pinfa
Phosphorus, Inorganic & Nitrogen Flame Retardants Association

Your newsletter for non-halogen fire safety solutions n° 113 May 2020

Looking forward in the present crisis

We are all impacted by the global COVID-19 crisis. Above all, we wish safety to you all, your families and your colleagues.

pinfa continues to function, from confinement, to enable exchange of information. Personal meetings have been switched over to online meetings for the time being and we are all getting used to new way of working remotely. pinfa workshops and conferences are on hold, until we have a clearer view when gatherings will be possible again. In parallel we are exploring and trying online options. However, we believe that direct personal interaction brings meetings to a better level and we look forward to when they will be possible again.

Those pinfa member companies with possibilities to do so are acting directly to support work on combating the pandemic (see below) as part of Cefic's wide engagement. The chemical industry as a whole is actively addressing both health and safety of company employees and concerns around material supply chains, see Cefic's COVID-19 Helpdesk

The economic crisis will pose major challenges for pinfa companies and for our customers, but safety (including fire safety), environment and climate change will be among key priorities in European recovery efforts. pinfa will be ready to support this.

pinfa particularly wishes to express our heartfelt appreciation to fire and emergency services, who are alongside nurses, doctors and hospital staff at the front of the Covid crisis.

Adrian Beard, pinfa President. Esther Agyeman-Budu, pinfa Sector Group Manager at Cefic.

pinfa-NA Adapts to the New Normal

Due to the impact of Covid 19 on travel and meetings, pinfa-NA has made changes to its outreach and technical programme for 2020. The SAMPE annual conference, Seattle, May 2020, has been cancelled and next year's SAMPE will be 24-27 May 2021 in California (Society for the Advancement of Material and Process Engineering). pinfa-NA had put together a session for Seattle on 'Aviation and FST' (fire, smoke and toxicity) with speakers from Boeing, FAA, 3M, Safran, Sabic, UL and Southwest Testing labs. We are now exploring other opportunities to present this programme.

The AMI Flame Retardants conference has been postponed from end March 2020 to 1-2 October 2020. pinfa-NA will present a paper on Fire Safety in Hybrid and Electric Vehicles and organise a panel discussion on changing requirements for Fire Safety and the formulation of FRs.

The first PIN FR Formulator Workshop, planned by pinfa-NA at Case Western Reserve University for October 2020, is postponed to 9-10 March 2021, Cleveland Ohio, with presentations on formulating with PIN FRs, a demonstration of fire testing labs, breakouts for problem solving and interactions with suppliers of flame retardants, synergists and fire testing services.

If Covid permits, pinfa-NA will also deliver educational sessions at CAMX (Composites and Advances Materials Expo) 21-24 September 2020, Orlando and Greenbuild, 5-6 November 2020, San Diego and pinfa-NA will have booths at Compounding World Expo, 4-5 November 2020, Cleveland, Ohio and at NPE (National Plastics Exhibition) 17-21 May 2021, Orlando, Florida.

submitted by Margaret H. Baumann, Vice-chair pinfa-NA, FRX Polymers www.pinfa-na.org

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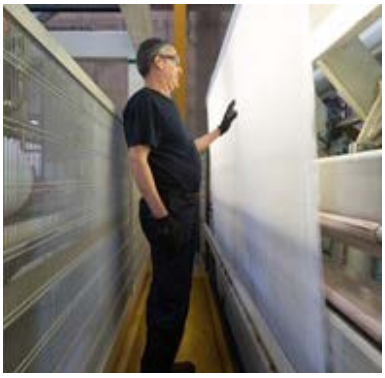
PANDEMIC



pinfa member companies engage in Covid crisis

Each of our companies is doing what it can to help fight the virus and to support health services and local communities. The examples below are just some of actions by pinfa member companies, other actions are not yet communicated as the priority is on doing not showing.

This is part of the wide engagement of the European chemical industry to meet demand for chemicals needed to produce critical materials and equipment for the crisis: disinfectants, diagnostic tests, ventilators, protective masks, gloves and gowns, medicines, protective clothing and intensive care unit equipment.

