pinfa
Phosphorus, Inorganic & Nitrogen Flame Retardants Association

Your newsletter for non-halogen fire safety solutions n° 181 April 2026

PINFA IN ACTION

Webinar: recycling strategies for FRs

7th May, 14h-14h45 (CEST): pinfa's 2nd sparks webinar, with Nacho Montesinos Beltrán, chemical recycling, AIMPLAS: "Closing the Loop: Recycling Strategies for Flame Retardant Additives." Register here. pinfa's first sparks webinar brought together 120 participants. This second webinar will discuss how fire safety can be combined with circularity, by recycling of flame retardant polymers:

- Current and emerging chemical recycling technologies,
- Recovery of flame retardants in polymer reprocessing, or reuse by retaining the flame retardant in the recycled polymer
- Implications for design of fire-safe, circular materials
- Discussion and questions

pinfa sparks webinar n°1, 5th February 2026, with Michael Grosshauser, Fraunhofer Institute for Structural Durability and System Reliability LBF: summary in pinfa Newsletter n°179 https://www.pinfa.eu/newsletter/pinfa-newsletter-issue-179-february-2026/ - watch online here. https://youtu.be/mH6uAYmdvis?si=IkMLVKophemJNm25

pinfa sparks 2nd webinar, Thursday 7 May 14h-14h45 (CEST), Closing the Loop: Recycling Strategies for Flame Retardant Additives https://x8y9l.mjt.lu/nl3/lr9_yBqOZ1A2iYKTHX96cg

pinfa-NA – SPE Flame Retardants Week

US Society of Plastics Engineers National Week of Flame Retardants with pinfa-NA: 12 online sessions, 80 participants. SPE brings together 22 500 members from over 80 countries and is the most well-known plastics professional society in the world. Sessions at SPE's 2nd Week of Flame Retardants, co-organised with

pinfa-North America, covered formulation of flame retardant polymer compounds, fire testing standards, regulation and PIN FR safety, drip suppressants, ATO and alternatives, smoke suppressants and borates, as well as expert round tables with plastics formulators and PIN flame retardant suppliers. Key conclusions are the wide range of different chemistries for PIN flame retardants and for PIN synergists; the acceleration of regulatory restrictions on brominated FRs and the advantages of proactive reformulation ahead of regulation, implications of possible PFAS restrictions (PTFE) on flaming-drip prevention, benefits of PIN smoke suppressants alongside PIN FRs, synergies of PIN FRs with mechanical and electrical plastics properties.

SPE – pinfa-NA National Week of Flame Retardants, 23-25 March 2026
https://www.4spe.org/i4a/ams/meetings/index.cfm?controller=meetings&action=startRegistration&conferenceID=703&reginit=1&pageID=9900

EU surveys to input to Fire Safety Guidance

pinfa submitted evidence and input to EU surveys to prepare Guidance on Fire Safety in building renovation & electrification.

This Guidance will be developed for the European Commission DG GROW (Fire Information and Exchange Platform, FIEP) and aims to support implementation of the Energy Performance of Buildings Directive (EPBD) and is expected to cover solar installations, energy storage systems (ESS), heat pumps, insulation and building envelope and other technical building elements.

pinfa underlined the importance of fire performance of materials used in building renewable energy systems, as solar energy in buildings, energy storage and heat pumps increase electrical power demand / transmission, so increasing fire risks. Fire resistance standards for materials used in all such equipment, including wiring and electronics, as well as insulation, are essential to provide a minimum level of fire safety, alongside engineering and design fire risk reduction measures. Installations and systems should be subject to both the fire safety requirements for electrical equipment and also building fire safety regulations.

pinfa considers that 'Performance Based' fire safety criteria are preferable where feasible. However, 'Prescriptive' fire safety standards should also be set for material fire performance standards, as case-by-case performance assessment may not be realistic for smaller buildings, in particular individual households, and control of competence and validity of such assessments can be difficult at this level (local building permitting officers may not have adequate resources to do such verification). Prescriptive fire performance standards for materials can ensure a base level of fire safety for all buildings, with Performance approaches enabling additional fire safety in larger buildings or specific applications.

