pinfa
Phosphorus, Inorganic & Nitrogen Flame Retardants Association

Your newsletter for non-halogen fire safety solutions n° 183 July 2026

PINFA IN ACTION

Webinar summary: upgrading recycling

Polyvel shared expertise and experience of upgrading recycled plastics, with Madeline Daecher and Dean Dodaro. pinfa North America webinar. Polyvel, is a US-based extrusion compounder specialised in additive masterbatches and custom formulations, delivering pellets for production of textiles, films and injection moulding. Demand for recycled plastics is increasing with regulatory or customer-specified recycling content targets. Re-compounding of post-consumer plastics poses demanding challenges, including lack of consistency and material unpredictability (even well sorted streams can contain 10 -20% of unintended polymer alongside the main polymer), contaminants (organic materials, heavy metals, brominated FRs), polymer deterioration and cost compared to virgin plastics. A range of targeted specialist additives can mitigate these challenges, including stabilisers (prevent polymer chain deterioration in re-processing), chain extenders (mitigate polymer deterioration), melt flow facilitators (reduce chain length or cross-linking), a range of odour managers using different pathways, compatibilisers (for mixed polymers), optical brighteners, lubricants, processing aids, desiccants … Flame retardants can ensure fire safety of recycled compounds, but with specific challenges such as unpredictable higher flammability compared to virgin polymer packages resulting from unintended additives or fibres in the input stream. Re-compounding performance can be improved by modular extrusion equipment equipped to provide feedback on additive behaviour during processing and real-time adjustment. Additive packages are optimised by collaboration with both customers, as regards requirements and tolerances, and with recyclers, to adjust collection and sorting where possible.

"Enhancing Recycled Plastics with Additive Solutions", free pinfa-NA webinar: Wednesday 17th June 2026. Watch online: https://www.pinfa-na.org/

pinfa Newsletter
pinfa, rue Belliard 40, B-1040 Brussels, Belgium
pinfa@cefic.be www.pinfa.org

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FIRE SAFETY

Testing of nightclub fire acoustic foams

Fire tests of non-FR polyurethane foam involved in nightclub fires show rapid ignition, high heat and smoke release.

The fire at Kiss Nightclub, Rio Grando do Sul, Brazil, in January 2013, killed 242 people and directly injured 636, excluding broader psychological and emotional impacts. Non flame retarded flexible polyurethane foam ceiling materials ignited by the band's pyrotechnics contributed to the fire tragedy. Analysis has concluded that if the foam had respected national fire safety standards, and with adequate safety exits, all deaths would have been avoided (see pinfa Newsletters n°s 137, 133). Similar causes have been identified in other nightclub fire tragedies: pyrotechnics, acoustic foam, overcrowding, inadequate safety exits, non-compliance with regulations or absence of permit (indicative list of nightclub fires here).

Evidence to the Kiss Nightclub police investigation report suggests that the foam installed for acoustics over the stage was not conform to building fire safety requirements (not FR), and was purchased as mattress foam and installed by non-qualified personnel.

Samples of polyurethane foam from the Kiss Nightclub and similar commercially procured foams were used in these fire tests, in preparatory small-scale tests and in two full-scale tests, in reconstructions of the Kiss Nightclub stage and dance floor. The full-scale tests were initiated by pyrotechnic devices positioned at height of a human hand as in videos of the actual fire.). The tests showed that two different FR foams did not ignite when exposed to sparks from the different pyrotechnic devices, whereas two out of three mattress foams did ignite. When exposed to flames, one of the two FR foams continued to show no burning and no smoke.

Polyurethane foam representative of that installed in the Kiss Nightclub showed peak heat release rate (pHRR) of 2465 kW, total heat release of 142 MJ and total smoke release of 259 m^2 (NFPA 286).

