pinfa
Phosphorus, Inorganic & Nitrogen Flame Retardants Association

Your newsletter for non-halogen fire safety solutions n° 147 March 2023

AMI | Events

Plastics in Electric Vehicles

6-7 June 2023 | Munich, Germany

AMI Plastics in Electric Vehicles conference

pinfa is a sponsor of the brand-new "Plastics in Electric Vehicles" conference, organised by AMI, Munich 6-7 June 2023. This will gather the whole automotive materials supply chain including OEMs and Tier 1 suppliers, focussing on cutting-edge technologies for weight reduction, safety improvements, cost savings, stylish designs, and more efficient manufacturing. This includes innovative applications in electrical systems, powertrains, exterior parts, and interiors. The speakers will also address strategic changes to the industry's structure and ways of operating, including the emergence of new players and the reduction of product development times. pinfa will discuss how PIN flame retardants can provide safe routes to address the specific new fire risks related to batteries, charging and high current power trains. pinfa members will present custom-designed PIN FR solutions for different EV materials and applications.

AMI "Plastics in Electric Vehicles", 6-7 June 2023, Munich, Germany
https://www.ami-events.com/eventPlasticsinEV

pinfa-NA at SPE automotive EV conference

pinfa-NA is a sponsoring and participating in the Battery and Thermal Materials sessions April 16-19 2023, Troy, Michigan. This the second SPE Automotive Division's Electric and Autonomous Vehicle conference. The first edition attracted over 600 participants in 2022.

https://speautomotive.com/2023-plastics-in-electric-autonomous-vehicle-conference/

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ECHA REGULATORY STRATEGY FOR FLAME RETARDANTS

Plans for FR assessment and regulation

ECHA document identifies most PIN flame retardants as low hazard, no regulatory action needed, including mineral, nitrogen, inorganic phosphate and several types of organophosphorus FR. ECHA (European Chemicals Agency) proposes "a wide and generic restriction" (under REACH) for all aromatic brominated FRs (with conditions), but with further preparatory work needed before a restriction dossier is developed, and calls for more data on aliphatic brominated FRs and some organophosphorus FRs. When more data is available (expected 2024), these groups will be reassessed with possible restriction processes not before 2025. Chlorinated FRs are considered to be already restricted or regulatory measures are already initiated.

The Strategy also notes that in addition to regulatory measures under REACH, the European Commission may introduce requirements on flame retardants in products under the Ecodesign Regulation, similar to the exclusion of any halogenated flame retardant in enclosures and stands of electronic displays (see pinfa Newsletters n°s 136 and 108).

pinfa provided detailed input to and met with ECHA during their preparation of this work, including providing the Peter Fisk study on grouping of organophosphorus PIN FRs (see pinfa Newsletter n°142).

The Strategy identifies the following groups of PIN FRs as requiring no regulatory action, or as of no significant hazard based on current information:

- For **inorganic phosphorus FRs, no regulatory action needed:** phosphates, polyphosphates, inorganic phosphinates, inorganic phosphonates and phosphorus.
- **Of organic phosphorus FRs, low or unlikely hazard:** non-cyclic alkyl aryl esters of phosphoric acid, other hydrogenphosphonates and alkyl phosphonates, their salts and esters, dibenzo oxaphosphorine oxide derivatives (DOPO derivatives), hydrocarbyl phosphinates
- Of **nitrogen FRs, no regulatory action needed for**: triazinetrione and triazinetriamine derivatives*, guanidylureas, cyanoguanidines and biguanidines group and the non-aromatic guanidines, piperazine-functonalised polyamines and primary aliphatic diamines and their salts, aliphatic and benzylic ureas**
- Of **inorganic FRs, no regulatory action needed for**: molybdenum and its simple compounds, zirconium and its simple inorganic compounds, sulfur and its oxides, halides, sulfides, sulfites, thiosulfates, sulfamides and most salts of sulfuric acid, inorganic silicon compounds***. Antimony (principally used as a synergist with halogenated FRs) is already classified as Carc. 2 and assessment is underway concerning genotoxicity. Some inorganic borates are already classified as Repro. 1B and extension of this classification to all inorganic borates is under consideration.
- **Other inorganic FRs** are not included in §5.5 (regulatory needs), presumably because there is no suggestion of risk, in particular **aluminium and magnesium minerals (ATH, MDH)** which are two of the highest volume PIN flame retardants, and minerals used in PIN FR synergists/smoke suppressants (iron, copper …).

The 85 page Regulatory Strategy document is published by ECHA, the European Chemicals Agency, implementing the European "Restrictions Roadmap under the Chemicals Strategy for Sustainability" (April, 20222, SWD-2022-128, see pinfa Newsletter n°138). ECHA notes the steadily growing demand for flame retardants and that changes to fire safety standards can influence flame retardant use in different products. ECHA underline that restrictions of one chemical in the past have tended to result in "regrettable substitution". The example is cited of decabromodiphenyl ethane (DBDPE) now being widely marketed as a substitute for decabromodiphenyl ether (DecaBDE, which is now on the POPs regulation – Persistent Organic Pollutants).

The ECHA document indicates (p. 28) that 349 flame retardants have been identified within chemicals registered under REACH, of which around 2/3 have been allocated to "groups" considered in this Regulatory Strategy, and of these around 3/4 are assessed. ECHA note (p. 31) that all aromatic brominated FRs tend to be persistent, but data is lacking on most of these substances. The hazard profile of aliphatic brominated FRs is considered more diverse (p. 36), and four are targeted as known to be problematic: brominated cycloalkanes, 2 brominated alcohols, 1 brominated phosphate. ECHA notes (p. 22) that brominated FRs tend have a smaller molecular size and higher mobility than might be expected from molecular weight, because bromine is heavy, leading to wide presence in soil, house dust, sediments, etc.

ECHA note that polymeric FRs are currently exempted from REACH, but that they may break down to smaller molecules (hydrolysis, sunlight, temperature, p. 22). It is underlined (p. 36) that a key question is whether bromine can be used when included in large molecule or polymeric FRs or "whether polymers should be free of bromine in future, as (i) the release/exposure potential to hazardous brominated substances during dismantling, recycling and disposal operations may not be sufficiently controlled (or excluded), and (ii) the presence of brominated flame retardants may encumber the move towards toxic-free material cycles, to achieve the objectives of Circular Economy". It is indicated that based on current knowledge ECHA cannot answer this question and recommends further investigations.

The Strategy document includes a 30+ page analysis of which FRs are used in which applications, markets for different FRs, in several instances citing pinfa publications as the source of data.