Project "Guidance on Fire Safety Linked to the Electrification and Renovation of Buildings" (FS-REBuild)

POLICY

European Commission on chemicals policy

Georg Streck, European Commission DG GROW F1 (REACH), updated pinfa on regulatory developments for flame retardants, at pinfa's General Assembly, 18th March. He explained that, following the Flame Retardant Strategy (see pinfa Newsletter n°170), the Commission has mandated ECHA (European Chemicals Agency) to prepare a restriction dossier for three* aromatic brominated flame retardants and this may be extended** (see pinfa Newsletter n° 179).

The Commission has also mandated ECHA to prepare an investigation report on organophosphorus flame retardants (OPFRs). This wide group also covers very different families of chemicals. Some types of organophosphorus flame retardants are already identified as non-problematic, whereas more data is needed on the possible health risks of others.

Information is particularly needed on the hazard properties of some OPFRs, on exposures, on End-of-Life and on technical and economic aspects of uses.

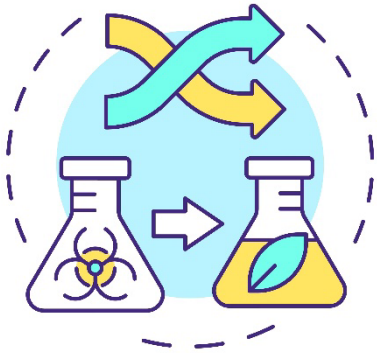
The European Commission's objective is to move from the current "one-by-one" regulation of chemicals to a more holistic group approach, with the aim of providing more certainty for industry, increased user confidence and to avoid regrettable substitution of restricted molecules by very similar replacements.

One possible mechanism which has been suggested by some stakeholders is a "dynamic link", whereby if one chemical is restricted because (e.g.) PBT/vPvB, then Harmonised Classification as (in this case) PBT/vPvB of another chemical with similar use / exposure profile would automatically lead to its restriction. A dynamic link CLP – Candidate List has also been suggested. This raises questions because the risks may not be the same (uses, migration, exposure …) and socio-economic impacts may be different (performance, costs, LCA …). Such a dynamic link already exists for tattoo inks under EU Regulation 2020/2081 but this is simpler because the use and exposure are narrowly limited.

** DBDPE, TBPH and BTBPE (and two substances containing these), identified as SVHC (Substances of Very High Concern) because vPvB (very Persistent very Bioaccumulative).*

*** 19 other non-polymeric aromatic brominated flame retardants are currently undergoing PBT/vPvB assessment (Persistent Bioaccumulative Toxic / very Persistent very Bioaccumulative).*

https://www.frissbe.eu/research/projects-secured for the European Commission DG GROW Fire Information and Exchange Platform (FIEP) https://efectis.com/en/fire-information-exchange-platform-fiep-2/



Brominated FR substitution centre

Mr. Streck presented the EU Brominated Flame Retardant Substitution Centre (HEFESTOS), see pinfa Newsletter n°172. This has now been contracted to AIMPLAS. The website will soon be operational www.hefestoshub.com. The aim is to support business with information and networking by coordination of different substitution centres (see e.g. ECHA list of 'Substitution networks and platforms').

A call for interest and participation in the HEFESTOS Brominated Flame Retardant Substitution Centre is open to companies and stakeholders. https://www.hefestoshub.com/ Contact: hefestos@aimplas.es

ISO Flame Retardant codes updated

ISO 1043 part 4 has been updated defining more precise code numbers for nitrogen and organo-phosphorus FRs. ISO 1043-4 previously gave codes only for "Nitrogen" and "Organo-phosphorus" flame retardant compounds.