"Burning Behavior of Polyurethane Foam Acoustic Insulation used in the Kiss Nightclub Fire", R. Almeida Freitas, J. Rodriguez, Architecture, Structures and construction (preprint) 2026
https://doi.org/10.21203/rs.3.rs-9416055/v1

Photo: Kiss nightclub fire Shutterstock 2254416065

EU CPR fire performance updates

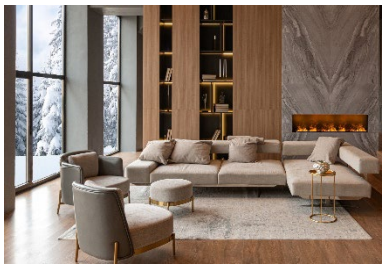
New rules now in force clarify declaration of reaction to fire and structural fire resistance of EU construction products. EU 2026/557, on fire resistance (maintenance of structural integrity and function), entered into force on 23rd June 2026 and EU 2026/331, on reaction to fire, entered into force on 11th May 2026. These are the first two steps in the definition of key horizontal characteristics intended by the revised Construction Products Regulation EU 2024/3110 (see pinfa Newsletter n°170). 2026/557 maintains continuity with the previous 305/211, so minimising industry and regulatory disruption. The tests were already in place, but are now harmonised, preventing the use of older or different national tests. These regulations provide the basis for EU harmonised declaration of product fire safety characteristics, under the CPR, so will contribute to legal certainty, market clarification and standardisation across Europe. Reaction-to-fire classification requires flame retardant use in many materials, and the CPR's performance-based approach will enable innovation in PIN flame retardant solutions.

Commission Delegated Regulation 2026/331 of 13 February 2026 "supplementing Regulation (EU) 2024/3110 of the European Parliament and of the Council by determining classes of performance in relation to the essential characteristic reaction to fire" https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=OJ:L_202600331

Commission Delegated Regulation 2026/557 of 16 March 2026 "supplementing Regulation (EU) 2024/3110 of the European Parliament and of the Council by determining classes of performance in relation to the essential characteristic resistance to fire" https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=OJ:L_202600557

Photo: Shutterstock 497522995

FURNITURE FIRE SAFETY



pinfa input UK furniture fire safety

pinfa opposes the UK's proposal to move backwards on furniture fire safety underlining that safe PIN FRs are available (see list submitted below). pinfa underlines the increasing fire risks in homes from ubiquitous electronics, electronics chargers, cables and batteries, often near or underneath furniture, and from an ageing population.

pinfa suggests that the UK retain at least an open flame fire safety requirement for domestic furniture, because the proposed smouldering cigarette test fails to reflect real furniture fire risk because many synthetic materials (especially furniture covering textiles) pass the test not by resisting fire but by melting away from the heat source in the test. In real furniture, the heat source would then contact other materials, in particular highly flammable cushioning foams.

pinfa notes that with smoulder test only requirements in place in Europe, furniture is the most common cause of home fires leading to deaths in The Netherlands (Lieuwe de Witte, 2020) and in the USA (NFPA, 1/8/2025) and that data suggests a slow increase in fire deaths in the USA since 2013 when TB117 was downgraded to cigarette test only.

UK Furniture Fire Safety Consultation, closed 23 June 2026
https://www.gov.uk/government/consultations/product-regulation-fire-safety-of-domestic-upholstered-furniture

Photo: Shutterstock 2152134547

Furniture PIN FRs accepted to be safe

pinfa has prepared a list of non-halogenated flame retardants considered to be safe: TCO or Ökotex or not Classified for heath/environment (or lose the Classification on application). This is included in pinfa's submission to the UK Government consultation on furniture fire safety, see above.

Photo: Shutterstock 2760956279

Comments or additions are welcome:

PIN flame retardants used in furniture and accepted to be safe

	Health or environment Classifications	TCO* accepted	ÖkoTex** accepted
Bisphenol A diphosphate	NO	YES	
Tetrakis (2,6-dimethylphenyl)-m-phenylene biphosphate	NO	YES	
Siloxanes and silicones, di-Me, di-Ph, polymers with Ph silsesquioxanes	NO	YES	
Phenoxyphosphazene / hexaphenoxycyclotriphosphazene (HPCP)	NO	YES	
Polyphosphonates	NO		YES
Phosphonic acid, (3([hydroxymethlyl]amino)-3-oxopropyl-dimethyl ester	NO	YES	
Reaction mass of 3-[(diphenoxyphosphoryl)oxy]phenyl triphenyl 1,3-phenylene bis(phosphate) and tetraphenyl 1,3-phenylene bis(phosphate)	NO	YES	
Proprietary organosphorus-based flame retardants	NO		YES
Ammonium polyphosphate	NO	YES	
Melamine polyphosphate	NO	YES	
N-alkoxy hindered amine	NO		YES