** triazinetriamine = melamine; already covered by harmonised classification as Carc. 2 & STOT RE 2. Melamine is also now on the REACH Candidate List. pinfa notes that this does not however concern melamine derivates used as FRs.*

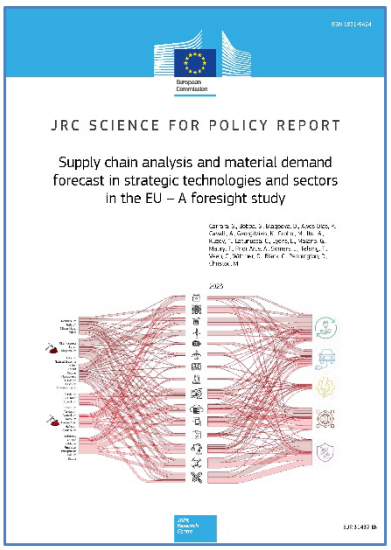
*** for thioureas further data is needed and regulatory measures are under consideration.*

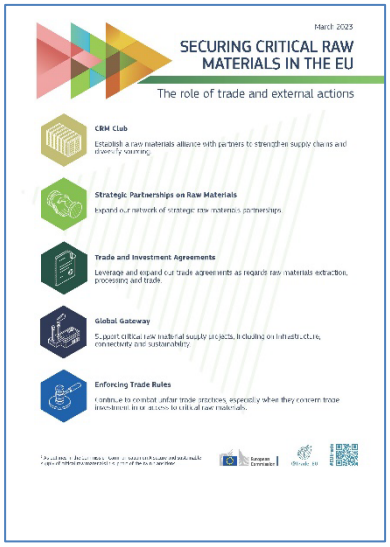
**** with appropriate precautions concerning potential silicosis in handling.*

ECHA press release "ECHA identifies certain brominated flame retardants as candidates for restriction", ECHA/NR/23/07, 15th March 2023 https://echa.europa.eu/-/echa-identifies-certain-brominated-flame-retardants-as-candidates-for-restriction

ECHA "Regulatory strategy for flame retardants", March 2023, ISBN 978-92-9468-261-1
https://echa.europa.eu/documents/10162/2082415/flame_retardants_strategy_en.pdf

PHOSPHORUS FRS IN CRITICAL RAW MATERIALS POLICY





P_4 proposed as "Critical" but not "Strategic"

Proposed EU Act keeps P_4 as a Critical Raw Material but fails to recognise its need for fire safety of strategic technologies. The proposed EU Critical Raw Materials (CRM) Act, published 16th March 2023, is open to public consultation to 16th May 2023, then will go to Parliament and Council. P_4 (confusingly termed "Phosphorus") remains on the list of 34 Critical Raw Materials* (as does "Phosphate Rock"), but is not included in the subset of 16 Strategic Raw Materials (SRMs). If adopted as proposed, the Regulation would fix, for SRMs only but not for other CRMs, targets for onshoring of processing (the EU currently has no P_4 production) and for reducing supply dependency, enable Strategic Projects and enable joint supply purchasing systems. The exclusion of P_4 from the SRM list is surprising in that the selection is based on the JRC Foresight Report, also published 16th March, which identifies P_4 as needed in all five strategic technology sectors considered and as one of the materials which the highest supply chain risk for several technologies. This Foresight report identifies P_4 as needed for battery electrolytes ($LiPF_6$), indium phosphide in semiconductors, and fire safety in "data storage and servers", but does not note that P_4 is also essential for fire safety in many of the other technologies (photovoltaics and renewable energy, laptops and smartphones, heat pumps, 3D printing, aerospace …) nor that it is needed for microchip etching, semiconductor Si to P doping.

pinfa will input to the discussion of this draft Regulation to underline the importance of phosphorus in fire safety in the strategic technology sectors considered, in particular renewable energies, batteries, information & communication technologies, aerospace.

** Critical Raw Materials (CRMs) are defined as "raw materials of high importance for the overall Union economy and for which there is a high risk of supply disruption"*

*** Strategic Raw Materials (SRMs) are defined as CRMs needed for "strategic technologies underpinning the green and digital transitions or for defence or space applications".*

European Commission press release, 16th March 2023 IP_23_1661 "Critical Raw Materials: ensuring secure and sustainable supply chains for EU's green and digital future" – includes links to Commission Communication, FAQ, etc.
https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661

Proposed EU Critical Raw Materials Act, COM(2023)160, 16th March 2023 https://single-market-economy.ec.europa.eu/publications/european-critical-raw-materials-act_en

JRC Foresight Report 2023 "Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study", S. Carrera et al., ISBN 978-92-68-00339-8 (266 pages)
https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

Public consultation to 16th may 2023
https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13597-European-Critical-Raw-Materials-Act_en

PINFA ACTIONS

pinfa recycling brochure published

pinfa publishes brochure summarising state-of-the art knowledge and testing on PIN flame retardants and recycling. The 20-page document, available in pdf, looks at how PIN FRs impact plastics recycling, and provides examples of recovery and recycling of PIN FRs and of PIN FRs to ensure fire safety of recycled materials. The brochure includes summaries of

- Fraunhofer LBF – pinfa trials of multiple cycle ageing - mechanical recycling of various PIN FR – polymer compounds
- PNO expert research and market perspective analysis on PIN FR recycling
- Fifteen recent science publications covering trials of (mechanical, solvent) recycling of plastics or cables containing PIN FRs, applications of PIN FRs to enable recycling of end-of-life plastics, textiles, etc., use of materials recovered from wastes to produce PIN FRs and recycling of elements recovered from PIN flame retarded materials for other uses

https://www.pinfa.eu/wp-content/uploads/2023/02/Pinfa_PIN-Flame-Retardants-_Recycling_2023.pdf

pinfa-NA sponsors research student

James Covello, student in Macromolecular Science and Engineering, Case Western Reserve University (CWRU, Cleveland, Ohio) has received the first pinfa-NA Merit Scholarship (US$ 2500): “I have been interested in fire protection research since my first semester as an undergraduate polymer engineering student at CWRU. Since then, I have had the opportunity to learn about fire-related phenomena, protection, and design and engineering. CWRU challenges us to think about not only the performance of polymeric materials but also responses to externalities such as, in my case, fire. I will incorporate these broad principles into my work regarding the environmental destiny of polymers as well as how they interface with humans across technical, social and environmental levels. In my thesis work, I am focused on developing a more mechanistic understanding of the protective performance of intumescent coatings through identification of the synergistic interactions of various components. Sustainability is a key driver for component selection, and I have had much success with tannic acid-based systems that show excellent performance regarding flammability mitigation of common plastics. The pinfa-NA research support award will allow me to further commit to research and to partially support further development of bio-based PIN intumescent coatings.”

https://www.wnekgroup.com/groupmembers and https://engineering.case.edu/macromolecular-science-and-engineering

NEW MEMBER PINFA-CHINA

JavaChem

Javachem develops performance P, P-N and nanoclay PIN FRs and synergists, **within an innovative range of plastic additives** including silicone additives, antistatic agents, polymer processing aids and functional masterbatches. Active R&D is centred on non-halogenated and eco-friendly solutions and clean production processes. The PIN FR range includes phosphorus-nitrogen intumescent flame retardant, alkyl hypophosphite P-FR, silicone flame-retardant synergist, silicon-coated anti-dripping agent and nanoclay char-forming agent. Customised products and production support are available for specific application needs and Javachem has active partnerships with leading plastics compounding companies. The product range enables thermal stability for processing, high temperature component operating, compatibility with various thermoplastics such as PC, PA6, ABS, PBT, PP and alloys. Javachem is a recognised National and Provincial "High Tech Enterprise" and four times winner of the Ringier Technology Innovation Awards for Plastics Industry. Javachem was founded in 2000 and has two production bases in Shaoxing, Zhejiang and Jiujiang, Jiangxi.

Dr Yuehui Zhou, Javachem: "We highly respect the mission and vision of pinfa. Joining pinfa China, we hope to better understand the direction and needs of PIN FRs, to address challenges for industrial applications and to support the safety and sustainable development of the non-halogenated flame-retardant industry."