Cefic member companies are rapidly adapting chemical processes at their production sites and forming new industry alliances to meet these needs.

FRX is using its knowledge of China's textile supply chain to screen Chinese suppliers and provide information to local hospitals and public bodies to obtain masks and donate to nursing homes and frontline medical staff.

Lanxess has donated concentrate for one million litres of disinfectant to 13 countries worldwide to save lives in Europe, the Americas and Asia.

Clariant is using its installations to formulate disinfectant, meeting nearly two thirds of Bavaria public authorities' supply objectives.

Solvay is donating hydrogen peroxide (H_2O_2) disinfectant to over health and emergency services in Belgium and has modified its production. Solvay has also modified its production to formulate hand sanitisers, donated to local health services.

DSM, with AFPRO and Royal Auping, has launched large-scale production of certified FFP2 masks, and will meet a quarter of The Netherlands urgent needs for healthcare workers.

Radici has organised with Plastik and local garment makers in Italy, use of its plastic films to produce hospital gowns according to hospital PPE specifications, donated to Bergamo hospital.

BASF has modified production to hydro-alcohol gel to supply hospitals, is producing face screens for health workers at its 3D-printing subsidiary Sculpteo, and is continuing supplying a wide range of key chemicals from its range including detergents, disinfectants and plastic additives for medical equipment.

Photos: Lanxess, Clariant, Radici, BASF.

FRX Polymers 25th March 2020 https://news.thomasnet.com/companystory/frx-polymers-joins-forces-with-chinese-american-association-of-lexington-to-help-boston-communities-amid-covid-19-crisis-40034796

Lanxess 19th April 2020 https://lanxess.com/en/Media/Press-Releases/2020/04/LANXESS-donates-one-million-liters-of-disinfectant-solution

Clariant 4/2020 https://www.clariant.com/de/Corporate/News/2020/04/Clariant-starts-monthly-production-of-2-million-liters-of-disinfectant-in-Gendorf-to-support-vital-i

Solvay 7th April 2020 https://www.solvay.com/en/press-release/solvay-makes-donations-to-hospitals-and-pharmacies-in-belgium

DSM 28th April 2020 https://www.dsm.com/corporate/news/news-archive/2020/2020-04-28-production-in-the-netherlands-of-millions-of-medical-facemasks-for-healthcare-professionals-has-started.html

Radici 1st April 2020 https://www.radicigroup.com/en/news-media/press-releases/radicigroup-to-deliver-personal-protective-equipment-for-doctors-and-healthcare-workers-fighting-covid_19-55035

BASF 22nd April 2020 https://www.basf.com/fr/fr/media/Communiques-de-presse-France/2020/BASF_Covid19.html

Cefic "Our Industry's Response To COVID-19" https://cefic.org/our-industry/our-industrys-response-to-covid-19/

REGULATORY AND STANDARDS

US EPA consults on chemicals assessment scopes

Risk evaluation scopes for the 20 priority chemicals listed under TCSA last year, including two chlorinated FRs and TPP, are open to comment to 26th May 2020. EPA identified in December 2019 twenty chemicals as "high priority" for risk evaluation under TSCA (Toxic Substances Control Act). These include eleven halogenated chemicals (of which two halogenated FRs, TCEP and TBBPA), six phthalates, formaldehyde, a fragrance ingredient, a rubber intermediate and the non-halogenated phosphorus ester FR TPP (triphenyl phosphate). EPA has now published "Draft Scope of the Risk Evaluation" documents for these twenty chemicals. These documents indicate which applications of the substances will be assessed for possible regulation. Public comment on the draft scope for TPP is open to **26th May 2020**.