** TCO the health, environment and worker protection label https://tcocertified.com/*
*** ÖkoTex https://www.oeko-tex.com/en/our-standards/standard-100-by-oeko-tex*

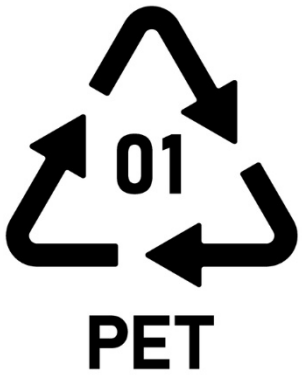
LCA says furniture foam FR health positive

LCA study of a sofa with and without melamine as FR in foam concludes overall health benefits of FR use, comparing toxicity risk of FR presence to health impacts of avoided fires. The study models a three-seat sofa with wooden frame, polyurethane foam cushions and armrest foams, synthetic leather upholstering and ABS stands, with or without 10% melamine in the foam. LCA covers manufacturing (with and without FR), use and end of life (municipal incineration with energy recovery). The main impacts on the LCA are from production of the wooden frame, production of the polyurethane foam and end-of-life disposal. The FR has little impact on these. The fire prevention benefit of fire-resistant sofas is estimated at 1.2 person fatalities per million sofas per year (from Runefors 2023). Health risk of melamine, taking into account its Classification, is based on USEtox (UNEP LCA Initiative), is "negligible". The reduction in health impacts of the sofa over its life cycle, from inclusion of the flame retardant, are estimated at 72 - 84%.

"Are melamine flame retardants in sofas beneficial from a life cycle perspective?", R. Aggarwal et al., RSC Sustainability, 2026, 4, 1593 https://doi.org/10.1039/d6su00022c The authors declare no conflict of interest.

Photo: Shutterstock 2634260281

RECYCLING

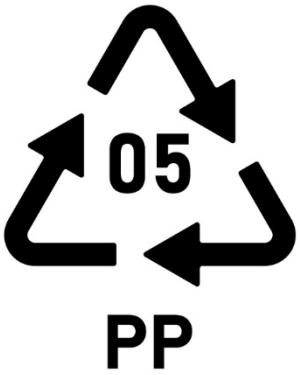


Recycling PET to carbon dot PIN FRs

Post-consumer bottle PET was one-step recycled to c. 2 nm functionalised carbon spheres, tested as PIN FR in PBT. The PET was shredded, cleaned and dried, then reacted with ethanolamine (1500 g PET to 975 ml MEA) at 280°C for 18 hours (pyrolysis). Resulting sold was filtered, dried and ground. This generated 'carbon dots': near-spherical carbon spheres with average diameter 2 nm, rich in surface functional groups (carboxyl, hydroxl …). 5% loading of the carbon dots in poly butylene terephthalate (PBT) reduced peak heat release rate by nearly 30% and increased LOI by nearly 50% (compared to neat PBT). The carbon dots are considered to act by developing protective surface char on the PBT (because of the surface functional groups) and by releasing CO_2 and by delaying decomposition and so burning of the PBT

"Kilogram-scale upcycling of waste poly(ethylene terephthalate) into carbon dots as efficient flame retardants for poly(butylene terephthalate) composites", M. Chaohui et al., Polymer Degradation and Stability 249 (2026) 112087 https://doi.org/10.1016/j.polymdegradstab.2026.112087