Javachem (Zhejiang Java Speciality Chemicals Co Ltd)
www.javachem.com

POLICY

Expert Committee on Sustainable Chemistry

Beyond Benign ECOSChem actionable definition and criteria for Sustainable Chemistry calls for "without hazards", to cover the chemical itself, input components, emissions and breakdown products. The ECOSChem Committee, convened by the University of Massachusetts' Lowell Center for Sustainable Production and green chemistry educating organisation Beyond Benign, brought together 20 scientists, international organisations, NGOs, business and investors worldwide in 2022-2023 and published an eleven page conclusions report in February 2023. An overall definition is proposed as "the development and application of chemicals, chemical processes, and products that benefit current and future

generations without harmful impacts to humans or ecosystems". This definition is detailed in 17 criteria covering equity and justice, transparency, health and safety impacts, climate and ecosystem impacts, circularity and the ability to be recycled and reused. Regarding Health and Safety, the proposed criteria specify "A sustainable chemical, material, product … will be without hazards to people and ecosystems, including hazardous components, emissions, and toxic by-products and breakdown products and not result in releases, including releases of by-products or breakdown products, that persist or bioaccumulate."

"Sustainable chemistry experts create blueprint for safer future", 27 February 2023 https://www.eurekalert.org/news-releases/981021

ECOSChem - Sustainable Chemistry Catalyst website with access to Report, preparatory document, etc https://www.sustainablechemistrycatalyst.org/projects

Image: The five pillars of sustainable chemistry, Expert Committee on Sustainable Chemistry, Lowell Center for Sustainable Production and Beyond Benign.

Clean Air Programme

UK debate on FRs and fire safety

Scientists suggest policy should prioritise "benign-by-design" for fire safety taking into account smoke and fire toxicity. Within the UK Research Initiative (UKRI) on clean air, scientists organised a round-table on chemicals and environmental health centred on flame retardants. This led to a published paper presented as a "Consensus Statement". Information is not provided as to which stakeholders took part in the round table. The paper is signed by a dozen scientists, a cancer NGO and a furniture upholsterer using natural materials.

This "Consensus Statement" includes the statements "There is significant uncertainty about whether and to what extent flame retardants contribute to fire safety" and "There is evidence that flame retardants exacerbate smoke and fire toxicity".

pinfa suggests that these statements are misleading and not consensual: there is agreement that flame retardants do contribute to fire safety in many applications; there is also evidence that flame retardants do not increase smoke or toxicity (see e.g. Blais 2020 in pinfa Newsletter n°140, CREPIM study for pinfa here, CREPIM tests for pinfa in pinfa Newsletter n°109).

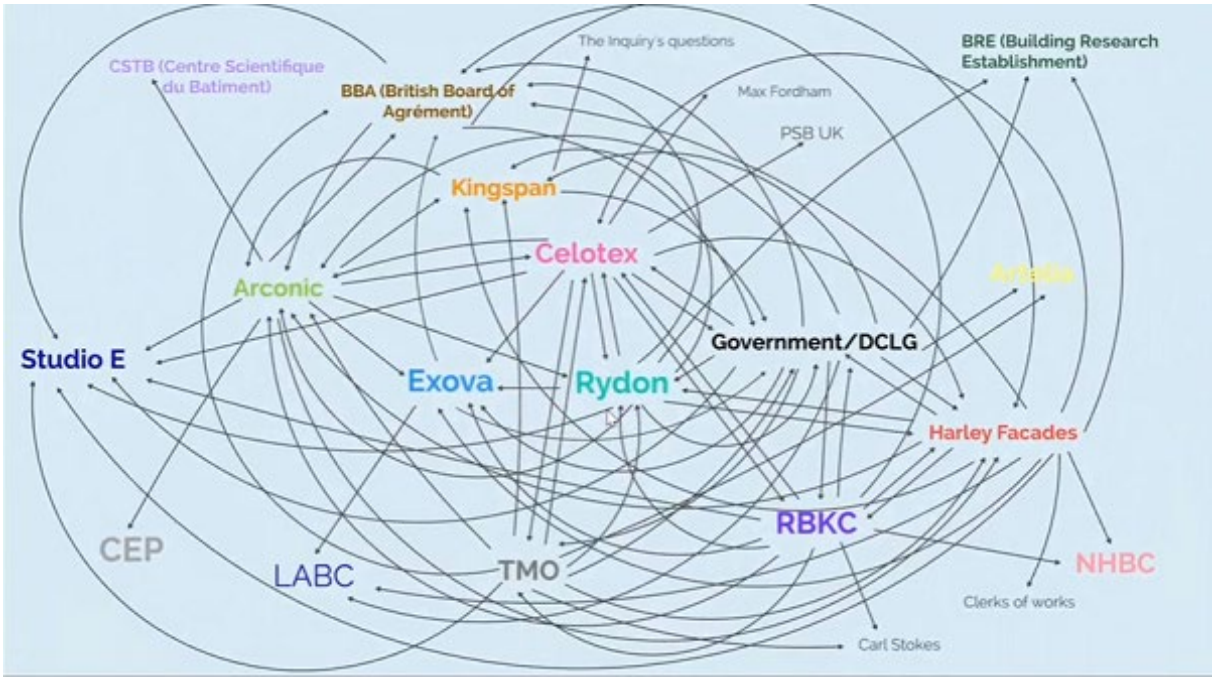
The document calls for policy to incentivise "benign-by-design" products, for example using inherently less flammable materials or fire barriers. The authors do not seem to take into account that this may be more feasible for certain applications, maybe furniture or building materials (but with design, performance and cost implications), than for e.g. transport or electronics applications. The document also contains policy calls which pinfa overall supports: high level of certainty about health and environmental safety of flame retardant chemicals before allowing them on the market (to avoid today's products becoming tomorrow's legacies) and a

labelling system to identify chemicals in products to facilitate recycling management.

"A new consensus on reconciling fire safety with environmental & health impacts of chemical flame retardants", J. Page, A. Stec et al., Env. International 2023 https://doi.org/10.1016/j.envint.2023.107782

"Understanding and managing health risks from exposure to flame retardants, and the broader implications for UK chemicals policy", P. Whaley, UKRI Clean Air, Human Health Round Table, 29 June 2022 https://www.ukcleanair.org/2022/06/29/understanding-and-managing-health-risks-from-exposure-to-flame-retardants-and-the-broader-implications-for-uk-chemicals-policy/

GRENFELL TOWER FIRE



Every Grenfell fire death was avoidable

Council to Grenfell Inquiry Phase 2 cites cladding material suppliers' "cynical and possibly even dishonest practices". Richard Millett, council to the Grenfell Tower fire official Inquiry has published a final statement summarising 400 days of evidence to Phase 2 of the Inquiry (summary of Phase 1 conclusions below). He suggested the Inquiry conclude "a long run-up of incompetence and poor practices in the construction industry and the fire engineering and architects' profession; weak and incompetent building control; cynical and possibly even dishonest practices in the cladding and insulation materials manufacturing sector; incompetence, weakness and malpractice by those responsible for testing those materials; the failure of central government to act, despite known risks" (etc.).

Images: "web of blame", Richard Millett, council to the Grenfell fire enquiry; wiki commons Carcharoth

The Council to the Grenfell Inquiry states his regret that every organisation involved, from the cladding materials manufacturers (Arconic, Kingspan, Celotex) to the UK Government, has tried to point their finger and blame someone else, citing Celotex who have said that their misleading description of a pivotal fire test was not 'causative' because the design team for the refurbishment failed to read it. The Inquiry Phase 2 panel will now conclude (report expected in coming months) concerning blame for the fire and the 72 deaths, and this is expected to be followed by penal actions.