For Nitrogen compounds, the current two codes become six: melamine, urea, monomeric melamine-based compounds (melamine salts), polymeric melamine-based compounds, N-alkoxy hindered amine-based compounds, other nitrogen-based compounds.
For Organo-phosphorus, the current three codes become five: aryl phosphates, chlorinated organic phosphorus compounds, brominated organic phosphorus compounds, methyl esters of phosphoric or phosphonic acid, other halogen-free organic phosphorus compounds.

ISO 1043-4 (2021) "Plastics – symbols and abbreviated terms – part 4: flame retardants", Amdt. 1:2026, available in English for e.g. 7.00 € from the Estonia standards organisation website www.evs.ee

IARC: chlorinated FR TCPP carcinogenic

TCPP (tris(chloropropyl) phosphate), a halogenated FR, has been classed probably carcinogenic to humans (Group 2A) by IARC (International Agency for Research on Cancer), on the basis of sufficient evidence for cancer in animal tests and strong mechanistic evidence in primary human cells. A summary of the IARC findings has been published and the full report will be published in 'IARC Monographs on the Identification of Carcinogenic Hazards to Humans'.

"IARC Monographs evaluation of the carcinogenicity of tris(chloropropyl) phosphate, butyraldehyde, and cumyl hydroperoxide", 27th March 2026 https://www.iarc.who.int/news-events/iarc-monographs-evaluation-of-the-carcinogenicity-of-trischloropropyl-phosphate-butyraldehyde-and-cumyl-hydroperoxide/

"Carcinogenicity of tris(chloropropyl) phosphate, butyraldehyde, and cumyl hydroperoxide", D. Lachenmeier et al., Lancet Oncology, 2026, 2 pages https://doi.org/10.1016/S1470-2045(26)00168-3

CONSULTATIONS

UK consultations on construction products

UK Government public consultations on safety of construction productions open to 20th May. See pinfa Newsletter n° 180.

UK consultation open to 20th May: "Construction Products Reform White Paper" https://www.gov.uk/government/consultations/construction-products-reform-white-paper

UK consultation open to 20th May: "General Safety Requirement for Construction Products https://www.gov.uk/government/consultations/general-safety-requirement-for-construction-products

EU consultation on PFAS restrictions

Open to 25th May. ECHA consultation on the SEAC Opinion on proposed EU restrictions on PFAS chemicals. The proposed restriction is unprecedented in covering over 10 000 different substances (the group of per- and polyfluoroalkyl substances). ECHA's RAC (Risk Assessment Committee) Final Opinion on the proposed restrictions, adopted 3rd March 2026, recommended a complete ban, with only one exception (for some PPE - personal protective equipment). RAC considered this justified because PFAS chemicals are persistent and accumulate in the environment. ECHA's SEAC (Socio-Economic Analysis Committee) draft Opinion, subject to the current consultation, proposes a ban with use-specific derogations. The consultation is therefore looking for information on specific uses of PFAS and tonnages used, on alternatives (availability, safety, technical and economic feasibility), time needed to develop alternatives and to switch to their use, impacts of a ban in terms of costs, jobs, services to society, as well as comments on the text of the SEAC draft Opinion. Sector specific information is requested on fourteen sectors identified as using PFAS and for which RAC proposed a complete ban. These include four in which PFAS additives (anti-drip) may at present be used alongside flame retardants to prevent flaming droplets in fire: textiles and similar (TULAC), electronics, energy, construction products. Eight other sectors are also cited but were not analysed by RAC, including sealing, machinery, military, technical textiles and broader uses.