Image: Shutterstock 2648629303



PIN FR effective in recycled polypropylene

An intumescent phosphorus-nitrogen PIN FR showed to be effective in both virgin and re-extruded PP (UL 94 V-0 3.2mm). Recycled PP was lab simulated by eight times re-extrusion at 210°C, so without any other polymers or contaminants likely to be found in real secondary PP streams. A PIN intumescent FR package of piperazine pyrophosphate and melamine polyphosphate (2:1) was added to virgin and to the re-extruded PP then fire and mechanical performance tested. Reduction in heat release rate was similar, but the PIN FR re-extruded PP showed a longer time to ignition, apparently resulting from denser char, maybe because of better dispersion of the FR due to lower viscosity of the re-extruded PP. The mechanical properties of the FR re-extruded PP were not compromised, other than a slight reduction in ductility. The authors conclude that multiple re-extruded polypropylene can be used in PIN flame retardant applications.

"Is Recycled Polypropylene Suitable for Flame-Retarded Applications?", G. Bernagozzi, ACS Applied Polymer Materials 2026
https://doi.org/10.1021/acsapm.6c00885

Image: Shutterstock 2648629303

NEW PRODUCTS

Envalior PIN FR biobased plastic

Siemens electrical coupling relays use plastic from 70% used food industry frying oil with PIN flame retardants. The 70% bio-based non-halogenated flame retardant polyamide 6 is supplied by pinfa member Envalior. It offers heat and chemical resistance and UL 94 V-0 fire performance (0.4 mm). The used cooking oil is no longer suitable for animal or human consumption, and Envalior's use to produce engineering plastics avoids incineration. The Siemens industrial electrical relays, designed to integrate with Siemens control systems, are compact, benefitting from the thin-wall PIN fire safety of the Envalior housing material, and offer performance including for B10d (failure rate), ATEX certification (explosive atmospheres), low current rail applications, long lifetime, Siemens EcoTech label.

"From frying oil to coupling relays: Siemens and Envalior collaborate on more sustainable electrical products", 10th October 2025
https://press.siemens.com/global/en/pressrelease/frying-oil-coupling-relays-siemens-and-envalior-collaborate-more-sustainable

Photo for illustration not using cited products: Shutterstock 2198185421

Polysiloxane for PIN FR olefins

Silma's multi-function PIN synergist for thermoplastic olefins improves fire performance, processing and compatibility. The non-halogenated liquid additive, without solvents, is effective in thermoplastic olefins (including EVA, LDPE, LLDPE, peroxide cured rubbers …) without modifying mechanical properties at typical dosages of 0.5 – 3%, and also in XLPE as a silane synergist. It acts as a lubricant improving processing and improves fire performance by increasing char and LOI (limiting oxygen index) and reducing heat and smoke release. By acting as a coupling agent and by improving filler – polymer bonding, it improves elongation at break, tear strength and crack resistance. It is especially effective in cable compounds with inorganic PIN FR loadings (MDH, ATH), improving processing (reduced energy consumption in extrusion, reduced die drool) and improving surface quality.

"SILMALINK AR 1025" https://www.silmaster.com/en/product/ar1025/

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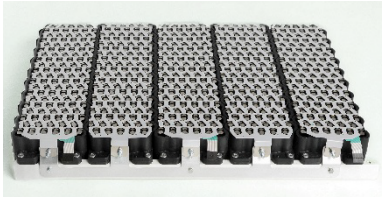


PIN FR polymers for EV applications

RadiciGroup (pinfa member) offers high-performance PIN flame-retardant plastics for demanding applications including metal replacement, in automotive, e-mobility and electrical and electronics applications. High end engineering polymers enable lightweighting and design flexibility, in which RadiciGroup's PIN flame retardant packages ensure non-halogenated fire safety. These products can include recycled polymer and for that reason, are particularly attractive in view of the upcoming introduction of the new European regulation on End-of-Life Vehicles (ELVs). RadiciGroup's glass-fibre reinforced PIN FR polyamides (PA6, PA66) for injection moulding can achieve UL 94 V-0 (down to 0.4 mm) and GWI 960°C with mechanical resistance and high electrical insulation.