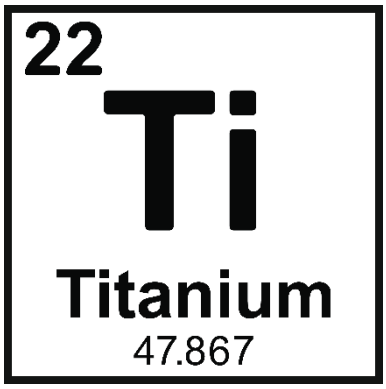
"Draft Scope Documents for High-Priority Chemicals Undergoing Risk Evaluation", US EPA (TCSA) 3rd April 2020 https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/draft-scope-documents-high-priority-chemicals-undergoing

*Public consultation on the draft scope for TPP, **open to 26th may 2020** https://www.regulations.gov/document?D=EPA-HQ-OPPT-2018-0458-0020*

ISO fire safety strategy under discussion

ISO/TC 92, horizontal committee on fire safety, has circulated for comment its 'Business Plan' defining key areas for standards development. ISO (International Standards Organisation) TC92 (Technical Committee) addresses all aspects of fire safety beyond those included in other specific technical standards, covering materials, products, structures and building occupant behaviour. ISO standards are often translated into national fire standards, e.g. in the EU Construction Products Regulation or the European railway standard EN 45545-2. The Business Plan proposes to develop further ISO standards work on fire testing, fire containment, fire safety engineering and fire threat to people, including application to new building materials. Specifically, for the coming four years, a range of work on smoke emission and toxicity, smoke effects and environmental impact of fires is defined.

***ISO TC/92** https://www.iso.org/committee/50492.html Note: the 19th February 2020 draft Business Plan is not available on the ISO website (document online is 2014) but via Committee members*



Titanium dioxide Classified Cat2 suspected carcinogen

The European commission has published the Classification of titanium dioxide (TiO_2) as a category 2 suspected carcinogen by inhalation, applicable in GHS from 9th September 2021. Liquid or solid mixtures containing ≥1% titanium dioxide with diameter ≤ 10 µm will have to be labelled Carc.2 H351 with the new warning phrases EUH211 or EUH212 respectively. Titanium dioxide has been shown to be an effective FR synergist, and if immobilised in polymers it is not respirable and not subject to this suspect carcinogen classification.

The new warning phrases: EUH211 "Warning! Hazardous respirable droplets may be formed when sprayed. Do not breathe spray or mist", EUH212 "Warning! Hazardous respirable dust may be formed when used. Do not breathe dust."

EU Official Journal publication, 4th October 2019 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2020.044.01.0001.01.ENG&toc=OJ:L:2020:044:TOC

UK Government £1 billion for fire risk claddings

The UK Government has announced an (additional) £1 billion fund to support replacement of non fire-safe cladding materials on tall buildings. This adds to UK£ 600 million already allocated to replace the highest risk ACM (aluminium composite material) cladding, as used on Grenfell Tower. The money will go both to public and private building owners. A condition for funding is that owners must pursue "action against those responsible for putting unsafe cladding". The Government has also released UK£20 million to fund fire services inspection and enforcement.

"Remediation of non-ACM buildings", UK Government, 11th March 2020 https://www.gov.uk/guidance/remediation-of-non-acm-buildings and "NFCC expresses its relief and welcomes Budget's cladding Announcement", UK National Fire Chiefs Council, 12th March 2020 https://www.nationalfirechiefs.org.uk/News/nfcc-expresses-its-relief-and-welcomes-budgets-cladding-announcement