ECHA stakeholder consultation on PFAS restrictions (consultation on draft SEAC Opinion), open to 25th May 2026 https://ec.europa.eu/consultation/runner/echa_pfas_seac_do_consultation

ECHA consultation guide and instructions: "Consultation on the SEAC draft opinion on restricting per- and polyfluoroalkyl substances (PFAS) – Guidance for respondents", March 2026 https://echa.europa.eu/documents/10162/17091/upfas-seac-do_consultation_guidance-for-respondents_en.pdf/68d5b13b-d7d6-f14b-2c3e-9b3c07c98113?t=1765956675386

RAC final Opinion "Committee for Risk Assessment (RAC) Opinion on an Annex XV dossier proposing restrictions on Per- and polyfluoroalkyl substances (PFAS)", ECHA/RAC/RES-O-0000007619-62-01/F, 2 March 2026 https://echa.europa.eu/documents/10162/d6aac737-e665-cbae-58c8-17780de44bd5

SEAC draft Opinion – open for consultation "Committee for Socio-economic Analysis (SEAC) [Draft] Opinion on an Annex XV dossier proposing restrictions on Per- and polyfluoroalkyl substances (PFAS)", ECHA/SEAC/RES-

O-0000007620-79-01/D, 10 March 2026 https://echa.europa.eu/documents/10162/9ecfb76d-6e69-c047-3228-16c78e42897f

ECHA PFAS "Annex XV Restriction Report" (proposal) March 2026 https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

Consultation on UK furniture fire regulations

Fourth consultation is open to 23rd June with significant changes proposed but furniture fire regulations maintained. Scope changes were already made to the UK Furniture Fire Safety Regulations in 2025, to remove certain children's and baby products from scope (see pinfa Newsletter n°170). The current proposal to change the fire testing requirements follows three previous public consultations, with presentation of a range of options in 2023 (see pinfa Newsletter n° 154).

The proposals now submitted for legal consultation by the new UK Government (elections 2024) propose to maintain sector specific fire safety regulation for furniture (rather than rely only on GPSR General Product Safety Regulations) but to remove the current requirement for open flame fire resistance and retain only cigarette resistance (smouldering fire source). The Government's consultation documents conclude that although "flame retardants have appeared to successfully reduce the number of fire casualties" evidence does not allow to identify to what extent downward fire statistical trends are due to other factors, such as installation of smoke alarms, fewer open fires in homes, safer cooking practices. The Government considers that removing the open-flame fire test requirement, in particular for foams in furniture, will lead to a reduction in use of flame retardants. It notes that stakeholders expressed concern about possible increases in smoke toxicity with flame retardant use, but rejects smoke toxicity testing as not feasible and not proportionate. The Government proposes to increase flexibility for furniture manufacturers by allowing either (smouldering fire source) testing of all component materials, or "composite" testing (of the final furniture item). Also, the proposal would remove second-hand, repair and re-upholstery from the Regulation scope (these would be covered by GPSR).

The consultation asks stakeholders four questions, with in each case agree/disagree and possibility to comment (limit 20 000 characters per comment):

- Removal of open-flame test, smouldering-source fire test only,
- Authorisation of either component or composite testing,
- Removal from scope of furniture repair and re-upholstering,
- Removal from scope of second-hand furniture.

UK Government consultation on Furniture Fire Safety Regulations. Open to 23rd June 2026 https://www.gov.uk/government/consultations/product-regulation-fire-safety-of-domestic-upholstered-furniture

UK consultations on product safety

Open consultation
Product regulation: the UK's new product safety framework

Open to 23rd June. Two public consultations on UK product safety regulations, and on related surveillance & enforcement. These consultations, in parallel to the above consultation on the UK Furniture Fire Safety Regulations, concern the UK General Product Safety Regulation (GPSR) and product safety market surveillance and enforcement. The proposals maintain the definition of product safety (covering use in duration, installation and maintenance), widening to cover all products unless specifically exempted, redefining product safety introducing the Precautionary Principle for health and the environment, ensuring accountability throughout the supply chain (in particular for e-commerce and online market places), moving towards digital-by-default product information and reinforcing coordination and coherence of regulations. A specific focus is on lithium-ion battery safety in consumer products.

