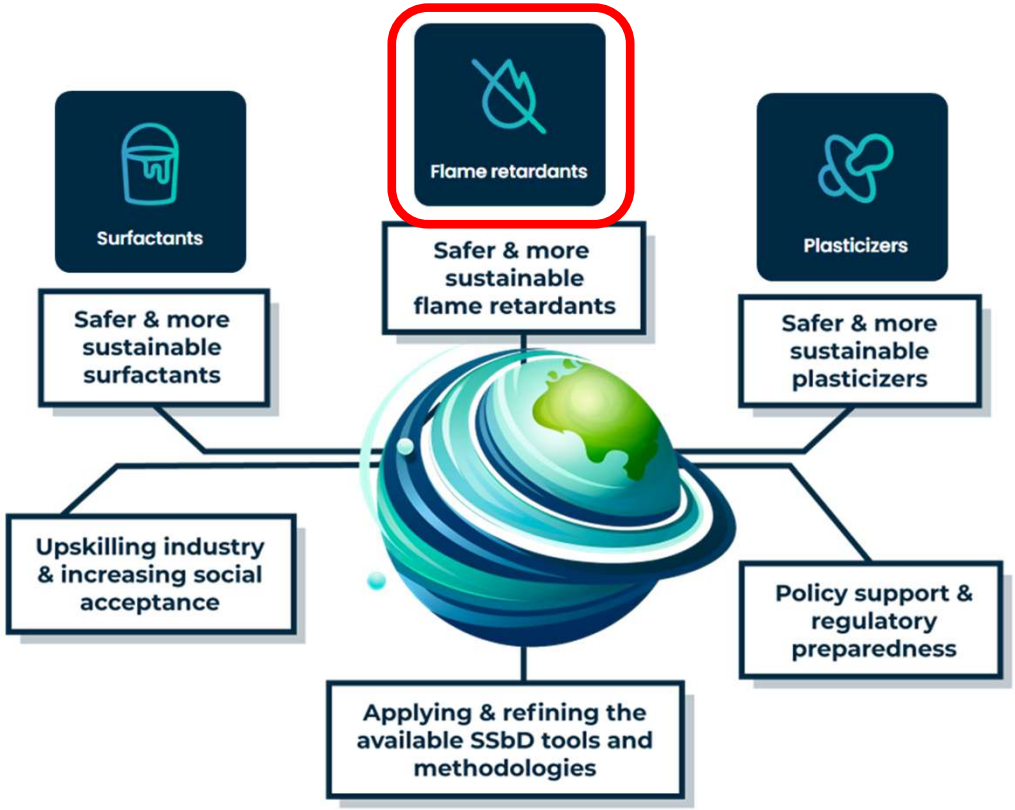
Increasing performance requirements for Flame Retardants

Property	Example
Flammability performance	UL 94 V0 + Glow wire ignition temperature 775 °C (GWIT)
Miniaturization – thinner cross sections	0.8 → 0.4 mm in UL 94 test
Mechanical properties	Elongation at break
Electrical properties, also after ageing	High dielectric strength & resistivity 150 °C / 1000 h
High Comparative Tracking Index (CTI)	> 600 V
Recycling	Using regrind up to 25%



CTI Test, photo: ©Clariant

PLANETS: Example for Designing Safe and Sustainable by Design (SSbD) Flame Retardants



PLANETS

Funded by the European Union

This project received funding from the European Union's Horizon Europe research and innovation programme under grant agreement n° 101177608. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Safe and Sustainable by Design (SSbD) Planets: Flame Retardants Case Study

48 Months duration	18 International partners	7 Countries involved	14.5 Mio. € budget



Materials used in Buildings and Construction

- **WHAT**: FRs are chemicals designed to prevent materials from igniting or to slow down the burning process
- **CHALLENGE**: General health and safety concerns regarding low molecular-weight halogenated flame retardants for foam application e.g., SR130, FR720, TCPP
- **PLANETS APPROACH**: Flame-retardant thermoplastic and thermoset foams containing new flame retardants developed by the Safe-and-Sustainable-by-Design approach = **safe for humans & environment!**