"Grenfell Inquiry 'able to conclude every death was avoidable' as its lawyer slams ongoing 'merry-go-round' of buck-passing", Inside Housing date 10 November 2022 LINK.

"Grenfell Tower Inquiry points to incompetence and 'web of blame'", PSJ 16 November 2022 LINK.

Grenfell Inquiry Phase 1 conclusions

Inquiry confirms that Grenfell fire started in fridge-freezer and catastrophically spread through PE, PIR and phenol cladding. The full report of Phase 1 of the Grenfell Tower Inquiry (856 pages) analyses the causes of the fire and of its catastrophic spread and the events of the night of the fire. Phase 2 (see above) is assessing the decisions which led to "the installation of a highly combustible cladding system" which caused the fire to spread rapidly over the whole high-rise building, breaching the construction fire compartmentalisation and resulting in 72 fire deaths.

The phase 1 report confirms that the fire started in a Whirlpool fridge freezer, in the kitchen of flat 16, with no evidence of any external electrical surge or fault being responsible for this and without it being possible to identify the specific cause of the fire within the appliance. It is underlined that fires can be expected to start in domestic electrical appliances.

The owner of flat 16 was woken by a smoke alarm, rapidly called the fire brigade and alerted the neighbours. The fire brigade arrived after 5 minutes. The inquiry report confirms that the alarm was correctly raised and that the fire services intervened rapidly. The catastrophe resulted from the spread of the fire through the cladding materials, installed during a major refurbishment 2012-2016, which rapidly breached all compartmentalisation. The fire brigade's "stay put" policy (telling residents to stay in their flats and close doors) was initially appropriate in a compartmentalised building, but not after compartmentalisation had been breached.

The heat from the fire in the fridge-freezer, possibly spreading to nearby materials, caused failure of the flat window, probably due to deformation of the uPVC frame of the windows (unplasticized-PVC windows installed in the refurbishment) and of the frame and surrounds of the Nuaire ventilation unit in the window (PC-ABS). Flames through the window space then ignited the exposed edge of the polyethylene core of the Arconic ACM rainscreen.

The main mechanism of the flame spread over the whole of the exterior of the building was melting – dripping of this polyethylene, with also PIR (Celotex) and/or phenol foam (Kingspan) insulation materials and components of the windows contributing to the fire spread. The same failures of windows and ventilation units then allowed the fire to spread from the burning cladding into other flats on other floors, by-passing the building's fire compartmentalisation. Other failures are also identified in the tower, in particular some fire doors failed to function.

The report considers that, over the lifetime of a block of flats, it is "almost certain that a kitchen fire of this magnitude would happen", and that the configuration and combustible materials of the (renovation) windows led to a "disproportionately high probability" that wire would then spread to the cladding.

"Grenfell Tower Inquiry Phase 1 report.", October 2019. Summarised here for context of Inquiry Phase 2 above.
https://www.grenfelltowerinquiry.org.uk/

Image: Grenfell tower fire, Natalie Oxford, wiki commons
https://twitter.com/nat_vampicca/status/874835244989513729

Grenfell "The Toxic Smoke Files"

Grenfell Inquiry raises questions on cladding smoke toxicity and flammability and insulation suppliers' information. Evidence published early 2023 by the official Grenfell Inquiry shows that Saint Gobain, who own Celotex, who supplied most of the insulation which burnt during the Grenfell Tower fire, had been questioning the smoke emissions and smoke toxicity of the PIR material several years before their installation in the Grenfell renovation in 2015. Despite this, Celotex passed fire tests for the insulation by putting the material behind fire-resistant panels (after a first test failure in which fire breached the panels) and then marketed the product as "acceptable for use" on high rise buildings, without clearly specifying the need for fire resistant protective panels to shield it. David Purser, expert to the Inquiry, has estimated that the polyethylene-core cladding and the PIR insulation both contributed around half of the toxic carbon monoxide in smoke in the Grenfell fire, but PIR also produced some hydrogen cyanide. He considers that the carbon monoxide was the primary cause of death and of incapacitation.

Simon Alengrin Grenfell Inquiry witness statement and documents, released Jen. 2023
https://www.grenfelltowerinquiry.org.uk/evidence/simon-alengrins-evidence-published-23-january-2023

"Grenfell Tower insulation firm behaved 'dishonestly'", BBC 16 November 2020 https://www.bbc.com/news/uk-54967895

"The toxic smoke files: new Grenfell inquiry evidence reveals knowledge of risks before deadly blaze", Inside Housing, 23 February 2023
https://www.insidehousing.co.uk/insight/the-toxic-smoke-files-new-grenfell-inquiry-evidence-reveals-knowledge-of-risks-before-deadly-blaze-80313

EFECTIS WORKSHOP – BUILDING FIRE SAFETY

Fire safety needs a competence and responsibility restart in the UK to address green building and new energy fire risks. 50 building and fire experts discussed how construction techniques are changing, leading to a need for fire regulations which allow innovation whilst ensuring that fire safety is not compromised.

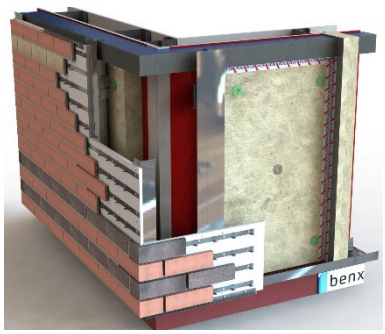
Daniel Joyeux, Efectis, opened the meeting, emphasising the need for multidisciplinary competence and training throughout the construction industry to ensure fire safety. Training of architects, engineers and building professionals needs to include understanding fire tests and materials fire behaviour. After 30+ years of relaxation, the UK today has probably among the most permissive building regulations but a loss of fire engineering competence.

Prof. José Torero Cullen, University College London, underlined the conclusions of the Grenfell fire enquiry that every one of the 72 fire deaths was avoidable (see this pinfa Newsletter). The enquiry has shown the failure of competence and responsibility at all levels of commissioning, ordering, façade insulation materials supply and installation. The deaths resulted from spread of fire, through the recently renovated façade, from one floor to others, by-passing the buildings fire compartmentalisation. For Prof. Cullen the answer is not more regulation: the UK's announced obligations for a second staircase and sprinklers requirements will imply high costs for buildings and are not necessary. Building regulations must be flexible to enable new designs and materials for energy savings, but must ensure compartmentalisation in high-rise buildings.

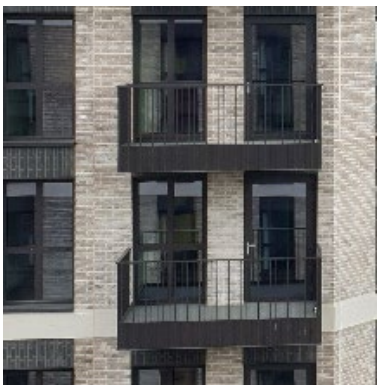
Nick Summers, UK Office for Product Safety and Standards (OPSS), explained the Office's new role as national regulator for construction products, responsible for enforcing product legislation (but not building safety which is the responsibility of other regulators such as the new Building Safety Regulator (BSR) in England). OPSS aims to raise confidence in construction products and will have powers to take action to ensure that businesses only place on the market products that are safe and that perform as claimed and intended. Early work has identified several products for initial review and potential future intervention, including fire doors, smoke dampers, cross laminated timber, plywood, cladding and insulation materials. The Building Safety Act 2022 provides the framework for new regulations covering the marketing and supply of construction products in the UK. The Department for Levelling Up, Housing and Communities (DLUHC) has overall policy responsibility and leads on developing the new regulations, with anticipated implementation not before 2024. The new regulations will ensure that all construction products on the UK market are covered by a regulatory framework, with businesses being required to ensure that the products they are marketing are safe.