UK Government consultation on General Product Safety Regulation and on market surveillance – enforcement. Open to 23rd June 2026. *https://www.gov.uk/government/consultations/product-regulation-the-uks-new-product-safety-framework*

UK Government consultation on "Product regulation: market surveillance and enforcement framework". Open to 23rd June 2026. *https://www.gov.uk/government/consultations/product-regulation-market-surveillance-and-enforcement-framework*

FIRE SAFETY

750 persons safely escape disco club fire

All 750 customers escaped safely from a fire at the K Club discotheque, Kehl, Germany, 29th March, showing that death and disaster can be averted in fires when fire safety precautions are in place, even in complex and crowded, high-risk public buildings. Press reports citing witnesses say that fire developed in the nightclub ceiling. In other nightclub fires, flammable ceiling materials have led to tragedy, including the 1st January 2026 Le Constellation bar fire at the Swiss Crans Montana ski resort in which 41 people died and 115 were seriously injured, with press reporting that video evidence shows acoustic insulation ceiling foam ignited by sparklers filling the bar with fire and smoke in 1 ½ minutes. pinfa notes flame retardants can prevent insulation foams from catching fire and burning rapidly but that official evidence is not yet available as to whether the ceiling foams used in these two bars respected fire safety obligations.

"La discothèque le K Club ravagée par un incendie près de Strasbourg, 750 personnes évacuées rapidement, pas de blessé", DNA Dernières Nouvelles d'Alsace, 29 March 2026 *https://www.dna.fr/faits-divers-justice/2026/03/29/a-kehl-la-discotheque-le-k-club-ravagee-cette-nuit-par-un-incendie*

PIN FRs best solution for PV fire safety

Science review concludes that flame retardants are the most promising approach for photovoltaic panel fire safety, in particular PIN FRs. They are considered less expensive, compatible with preferred PV encapsulation systems (generally using polyolefins or ethylene vinyl acetate), compared to system engineering approaches or to use of inherently less flammable materials. The review explains the interest of phosphorus and nitrogen PIN FRs, considered of lower toxicity. Different FR systems and fire testing methods are presented and a structured framework is presented for fire testing of PV materials and modules. The review notes that there is little published research on FRs in PV encapsulants, impacts on material properties and on transparency. The authors consider that more research is needed on smoke emission, fire testing of PV panels as part of a building structure and PV recycling.

"Advanced Flame Retardant Strategies and Fire Performance Assessment for Safer Photovoltaics in Buildings: A Two-Part Review", F. Ollagnon et al., Advanced Functional Materials 2026, 36, e09194 https://doi.org/10.1002/adfm.202509194

Fire tests show benefits of FRs in PV panels

Flame-retardant coatings show significant reduction of fire risk for BIPV (Building Integrated Photovoltaics). 100 mm square mock PV panels were cone calorimeter tested. The panels consisted of a glass covering sheet, solar cell, front and back sheets of EVA (ethylene vinyl acetate) and a PET back sheet (polyethylene terephthalate). These were tested with and without two flame-retardant coatings (urethane and epoxy based intumescents): back or front coatings of one or the other or both treatments. The FR coatings reduced peak heat release rate by a factor of 2 to 10. The epoxy coating alone significantly reduced total smoke release (TSR), whereas the urethane coating increased it (in all cases, the coatings increased the amount of combustible polymer material). The study concludes that both types of intumescent coating effectively reduce fire risk of the photovoltaic panels.