Enabling Fire Safety Without Compromising Circularity

Supporting Circular Material Systems

- End-of-Life Vehicles Regulation (proposal): **Mandatory recycled plastic content for vehicles.** Target 2030: 25 % PCR, including 6 % coming from closed loop.
- Circular economy considerations are increasingly integrated into discussions on material design, use and end-of-life management.
- **Fire safety and circularity should be addressed together** to enable sustainable products across multiple sectors including **construction, electronics, batteries and renewable energy**.
- **pinfa contributes through technical exchange**, stakeholder engagement and dissemination of scientific knowledge.



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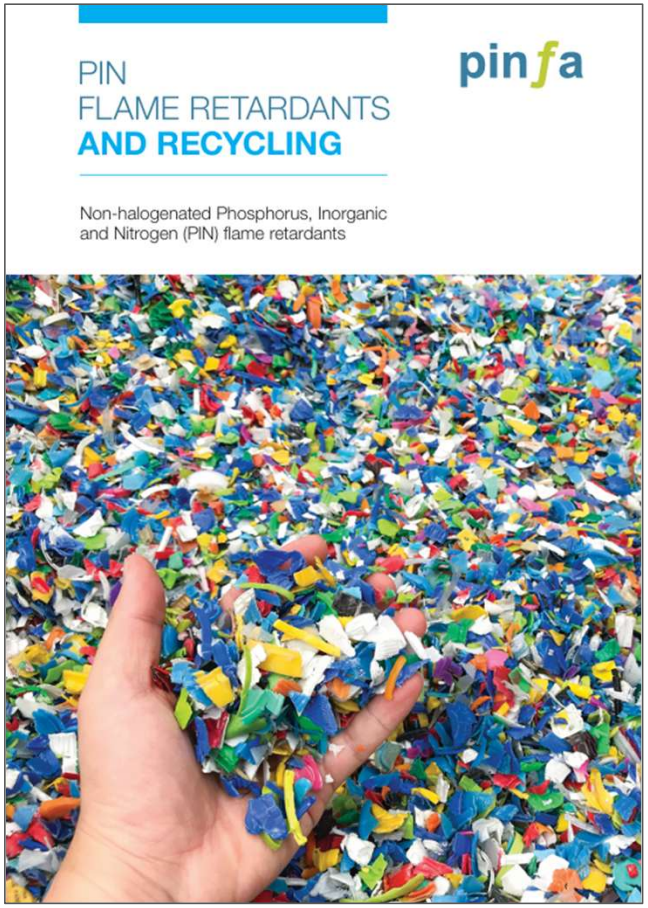
Enabling Fire Safety Without Compromising Circularity

Advancing Knowledge on Recycling of Flame Retarded Materials

- Emerging Areas
  - Design for recycling
  - Material identification and sorting
  - Maintaining fire performance in recycled materials
  - Enabling high-value recycling pathways
  - Providing scientific input to regulatory discussion