FIRE AND COMMUNICATIONS

2nd Symposium on Public Safety

This specialist workshop discussed fire safety challenges in today's society. NIST and UL videos show how fast flashover can occur in a modern home. The workshop at Case Western University (CWRU), Ohio, was organised by Hatsuo Ishida, and brought together 120 participants. Innovative flame retardant solutions were presented and twelve PINFA-NA member companies attended. Terry Brady, Underwriters Laboratories (UL), interviewed by Suzanne Rivera, CWRU, underlined the importance of research into flammability and collaboration with stakeholders. Stephen Kerber, Underwriters Laboratories (UL), emphasised how modern materials generate fire risk, pointing to the NIST video which shows how a 1960's furnished room takes nearly 30 minutes to reach flashover, whereas a room with modern materials reaches flashover in less than 3 minutes, comparing this to the 6 – 10 minutes average response time for fire services. Another video by UL showed the dramatic effect of a closed bedroom door on flame/smoke spread in a house fire, with the bedroom door closed scenario giving ample time to escape, not so for the open door. Alex Morgan, University of Dayton, summarised developing fire issues in automotive and transportation. Tim Reilly, PINFA-NA and Clariant, outlined industry requirements for tomorrow's flame retardants and challenges in commercialisation. Serge Bourbigot, University of Lille, France, Jamie Grunlan, Texas A&M and Douglas Fox, American University, presented innovative approaches to textile and foam flame retardancy using various inorganic platelets. Gary Wnek, CWRU, presented development of polyacrylic acid salts as char formation synergists. Hatsudo Ishida, CWRU, presented benzoxazines as a class of inherently flame-retardant thermoset polymers.

2nd Symposium on Public Safety and Workshop, Case Western Reserve University, Feb. 18-19, 2020, Cleveland, Ohio USA

Media show dangers of fire

A short, amateur video posted by the New York Times shows fire engulfing a family house and close escape of a child on a sofa, thanks to fire alarms sounding, just before flashover occurs. Other media, including USAToday, report a United airlines flight having to make an emergency landing in Florida after a passenger's backup device battery caught fire in their bag. The crew contained the fire using a fire resistant case.

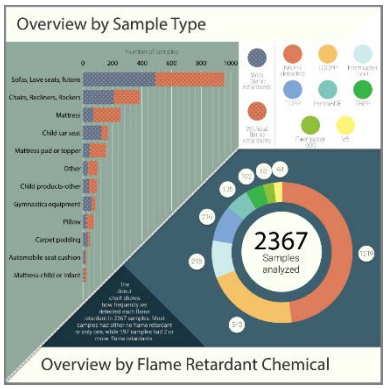
New York Times, 1st March 2020 "Terrifying house fire nearly engulfs child sleeping on couch"
https://nypost.com/video/terrifying-house-fire-nearly-engulfs-child-sleeping-on-couch/

"Plane makes emergency landing after passenger's battery charger explodes"
https://www.iol.co.za/travel/travel-news/plane-makes-emergency-landing-after-passengers-battery-charger-explodes-43922570

North America Modern Building Alliance launched

NAMBA will coordinate advocacy on fire safe use of plastic materials in construction envelopes, as does Modern Building Alliance in Europe. NAMBA is headed by the American Chemistry Council and brings together so far eight executive members from the chemicals, polymers, insulation and roofing and construction materials industries.

https://plastics.americanchemistry.com/Product-Groups/North-American-Modern-Building-Alliance.aspx



US furniture industry claims to launch FR-free test

UFAC has launched a programme to test whether furniture "is free of the most common flame retardant chemicals" … without specifying which these are. The UFAC (Upholstered Furniture Action Council) programme, launched February 2020, appears to refer to the Duke University foam testing project which indicated in 2016 that it tests seven brominated FRs (below). It is not clear if this Duke information is up to date, and the UFAC website does not specify which flame retardants are tested in its programme, nor even how many. UFAC states that testing is initially limited to foams, but aims to expand also to upholstery. It is added on to UFAC's existing "Make Life Safer" label for furniture manufacturers which verifies smoldering cigarette only fire safety resistance. UFAC's supporting website claims that "many" flame retardants have a long list of adverse health effects covering nearly everything imaginable (endocrine and thyroid disruption, immune system, reproductive toxicity, cancer, foetal and child development, neurologic function and obesity) – supported by no references (the superscript "2" has no link).

pinfa considers irresponsible to launch and promote such testing with no clear indication of what is tested (which FRs) and with unsupported and misleading statements about flame retardants.

The seven brominated FRs tested under the Duke project: Firemaster 550, Firemaster 600, TDCIPP, TCIPP, V6, PentaBDE, TBPP (see here).