"Quantitative assessment of fire risk in building-integrated photovoltaic (BIPV) modules coated with fire retardant materials for enhanced fire resistance performance", H-K Park et al., Case Studies in Thermal Engineering 72, 2025, 106285 https://doi.org/10.1016/j.csite.2025.106285

Greenhouse emissions of PV fires

Emissions from fires in photovoltaic (PV) panels are estimated to be 100x lower than those from PV panel manufacture. Based on fire statistics for PV panels and estimations of emissions during the fire, fire extinction and replacement of damaged panels and parts of buildings, greenhouse emissions from PV panel fires are estimated at 0.3 $gCO_{2\text{-equ}}$/kWh of electricity produced (over the panel's life). This can be compared to around 44 $gCO_{2\text{-equ}}$/kWh greenhouse emissions over a panel's normal lifetime (mainly from manufacturing, little impact from panel disposal/recycling, zero emissions from use) and to 480 $gCO_{2\text{-equ}}$/kWh for average electricity production globally. PV fires are estimated to occur at 0.03 fires / year / MV installed PV (Ong et al., see pinfa Newsletter 143). Buildings are estimated to be damaged or destroyed in over 40% of PV fires.

"Greenhouse gas emissions related to fires in photovoltaic installations", R. Stølen, Int. J. Ambient Energy 2024, vol. 45, no. 1, 2367734, https://doi.org/10.1080/01430750.2024.2367734

Safety concerns for "plug in" home PV

Fire safety expert concerns on UK Government proposals to facilitate plug-in self-install solar panels or batteries. The UK is accelerating green energy as "the only route" to energy sovereignty, to end dependency on volatile fossil fuel prices. The UK's current renewables installation auction was the biggest to date and will mean total authorised capacity sufficient to power 2/3 of UK homes. The UK Government is now working with supermarkets and retailers to roll out self-install plug-in solar panels: low cost, portable, to be installed on balconies or outdoor places and plugged into an existing mains socket. However, Stuart Patience of Hollis (construction consultant), underlines that solar PV poses specific electrical risks, not adapted to self-installation, and fire risks including combustible materials, ignition sources and fire-load on balconies or other external spaces. He indicates that including plug-in battery storage with such systems adds further risks. Questions include whether the plug-in installations will be covered under existing building or appliance safety regulations, or under specific new regulations.

"Government to make 'plug-in solar' available within months", UK Government, 24th March 2026 https://www.gov.uk/government/news/government-to-make-plug-in-solar-available-within-months

"Government's plan for 'plug-in' solar panels raises fire safety concerns", FM Matters, 30th March 2026 https://www.fsmatters.com/Plug-in-solar-panels-raise-fire-safety-concerns

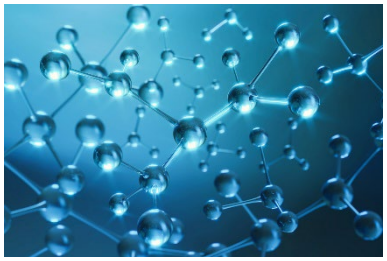
PIN FR INNOVATION

Replacing harmful flame retardants

pinfa member Flamaway – CTF 2000 is part of the Belgium BBBC project FONT for SSbD PIN flame retardants for textiles. The project aims to replace brominated flame retardants for textiles (such as DBDPE or TBBPA) by safer, bio-based flame retardants, using the EU SSbD (Safe & Sustainable by Design) Framework (to TRL 1-3 based on lignin chemistry), and to develop targeted ecotoxicological testing methods adapted for small sample sizes and in silico (computer modelling and AI) to optimise SSbD PIN FR chemical design and selection for safer textiles. The project brings together Apeiron, KU Leuven, CentexBel and Flamaway-CTF2000 and runs from 2025 to 2026

"Project FONT: Replacing Harmful Flame Retardants with a Bio-Based Innovation ", https://economie.fgov.be/en/themes/enterprises/calls-projects/belgium-builds-back-circular/project-font-replacing-harmful

The FONT project is funded by the Belgian National Plan for Recovery and Resilience BBBC (Belgium Builds Back Circular) initiative "Substitution of Hazardous Substances" and NextGenerationEU.