Christopher Smith-Wong, BSI (British Standards Institute), underlined that many buildings in the UK today need fire safety renovation work, and at the same time fire safety is impacted by changes in building contents with new energy systems and lithium-ion batteries. British Standard BS 9991 "Fire safety in the design, management and use of residential buildings" is under revision. The draft submitted to public consultation in 2021, online here received 1 800 comments, a record for any British Standard, and will include major changes. A new BS 9792 "Fire risk assessment – Housing" is expected in 2024 and a possible future revision of BS 8414 for classification of external cladding systems is unlikely is until the findings of ongoing research programmes are published.

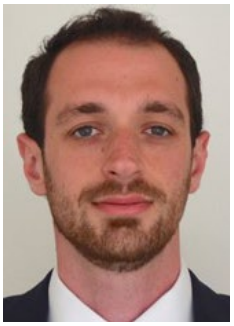
Alan Robb, Benx, façade system providers, explained that currently there is limited fire classification for whole rainscreen systems under BS EN 13501, although data is available for components. The variability of testing under this standard, including sometimes different fire loads, when combined with complimentary testing such as BS EN 1364/5, BS 8414 and even anomalies with the TGD 19 assessment, makes for a challenging environment when looking at façade systems holistically. Robb also explained that although BS 13501 in conjunction with BS 8414 testing is a recognised method of compliance testing for exterior wall systems there are issues around implementation and interpretation of this.



Nick Haughton, Sapphire Balconies, explained that there are today concerns with balcony fires. This was flagged in the BRE 2016 report "Fire safety issues with balconies". Traditional concrete construction of flat balconies has been replaced by other materials and increasingly by glide-on construction, in order to reduce on-site labour at height. A1 or A2-d0 materials are today used for structure, decking, balustrade. However, balcony fires are often related to materials and furniture placed there by residents (e.g; a barbecue, and a motorbike on the balcony, Hicken Road Brixton 2016), cigarettes falling from the balcony above onto furniture, flammable materials used to ensure privacy .... Reinforced glass cannot be used because if it cracks it may fall. Laminated glass avoids this risk (held by the polymer layer) but is currently excluded by bans on non-combustible materials. Overall, the presentation called for a change in perspective in which balconies are no longer viewed as solely metal structures requiring a specific class A fire rating. Instead, the emphasis was placed on understanding the critical impact that residents' use and furnishing of balconies can have on fire safety. By broadening the focus to include these aspects, balcony fire safety can be approached in a more comprehensive and effective manner, leading to safer and more sustainable balcony design for the future.



Sam Sambasivan, Transport for London (TfL), explained that fire performance of materials and smoke and toxic fumes, with minimisation of fire load, are critical for underground mass transit, because of the risks posed by high user density, limited and often non-compliant exits and moving potential fire sources (trains). Wall and ceiling elements must be A1 or A2 (BS 476 part 11), effectively excluding polymers. Combustible materials cannot be feasibly avoided in many small components or electronic equipment such as LED panels and these are subject to stringent fire testing. Even non-combustible materials are subject to smoke emission and gas toxicity testing. Compliant PIN flame retardant solutions exist for a range of polymers including epoxies, polycarbonate, polyester, polyamide, acrylic.



Mohamad El Houssami, Efectis, underlined the specific fire dangers posed by lithium-ion batteries. Battery fires result from poor battery design or manufacture, leading to failures and short-circuits, from accidental puncture, temperature, or from faulty wiring installations or misuse. On overheating, they evolve explosive and toxic gases, leading to major, new fire safety challenges in buildings, both for e-mobility devices brought into flats to charge, as well as cars in garages. Batteries in building contents are increasing both the number and the risks of fires.

Conference discussion points:

- The demand for building fire safety has increased, resulting in an increase in compliance checks, but these are often too late, after completion not during design.
- The “Golden Thread” of responsibility for fire safety at all levels is essential and must be re-established, covering building commissioning, design, contracting and implementation – installation.
- Concerns are raised about lack of fire safety knowledge, and competence in the construction sector. This is a key lynchpin to improvement and to addressing past short-comings. Initiatives are underway including industry’s Competence Steering Group the building Safety Regulator’s new Industry Competence Committee.
- The UK’s Construction Regulations are diverging away from EU law with the revision of the EU Construction Products Regulation (CPR). On the other hand, the UK market has already moved away from British Standards to EU CPR.
- Façades are now much safer as combustible materials are banned, but some flexibility is needed where fire-safe combustible materials can be shown not to increase risk, such as laminated glass.

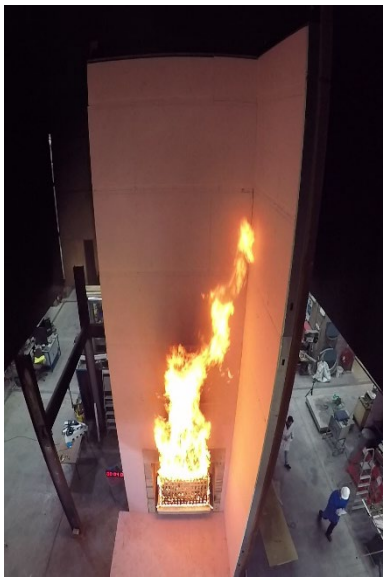


Photo: Efectis façade testing

Efectis workshop “International Building Safety Workshop”, London 14th February 2023 https://efectis.com/en/international-safety-workshop-2/

FIRE SAFETY

Electrical failure or malfunction causes fires

Homes fires related to electrical failure or malfunction kill 390 people, injure 1 300 and cost 1.5 bn US$ yearly in the USA. The NFPA (US National Fire Protection Association) report assessing 2015-2019 data concludes that electrical problems caused 13% of US home structure fires and 21% of property damage costs. Nearly half of these fires were related to electrical distribution, lighting and power transfer equipment (see pinfa Newsletter n°146), and nearly one quarter to cooking and heating equipment, the remainder to fans, air conditioners and other domestic appliances. Around 2/3 of the fires were caused by arcing and around one fifth by heat or sparks from the electrical equipment (remainder: other). Wires or cables were the first identified item to catch fire in one third of cases, and appliance casings or housings in around one tenth. The US Fire Administration has published somewhat lower figures, estimating 23 400 fires per year (2011-2020), leading to 200 deaths, 975 injuries and 1.4 bn US$ losses. The Administration indicates that the number of electrical-caused fires has increased by +2% over the ten years, and dollar losses by +18%

"Home Fires Caused by Electrical Failure or Malfunction", R. Campbell, NFPA, Nov. 2021 LINK.