"RadiciGroup showcases metal replacement and recyclable solutions at PLAST 2026", June 2026
https://www.specialchem.com/plastics/news/metal-replacement-and-recyclable-solutions-radicigroup-at-plast-2026

"Radiflam® S RV150 HF 3739 BK'
https://www.specialchem.com/plastics/product/radicigroup-radiflam-s-rv150-hf-3739-bk

Photo: RadiciGroup - Battery module for electric cars 2026

Non-halogenated PIN FR masterbatches

Global supplier Ampacet has launched low- and zero-halogen phosphorus FR polypropylene masterbatches for E&E and construction. The masterbatches meet international standards for non-halogenated materials IEC 61249-2-21 and EN 50642, do not contain antimony, and can deliver UL 94 V-2 in various colours. They are adapted for use in polypropylene injection or extrusion for electrical, electronic and construction applications. Ampacet underline that the PIN (non-halogenated, non-antimony) flame retardant solution ensures low smoke and low toxic gas emissions in fire. These products add to Ampacet's existing range of non-halogenated masterbatches, including for polyethylene films.

"Ampacet Introduces Low Halogen and Halogen-Free Flame Retardant Masterbatches" https://www.ampacet.com/ampacet-introduces-low-halogen-and-halogen-free-flame-retardant-masterbatches/

Photo for illustration not using cited products: Shutterstock 2768121463

PIN FR for furniture fire safety

Axelium launches furniture and bedding fire barrier solution based on its organo-silicon PIN flame retardants. The non-halogenated, non-antimony FR treatment can be applied to textiles or foams, including cotton and viscose (regenerated cellulose), to provide water-resistant, flame retardant barrier. Application uses conventional textile finishing equipment. Treated fabrics self-extinguish in under four minutes (16 CFR 1633), show reduced fuel load and retain fabric strength. See also Axelium organosilicon PIN FRs in pinfa Newsletter n°62.

"Alexium Unveils New Proprietary Flame Retardant Technology" 19 September 2025 https://bedtimesmagazine.com/2025/09/alexium-unveils-new-proprietary-fire-retardant/

Alexium AlexiShield https://www.alexiuminternational.com/alexishield/

Photo for illustration not using cited products: Shutterstock 581220724

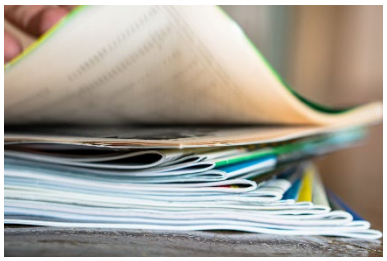
RESEARCH AND INNOVATION

Functionalised tannic acid + AldPi in PA66

Europium (Eu^{2+}) – tannic acid (TA) complex with aluminium diethylphosphinate (AldPi) for PIN fire safety in polyamide, achieving UL 94 V-0 (2 mm) with lower total loading (8% AldPi + 2% eu-TA compared to 15% AldPi). The Eu-TA complex was produced by mixing aqueous solutions, centrifuge separation of the resulting dispersion, then drying, generating a complex with around 13% europium, 39% carbon, 47% oxygen+hydrogen. Peak heat release with 15% AldPI was over -40% lower than for neat PA66 and was over -40% lower with 8% AldPi + 2% eu-TA. This combination increases Limiting Oxygen Index from 26% for neat PA66 to 33%.

This Eu-TA + AldPi combination also maintains PA66 mechanical properties significantly better than does 15% AldPi. Analysis showed that the Eu-TA resulted in a more compact and stable char layer than AldPi alone, and also reduced emission of combustible volatile gases.

"Bio-derived tannic acid-Eu(III) coordination synergizes with aluminum diethylphosphinate for low-loading and high-efficiency flame retardancy in PA66", Z. Liu et al., RSC Adv., 2026, 16, 23399–23409, https://dx.doi.org/10.1039/d6ra02012g Photo: Shutterstock 2487073077



MDH: production, applications, development

Extensive review of current and potential production routes, applications, functionalisation and fire safety benefits of MDH (magnesium di hydroxide), a widely used PIN flame retardant.