- PINFA – FRAUNHOFER LBF: Test of Recycling Pin Flame Retardant Plastics

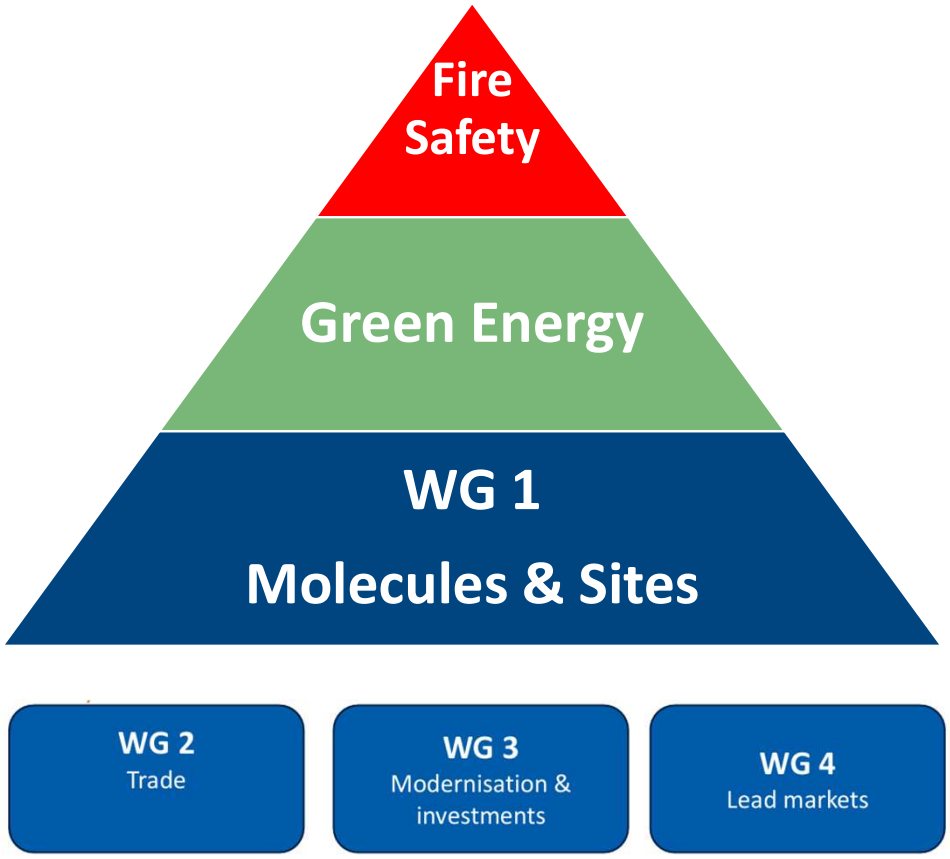
POLYMER	PIN FLAME RETARDANT(S)	PROCESSING	PROCESSING TEMPERATURE
PP (polypropylene)	30% APP (ammonium polyphosphate)	Injection moulding (pellets)	230°C
	27.5% piperazine pyrophosphate	Injection moulding (pellets)	200°C
	0.5% Triazine derivative	Extrusion (film)	210°C
	1% N-alkoxy hindered amine	Extrusion (film)	210°C
LLDPE (low density polyethylene) + 5% coupling agent	60% ATH (aluminium trihydroxide)	Injection moulding (pellets)	140 -165°C
	62% ATH + 3% sepiolite	Injection moulding (pellets)	140 -165°C
Polyamide PA66 with 30% glass fibre	20% DEPAL (aluminum diethyl phosphinate)	Injection moulding (pellets)	290°C
Polyamide PA6 with 30% glass fibre	20% DEPAL (aluminum diethyl phosphinate)	Injection moulding (pellets)	270°C
	10% melamine cyanurate	Injection moulding (pellets)	230°C
PC/ABS (80/20)	12% phosphate ester	Injection moulding (pellets)	260°C