"Residential Building Electrical Malfunction Fire Trends (2011-2020)", US Fire Administration https://www.usfa.fema.gov/statistics/residential-fires/electrical.html

Two million item fire risk product recall

Electrical fault in air fryers causes recall of two million items: wire connection risks overheating and causing burns or fire. Air fryers cook without oil. Nearly 2.3 million Cosori Air Fryers, (Atekcity), of a number of models, sold in the USA, Canada and Mexico, have been recalled after over 200 reports of fryers catching fire, burning, melting, overheating or smoking, with 10 incidents reported as resulting in minor injuries and 23 reports of property damage. This recall illustrates the ubiquitous potential fire causes present in all electrical equipment (overheating, short circuits and arcing) and therefore the need to ensure that the polymeric materials used in these items (for reasons of electrical safety, weight and design) do not ignite (in wiring, electronics, casings).

"Two Million COSORI® Air Fryers Recalled by Atekcity Due to Fire and Burn Hazards (Recall Alert)", US Consumer Product Safety Commission (CPSC), 23 February 2023 https://www.cpsc.gov/Recalls/2023/Two-Million-COSORI-Air-Fryers-Recalled-by-Atekcity-Due-to-Fire-and-Burn-Hazards

High-rise fire Chicago

Rapid fire spread up nine floors of a high-rise building, Kenwood, Chicago, 25 Jan. 2023, killing one and injuring nine. The fire is indicated to have been started by smoking materials igniting combustibles in a bedroom. The fire spread rapidly upwards from the 15th to the top (24th) floor of the building, probably pushed by wind, but did not spread sideways. The 25 year old, 300 flat building had an ongoing record of fire safety inspection failures concerning alarm systems, fire system inspection and testing, water supply to fire installations, door tags and failure to file a high-rise exterior wall report.

"Deadly high-rise fire caused by careless use of smoking materials, Chicago Fire Department says" https://abc7chicago.com/fire-chicago-high-rise-kenwood-apartment/12737165/

Lithium-ion battery fire dangers

NBC TV network Today news shows lithium ion battery fires with videos of batteries catching fire and exploding in the home and in industry. New York recorded 216 lithium-ion battery fires in 2022, with 147 injuries and 6 deaths. Full-scale furnished room testing is shown, commented by Steve Kerber of UL. An e-scooter battery is deliberately overcharged. After two hours, smoke appears. Seventeen seconds later it explodes. 12 minutes later the room is engulfed with flames. Experience of Arizona firefighters in a battery energy storage unit explosion is presented. NBC News recommends to buy certified batteries, never overcharge and not charge when unattended.

Officials sound alarm over rise of lithium-ion battery fires - YouTube

E-mobility fires in France

Fires presumed to have started in e-scooter batteries lead to deaths and multiple damage in France. Experts in France (ONSE) indicate that 20 – 35% of home fires have as principle cause electrical faults. Fires causes by e-bikes, e-scooters and other e-mobility devices are increasing, as consumers bring these into their homes to charge, not the garage. E-device fires cited include La-Chapelle-sur-Dun, Puteaux, and Ingré, Le Loiret.

"Trottinettes, vélos électriques… risques d'incendie à grande vitesse !", 2 February 2023, Construction21
https://www.construction21.org/france/articles/h/trottinettes-velos-electriques-risques-d-incendie-a-grande-vitesse.html

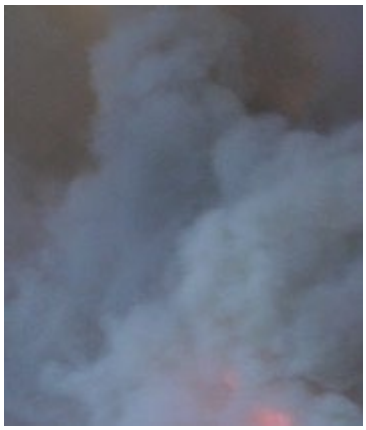
Aircraft cabin fire that didn't happen

A passenger's electronics battery ignited in the back pocket of an aircraft seat in the air. The fire did not spread. The crew of the Newark-bound United airlines flight contained the fire by putting the battery into a containment bag. The plane then returned safely to San Diego airport. Six people received precautionary medical treatment. The incident illustrates how fire safety requirements for seat textiles and aircraft interior materials can prevent fire spread. The US FAA (Federal Aviation Authority) indicates nearly sixty incidents per year involving lithium-ion battery fires or overheating in airplanes.

ABC News, 7 February 2023 https://abcnews.go.com/US/4-injured-after-battery-caught-fire-united-flight/story?id=96953705

DailyHive 10 February 2023 https://dailyhive.com/canada/united-airlines-battery-pack-fire

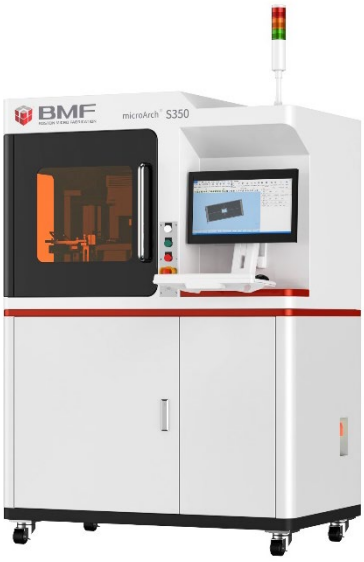
INNOVATION AND RESEARCH



Smoke suppressants with PIN FR

Mineral additives reduce smoke and fire toxicity with a PIN FR, and improve and modify flame retardant effects. Four mineral PIN smoke suppressants (zinc stannate, zinc phosphate, titanium oxide and hydrotalcite) were tested at 1 % loading (and 5% for zinc stannate) with 18% of the PIN flame retardant AlPi (diethyl aluminium phosphinate) in polyamide 6.6 + 25% glass fibres. In cone calorimeter tests, all four smoke suppressants reduced peak heat release rate (PHRR) of the PIN FR polyamide glass fibre compound, but at 1% only hydrotalcite reduced total smoke production. In a smoke density chamber, only zinc stannate and hydrotalcite reduced peak smoke density but hydrotalcite significantly reduced time to ignition. At 5%, zinc stannate reduced PHRR by 30%, total smoke production by over 40%, peak smoke density by 60% and toxic emissions of carbon monoxide and hydrogen cyanide by 70% as well as reducing smoke particle size. The authors conclude that the mode of action of AlPi was switched from gas to condensed phase, resulting in increased dense char, suppressing smoke release and improving fire protection.

"No business as usual: The effect of smoke suppressants commonly used in the flame retardant PA6.6 on smoke and fire properties", S. Goller et al., Polymer Degradation and Stability 209 (2023) 110276, https://doi.org/10.1016/j.polymdegradstab.2023.110276



BMF micro-precision 3D printing

25 µm PµSL printer uses PIN flame retardant UL 94 V-0 photopolymer resin for fast, precision additive production. BMF (Boston Micro Fabrication) was founded in 2016 and offers performance precision Projection Micro Stereolighography (PµSL) 3D-printers. The technology polymerises additive layers of liquid polymer resin with flashes of UV light. Today over 200 sites worldwide are operating the company's printers to produce small and micro-sized components for R&D and prototyping. BMF's new microArch 350 printer offers faster print speed for higher volumes, with build size up to 100x100x50 mm, for industrial production. Applications include miniaturised parts in electronics, optics, medical devices, microfluids, aerospace.