This 50-page research analysis presents the different current industrial routes for production of MDH (mainly from mining or hydration of MgO) and possible future routes and options to reduce energy consumption, including recovery by precipitation from magnesium rich waste brines from e.g. desalination. Processes aim to optimise not only particle size but also surface area, pore size distribution, basicity.

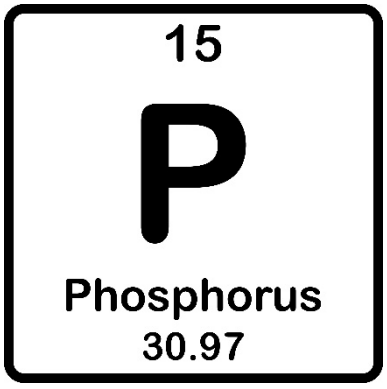
The mechanisms of MDH in protecting from fire are explained: absorption of heat by endothermic decomposition and release of water vapour. MDH also contributes to stiffness, modulus and heat deflection in polymer compounds, and its basicity contributes to counter acid degradation.

Processes for optimising MDH's fire safety effectiveness and polymer compatibility are presented. Particle size control is important: industrially today by milling or controlled precipitation, potentially in the future by microwave, ultrasound, microemulsions. The density of surface hydroxyl (OH) groups in MDH enable modification and functionalisation, to address polymer compatibility issues, improve dispersion, reduce hydrophilicity or improve fire performance (synergy with char forming or ceramifying substances), e.g. with organic silanes, fatty acid – metal soaps, maleic anhydride.

Application in a wide range of polymers is discussed, including relevant strategies for improving compatibility, mechanical and fire performance.

The review concludes that MDH is a robust, safe and sustainable PIN flame retardant, including for low-smoke applications, for polymers, wood, natural fibres, subject to appropriate compatibilsation and functionalisation, often in synergy with phosphorus and nitrogen PIN FRs to enable lower loadings or targeted fire safety performance.

"Investigation of Magnesium Hydroxide as a Halogen-Free Fire-Retardant Filler for Advanced Polymer-Based ", F. Ferrante et al., Composite Solutions: A Review Polymers 2026, 18(11), 1386. https://doi.org/10.3390/polym18111386 Photo: Shutterstock 1666407622



Structure and chemistry of phosphorus FRs

Science update on how phosphorus PIN FRs work, structure, chemistry, toxicity and perspectives. Bob Howell, Central Michigan University, starts by noting that organophosphorus compounds have become prominent in fire safety with recognition of the hazards of organohalogens. The fire safety effectiveness and the toxicity of organophosphorus PIN FRs are strongly dependent on the oxidation state of the phosphorus (from -+5 e.g. inorganic phosphates, phosphate esters, biological organophosphorus compounds such as DNA, to -3 e.g. phosphine). This is explained in detail in pinfa Newsletter n° 170, and see also n°s 171, 175. Compounds with higher P oxidation states tend to decompose at relatively low temperatures, releasing acid at the onset of fire, so contributing to char formation. Those with lower oxidation states tend to decompose at higher temperatures, releasing PO radicals which react with the degrading polymer or act against fire in the gas phase. Lower P oxidation states tend to be associated to lower toxicity. Acids from phosphate esters can promote cationic crosslinking in degrading polymers, so reinforcing char. Functionality can be extended by including different P oxidation states in the same molecule. The author expects future organophosphorus PIN FR developments to centre on organophosphorus oligomers (to limit migration out of polymers), based on non-toxic and biodegradable bio-based compounds for sustainability. Hyperbranched oligomers offer polymer compatibility and many end groups which can be reacted with targeted phosphorus groups (phosphates for solid phase or phosphonates for gas phase activity).

"Controlling the Flammability of Polymeric Materials: Organophosphorus Flame Retardants—Synthesis, Structure, Toxicity, Mode of Action", B. Howell, Journal of Polymer Science, 2026; 0:1–10
https://doi.org/10.1002/pola.70214

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