Key Raw Materials and Fire Safety

Strengthening the European Chemical Industry

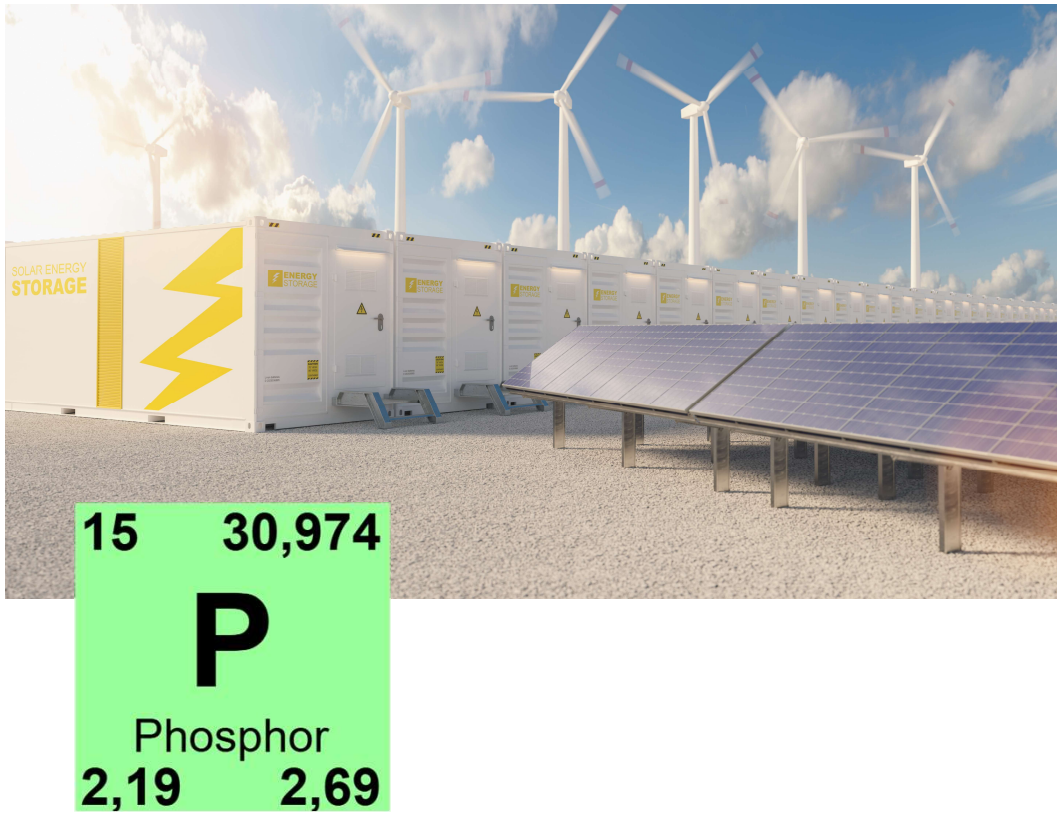
- CCA (Critical Chemicals Alliance) is a **key initiative under the European Chemicals Industry Action Plan** adopted in July 2025 and started October 2025
- High-level members of the alliance from industry, Member States and regional authorities are involved
- The plan provides a strategic framework to modernize and **strengthen the competitiveness, resilience and sustainability** of Europe's chemicals sector, a cornerstone of the EU economy
- The alliance aims to **address global trade challenges, including unfair competition and supply chain dependencies**



Key Raw Materials, Renewable Energy and Fire Safety

Strengthening the European Chemical Industry

- **Elemental phosphorus (P4)** has been investigated as it is a potential key molecule, highlighting its importance for European industrial value chains.
- **Phosphorus-based chemicals enable strategic** sectors, including **battery technologies**, electronics & semiconductors, **renewable energy systems** and **fire-safe materials**.
- **Phosphorus flame retardants are essential for meeting fire safety requirements** in polymers, cables, electrical & electronic equipment, batteries and infrastructure applications.
- The assessment by CRMA illustrates the growing **connection between key raw materials, resource security, industrial resilience and fire safety** in support of Europe's green and digital transition.



PINFA Membership Invitation

Interested in the Future of Flame Retardancy? Join Pinfa!

The **voice** of flame retardants manufacturers and users. **Why join?**

- **Network** with industry leaders
- Impact on **policy & regulation**
- Advance **sustainable fire safety solutions**

Members include:
Plastics processors & converters • Compounders • Resin & thermoset producers • Adhesives & coatings manufacturers • Flame retardant producers • Associations



www.pinfa.eu

Thank you.

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About Cefic

Cefic, the European Chemical Industry Council, founded in 1972, is the voice of large, medium and small chemical companies across Europe, which provide 1.2 million jobs and account for 15% of world chemicals production. Cefic members form one of the most active networks of the business community, complemented by partnerships with industry associations representing various sectors in the value chain. A full list of our members is available on the Cefic website.
Cefic is an active member of the International Council of Chemical Associations (ICCA), which represents
chemical manufacturers and producers all over the world and seeks to strengthen existing cooperation with global organisations such as UNEP and the OECD to improve chemicals management worldwide

Cefic sector group

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Transparency Register n°64879142323-90