"BMF Unveils microArch™ S350: The HighestThroughput Microscale 3D Printer", 8/11/2022 https://bmf3d.com/news/bmf-unveils-microarch-s350/

Nexans invests in PIN fire safe cables

Nexans, world electrification leader, is to invest 40 M€ in Autun, France, for an expertise centre on non-halogen fire safe cables. Nexans was established in France 120 years ago and today has 14 production sites in France, 25 000 staff worldwide and over 6 bn€ annual sales. The Group is a leader in design and manufacturing of cable systems for energy generation, distribution and use, industry and telecoms and data transmission, and is pledged carbon neutral by 2030. Announcing the investment, Nexans underlined expected changes in fire safety standards in tertiary buildings, with increasing requirements that wires and cables must have low smoke toxicity. Nexans is responding by centring on cables without PVC and without halogens. Nexans will also actively develop recycling.

Nexans PIN fire safety solutions: see pinfa Newsletters n°s 144, 97, 75

"Nexans reaffirms its presence in France and invests 40million euros in its Autun plant in Saône-et-Loire", 11 January 2023 LINK.

PIN flame retardant dyes

German Government funded DTNW project will develop non-halogenated reactive fabric dyes with FR properties. Every textile finishing process involves washing and drying of textiles, which requires water and energy. By combining into one the two processes of dyeing and flame retardants finishing, both resources can be saved. DTNW (Deutsches Textilforschungszentrum Nord-West gGmbH) is developing new one-pot synthesis flame retardant dye products, which ensure both dyeing and fire protection of fabrics such as cotton or polyesters. The chemical immobilisation of the PIN FR-dyes onto the surface of finished textiles is expected to ensure very low environmental exposure and high durability.

The project is financed by AiF (IGF No. 22599 N) (German Federation of Industrial Research Associations) of the German government
https://www.dtnw.de/en/projekt/flammschutz-farbstoffe/

Bone phosphate as PIN flame retardant

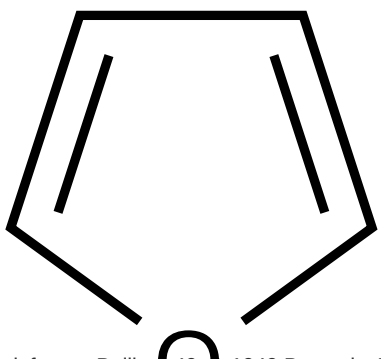
Hydroxyapatite extracted from animal bones showed fire protection effects on jute fibres in polymer composites. The hydroxyapatite (HAP, the calcium phosphate mineral structure of bones) was dissolved out of the bones using 20% sodium hydroxide, releasing a slurry of micro-HAP particles, which were then neutralised and calcined at 1000°C. The jute fibres were functionalised with 20% sodium hydroxide then repeatedly dipped in micro-HAP solution. The treated jute fibres were then incorporated into vinyl ester resin (VER) composites. Heat release rate of the treated jute was reduced by c. 80% compared to untreated fibres, and was reduced by around 2/3 for composites. Tensile strength and impact energy of the composites were increased. The micro-HAP generates char during combustion, reducing release of volatile, flammable gases.

"Renewable micro hydroxyapatite (mHA) extracted from animal bones, and fabricated mHA-Jute-vinyl ester bio-composite as an intumescent green flame retardant material", R. Cheedarala et al., Mater. Adv., 2023, 4, 1171–1187, https://doi.org/10.1039/d2ma01029a

Biobased PIN FR for wool

Phytic acid (a natural organophosphate) with ammonia gave a washable phosphorus nitrogen fire safety treatment for wool. Phytic acid (PA) is a phosphorus-rich organic molecule found widely in plant seeds, where it is a natural phosphorus nutrient store. PA was reacted with ammonia solution (which can be also bio-based by stripping of e.g. digestate or manure), then covalently reacted onto wool fibres at 90°C using dicyandiamide as catalyst (reaction of the phosphate group of PA with OH groups on wool fibres), followed by drying at up to 160°C, then washing). The treatment increased LOI from 24 to 32, and the treated wool fabric (125 g/m^2) achieved B_1 in the vertical burn test GB/T 5455 (char length reduced from 30 to 10 cm) and was self-extinguishing, including after 15 wash cycles. Maximum smoke density was reduced by 14%. Tensile strength of the fibres was increased. The ammonia phytic acid is considered to improve fire safety by generating highly graphitised aromatic char.

"Covalent flame-retardant functionalization of wool fabric using ammonium phytate with improved washing durability", X-W. Cheng et al., Industrial Crops & Products 187 (2022) 115332
https://doi.org/10.1016/j.indcrop.2022.115332



Biobased polymeric PIN FR for epoxy

Furfuralcahol (from furan extracted from biomass) reacted with polyphosphazene is tested as plasticising PIN FR in epoxy. Furfuralcohol has a heat-resistant oxygen heterocycle structure and a reactive hydroxyl group. In this study, it was reacted via the commercially available intermediate HCCP (hexachlorocyclo-triphosphazene) to produce a polyphosphazene (PFMP = polybis (2-furanmethanol) phosphazene) consisting of linked identical

monomers (P=N)-(furfuralcohol)$_2$. 15% PFMP in DGEBA epoxy increased LOI from 25 to 33, decreased peak heat release rate by more than 50% and enabled UL 94 V-0 (thickness not specified). The PFMP is considered to act in both solid phase, catalysing thermally stable char formation, and gas phase, by releasing PO$^{\cdot}$ and $PO_2^{\cdot}$ radicals. PFMP also improves the mechanical performance of the epoxy, transforming brittle fracture to ductile fracture. 15% PFMP increases impact strength (+12%), tensile strength (+40%) and elongation at break (+35%).

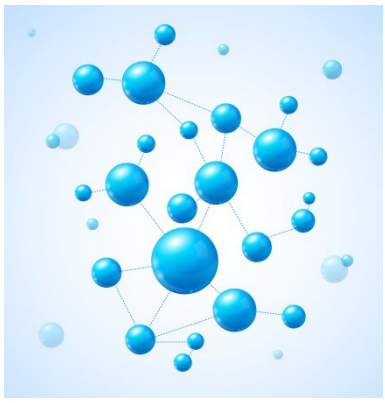
"Biomass-derived polyphosphazene toward simultaneously enhancing the flame retardancy and mechanical properties of epoxy resins", Y. Xiao et al., Chemosphere 311 (2023) 137058
https://doi.org/10.1016/j.chemosphere.2022.137058

Molecule of furan: Wikimedia

Phosphorus silica PIN FRs synergy

Phosphorus and nitrogen functionalised silica showed to be an effective flame retardant in thermoplastic polyurethane. Silica was amine then propargyl functionalised, then reacted with a phosphorus and nitrogen containing derivate of pentaerythritol using alkine-azyde "click" chemistry. This produced a phosphorus functionalised silica (PhosFS = 2,6,7-Trioxa-1-phosphabicyclo [2.2.2]octane, 4-(Azidomethyl)- 1-oxide, a phosphorus molecule similar to PEPA). With 10% loading of PhosFS in thermoplastics polyurethane (TPU), UL 94 V-0 (3 mm) was achieved with no flaming dripping (NR for neat TPU, V2 for the same loading of non-functionalised silica). LOI was increased from 19% (neat TPU) to 28.5%, char residue at 700°C increased from 4% to 20% and thermal stability was increased from 291°C to 308°C. These effects are considered to be due to generation of a uniform and dense char and linking between the PhsFS and the TPU.