UFAC website: https://ufac.org/ and Duke foam project http://foam.pratt.duke.edu/

PIN FR APPLICATIONS AND INNOVATION

FR glass-fibre reinforced polyamide for 3D-printing

Following the launch of carbon-fibre reinforced printing (pinfa Newsletter n°112), with Windform® FR1, CRP Technology has now launched Windform® FR2, a glass-fibre reinforced polyamide for SLS (selective laser sintering) 3D-printing. Windform® FR2 is off-white (not black), is electrically insulating, allows good surface resolution and offers a smooth surface finish. Both materials have passed the FAR 25.853 12-second vertical and 15-second horizontal flammability tests, the 45° Bunsen burner test and smoke density tests. Both materials are adapted for automotive, consumer and aircraft applications.

"CRP Technology introduces Windform® FR2, a cutting-edge composite material for Additive Manufacturing", 10th February 2020 https://www.industrial-lasers.com/additive-manufacturing/article/14167344/crp-technology-intros-cuttingedge-composite-material-for-laser-sintering

PIN FR polyester from waste plastic

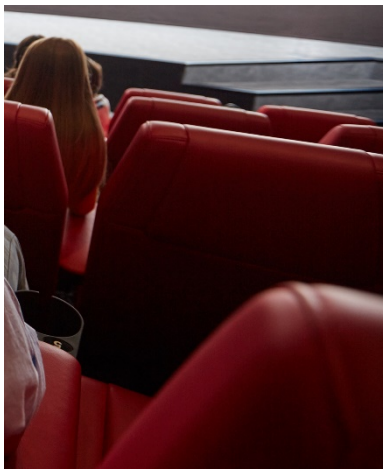
Clariant and Lavergne have launched a PIN flame retardant polyester produced from ocean-bound plastic (OBP). This is plastic waste, collected in Haiti, which would have reached the ocean if it had not been recovered. Some 8 million tonnes of plastic are estimated to enter the world's seas each year. The new OBP-based compound, Lavergne VYPET OBP-FR is 30% glass fibre reinforced PET (polyethylene terephthalate). It offers UL94-V0 (0.8 mm) fire performance, achieved using PIN flame retardants from Clariant, in particular phosphinates which offer GreenScreen Benchmark 3 and have been demonstrated to be compatible with plastics recycling. The PIN FR and synergists used ensure that the compound is adapted for E&E applications, requiring structural and aesthetic qualities, and is compatible with reprocessing of post-consumer plastics. pinfa member Clariant is a phosphorus FR specialist. Lavergne is a Canada-based world leader in engineering resins from recycled plastics.

"A new high-performance life for plastic waste: Lavergne and Clariant develop halogen-free flame-retardant compounds for electronics based on recycled ocean-bound plastics (OBP)", 27 February 2020 https://www.pressreleasefinder.com/Clariant/CLAPR1660/en/

Solid silicone rubber for improved rail fire safety

Wacker has launched a flame retardant solid silicone rubber, meeting EU railway fire safety standards (EN 45545-2), meeting HL2 for R1 and R7 requirements. This is achieved in ELASTOSIL® R 771 by enhancing the inherent fire performance of silicones with a halogen-free flame retardant. The solid silicone can be molded using conventional processing, extruded or calendered, to produce parts, profiles, panels, films and fabric-reinforced silicone sheets. Applications include both railways and buildings, wherever high fire safety performance and low smoke, low smoke toxicity are required. Wacker is a Munich-based global chemical company specialised in polymers, silicones and polysilicon and bio-solutions.