PIN FRs for polyurethane elastomers

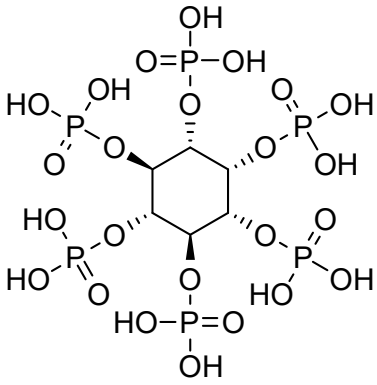
Data on mechanisms, effectiveness and properties of additive and reactive PIN FRs are analysed from 140 publications. The authors consider that halogenated FRs are decreasingly used because of environmental concerns and release of corrosive gases in fires. PIN FRs discussed include primarily phosphorus-based FRs, because of compatibility with polyurethane elastomers and effective performance. They act both in the gas phase (releasing radicals which inhibit burning) and in the solid phase (generating a fire-protective char layer). Nitrogen-based PIN FRs, including melamine compounds, triazoles, tetrazoles and imidazoles, act by diluting fire gases and by stabilising the char layer (e.g. by forming carbonised graphite nitride). Silicon-based PIN FRs, e.g. POSS (Polyhedral oligomeric silsesquioxane) generate dense carbon char embedded with silicon dioxide. Boron-based PIN FRs generate boron-carbon layers in char which inhibit heat transfer. Selenium-containing PIN FRs remove radicals in fire gases, inhibiting burning. Reactive PIN FRs, often with chain extenders, can act in polyurethane elastomers by cross-linking the polymer, so reducing flammability.

"Review. Strategy for Constructing Phosphorus-Based Flame-Retarded Polyurethane Elastomers for Advanced Performance in Long-Term", Y. Luo et al. Polymers, 2023, 15, 3711. https://doi.org/10.3390/polym15183711

Biobased phosphorus PIN FRs for PA66

Lab study of DOPO-functionalised biobased muconic acid as a reactive phosphorus PIN flame retardant for polyamide-66. Bio-sourced trans-3-hexenedioic acid (t3HDA) was reacted with DOPO (dihydro- 9-oxa- 10-phosphaphenanthrene- 10-oxide, an organophosphorus PIN FR building block) in dimethyl formamide (solvent and catalyst), followed by hydrolysis by lithium hydroxide, washing and precipitation. This was then copolymerised into polyamide-66, resulting in 5 – 11% loading of DOPO. Results showed that heat release rate was reduced by around 1/3 by this bio-based reactive PIN FR strategy without significantly deteriorating the polyamide mechanic performance characteristics.

"Leveraging the bio-enabled muconic acid platform via phospha-Michael-addition: intrinsically flame retardant nylon-66/DOPO copolymers", P. Carter et al., RSC Sustainability, 2024, 2, 2968
https://doi.org/10.1039/d4su00184b



Biobased P-N-Si transparent PIN FR coating

The biological phosphorus molecule, phytic acid, was reacted with a N-Si cation to produce a PIN FR coating for wood. Phytic acid is widely present in seeds and grains and is nature's phosphorus storage molecule. Phytic acid sodium salt was here reacted with N-[3-(trimethoxysilyl) propyl]-N,N,N-trimethylammonium at 60°C. The resulting molecule was coated onto wood by brushing at 500 g/m^2, resulting in a cross-linked polysiloxane. The coating remained transparent and did not damage the wood fibre grain. When the phytic acid and N-Si compound were reacted at a 1:1 ratio, the resulting coating increased LOI (Limiting Oxygen Index) from 26 (untreated wood) to 36, reduced peak heat release rate by around -20% and reduced total smoke release by around two thirds. Fire performance was achieved by development of a strong intumescent char layer.

"Highly Transparent Fire-resistant Coatings with Intumescent Three-source Integration", X-L. Zeng et al., Chinese J. Polym. Sci. 2024, 42, 907–915, https://doi.org/10.1 007/s10118-024-3100-1 Image: Wiki – Harbinary.

PUBLISHER INFORMATION

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