"Phosphate functionalized silica for improved flame retardancy and thermal stability of thermoplastic polyurethane", Shhikha, L. Nebhani et al., ACS Appl. Polym. Mater. ACS Appl. Polym. Mater. 2022, 4, 9, 6332–6341, https://doi.org/10.1021/acsapm.2c00551

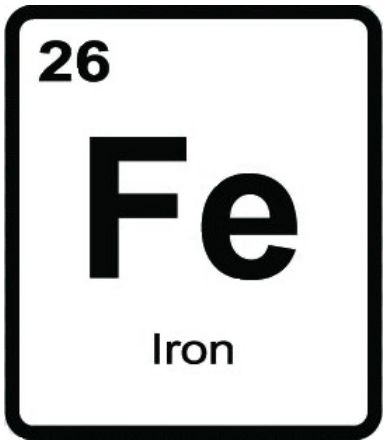


Macromolecular phosphorus nitrogen FR

A branched chain dialkyl phosphinate – dialkyl ammonium PIN FR achieved UL 94 V-0 (1 mm) in polyamide PA6. The macromolecular PIN FR was prepared by reacting a commercial phosphorus containing cyclic acid anhydride (2-Methyl-1,2-oxaphospholan-5-one-2-oxide) with polyethylenimine, at a molar ratio of oxaphosphalane to amine groups of 1:2. The resulting PN FR had a phosphorus content of c. 13%. UL 94 fire testing showed V-0 (1 mm) for polyamide PA6 with 10% of the PN FR, compared to V-0 for 10% of the commercial aluminium-phosphorus PIN FR AlPi, V-2 for 10% melamine cyanurate, APP or red phosphorus and V-2 or NR for only 1% loadings of the different tested FRs. Glow wire test performance is improved from NR (neat PA6, 850°C) to pass with 5% PN FR (even at higher temperature 960°C). Mechanical

properties of the polyamide are slightly modified (increased stiffness, reduced elongation at break), extrusion and injection moulding processing are compatible, and electrical resistivity is significantly improved (up to 3 x increase).

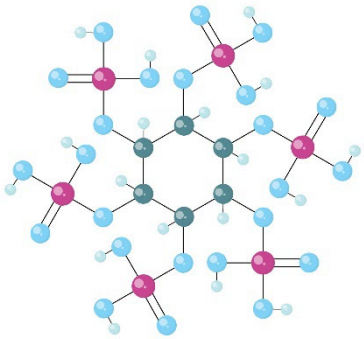
"The effect of the presence of a macromolecular organophosphorus flame retardant, poly (N-[3- oxopropyl methylphosphinate] ethyleneimine), on the flammability, thermal stability, and mechanical properties of polyamides", M. Helmy et al., Fire and Materials. 2022; 1–10, https://doi.org/10.1002/fam.3092



Polymeric iron phosphorus nitrogen PIN FR

P-functionalised polyethyleneimine with iron salt achieved UL 94 V-0 in epoxy and improved mechanical properties. The commercial nitrogen containing polymer polyethylenimine (PEI) was reacted with phosphoric acid, then combined with ferric (Fe^{3+}) salt, giving an iron – phosphorus – nitrogen polymeric PIN FR (PEIP-Fe). At 3% loading in DGEBA epoxy, UL 94 fire performance was improved from NR to V-0 with no dripping (3 mm). LOI was increased from 25.6 to 27.8, peak heat release rate was reduced by nearly 50%, peak smoke production by 20%. Impact, tensile and flexural strength of the epoxy were improved. Fire performance improvement was considered to be the result of compact and continuous char generation (catalysis of charring and of cross linking) and of gas phase action ($P\cdot$, $PO\cdot$). Mechanical benefits are considered to be related to intermolecular cavities, active amino groups and chelating effects in the epoxy.

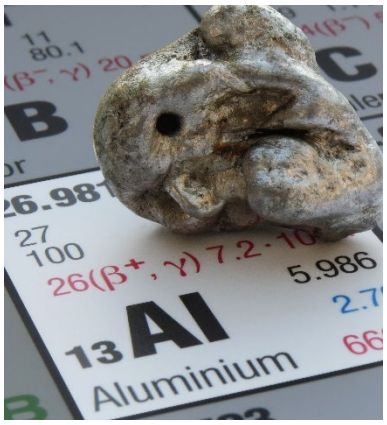
"Simultaneously improving the fire safety and mechanical properties of epoxy resin with iron phosphonated grafted polyethylenimine", X-H. Shi et al., Polymer Degradation and Stability 206 (2022) 110173 https://doi.org/10.1016/j.polymdegradstab.2022.110173



Metal melamine phytate PIN FRs

Phytic acid (natural organophosphate), with melamine and metal ions, reduced fire, smoke and toxic gases in polyamide. Melamine (an organo-nitrogen molecule) was reacted with phytic acid (the biological phosphorus storage molecule of plants) to produce melamine phytate platelets, on which different transition metals (copper, nickel, zinc) were surface deposited (at 0.9 – 1.9 % w/w). Melamine phytate with no metal and with each of the three metals was tested in glass fibre reinforced polyamide PA6 (18% GF) at 12% FR loading. LOI was improved from 21.5 (neat glass-fibre PA6) to 28.5 – 30, peak heat release rate was reduced by over 30% and total smoke production by nearly 40%. The inclusion of transition metals showed synergy with the melamine phytate PIN flame retardant, with copper being most effective, considered to be due to catalytic effects and generation of glassy char.

"Novel transition metal modified layered phosphate for reducing the fire hazards of PA6", X. Qian et al., Composites Communications 37 (2023) 101442 https://doi.org/10.1016/j.coco.2022.101442



Aluminium silica PIN FR treatment for wood

PIN mineral salts and water-borne epoxy were used to fire safety treat wood, reducing flammability and fire gas toxicity. Fire safety is critical to enable use of wood as a renewable carbon-sink material for green building. PIN mineral salts, with good environment profiles, sodium silicate and aluminium sulphate, with water-borne epoxy, were impregnated into poplar wood by 2-step pressure/vacuum immersion. This resulted in double oxide layers within the wood. The water-borne epoxy (with triethanolamine curing agent) was used to reduce mineral losses from the wood. Total loading in the wood was 40% w/w. Peak heat release rate was reduced by around 40%, peak smoke release by around 35% and peak carbon monoxide release by nearly 75%. Toxic smoke gas emissions such as ketones were also significantly reduced. The authors conclude that this is an environmentally friendly fire safety treatment of wood, enabling low smoke and toxic gas emissions in fire.

"Synergistic effects of Al/Si double oxide on flame-retardant and smoke-suppressant wooden materials", Z. Sun et al., J. Building Engineering 59 (2022) 105037 https://doi.org/10.1016/j.jobe.2022.105037

OTHER NEWS

Mechanisms of TPP (organophosphorus PIN FR) effects on liver cells. Study shows that TPP (tri phenyl phosphate) at 50 µM concentration leads to spontaneous cell death (apoptosis) in mouse liver cells. RNA sequencing showed that TPP particularly modifies gene expression for endoplasmic reticulum stress (errors in protein folding) and autophagy (breakdown of proteins and materials within the cell). pinfa note: the concentrations of TPP tested were e.g. more than four orders of magnitude higher than concentrations of TPP found in human hair, which is considered to concentrate contaminants (70 ng/kg TPP in hair, Chupeau et al., pinfa Newsletter n°140).

"Triphenyl phosphate (TPP) promotes hepatocyte toxicity via induction of endoplasmic reticulum stress and inhibition of autophagy flux", M. Li et al., Science of the Total Environment 840 (2022) 156461 http://dx.doi.org/10.1016/j.scitotenv.2022.156461

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