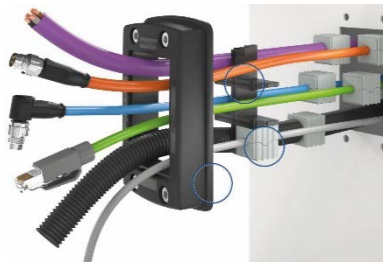
"EU Fire-Safety Standard for Rolling Stock: WACKER Presents New Solid Silicone Rubber for Improved Fire Safety", 25 July 2019 https://wacker-k2019.com/press-releases/



PIN FR coating for agreeable, safe seating

Swiss-based global colour and chemicals company Archroma, has launched new water-based, very low VOC polyurethane coatings applicable to wide range of fabrics, nonwovens and papers, for both indoor and outdoor applications, and particularly adapted for synthetic leather. The coating improves mechanical properties of textiles, such as strength and scratch resistance. Combined with Archroma's non-halogenated flame retardants, the coating is the core of the company's "Safe Seat" system for synthetic leather upholstery. It can be applied by impregnation, coating (paste or foam) or spray and is compliant with the textile and synthetic leather processing ZDHC (Zero Discharge of Hazardous Chemicals) scheme (see pinfa Newsletter n°90) and with the Bluesign responsible and sustainable textile manufacturing scheme.

VOC = volatile organic compounds. "Archroma to introduce new water-based ultra-low VOC coating technology", 15 July 2019 https://www.archroma.com/press/releases/archroma-to-introduce-new-water-based-ultra-low-voc-coating-technology and https://www.archroma.com/press/releases/archroma-heads-to-techtextil-with-innovations-and-system-solutions-for-enhanced-sustainability-color-and-performance



PIN FR compounds for multi-component applications

Kraiburg TPE has developed a series of PIN flame retardant TPE with adhesion to polyamide compounds There is a strongly increasing demand for multi-material components, bringing together both engineering plastics (for mechanical performance), in particular polyamides, and TPE's (thermoplastic elastomers) for functions such as sealing, vibration or sound damping, soft-touch or grip. Kraiburg's new PIN FR TPE series combining fire performance with excellent adhesion, enabling combination in complex multi-component parts. Adhesion was shown to depend on the properties of the polyamide, the flame retardants and on the glass fibres. UL94-V0 @ 3 mm was achieved, with a TPE compound offering low melt temperature (190°C) for easier processing. Peeling resistance of 2.5 N/mm and above (VDI 2019) was shown. Applications include electrical engineering components such as connectors, relay components or switch boxes. Further flame retardant TPE series, for example with adhesion to polypropylene, are available in the portfolio of Kraiburg TPE. Kraiburg TPE GmbH & Co. KG is a leader in specialist and industrial TPEs.

*"*Flame-retardant TPEs with adhesion to polyamides*" 4 September 2019*
https://www.pressreleasefinder.com/prdocs/2019/KRAPR048EN0919_Flammenschutz.pdf

Bio-based FR for cotton textiles

Devan Chemicals has launched a new bio-based flame retardant for cotton and cotton/viscose blends, first of a Bio-Flam range under development. Devan Chemicals is a Belgium-based specialist textile chemical company. Bio-flam P307 is halogen-free (to EN 16785-1 2015) and DIN certified >85% bio-based. Used on mattress ticking, it can achieve EN 597 1 & 2 fire performance, BS7175 – crib 5, CFR 1632.6, Cal Prop 65. The product is also biodegradable, so compatible with the European Commission objective of recycling of mattresses by 2030. The product can also be applied on other substrates and in other applications. Devan's existing Eco-flam flame retardant range are all non-halogenated and do not contain antimony, and are applicable to a wide range of textiles including mattresses, upholstery, acrylic, clothing, tents, non-woven, carpets, high-tech fabrics and aircraft interiors.

"Novel sustainable technologies from Devan", 14th May 2019
https://www.innovationintextiles.com/novel-sustainable-technologies-from-devan/

ZeMac copolymers for PIN FR polymer performance

Vertellus has developed ZeMac copolymers for high RV (relative viscosity) nylons for performance extrusion components. Applications include automotive parts, piping, E&E, switches & lighting, printed circuit boards and textile fibres. The copolymers are non-halogen and are based on alternating ethylene and maleic anhydride groups. They increase tensile strength and mechanical performance, enable production of branched high RV nylons, and are especially interesting in PIN flame retardant formulations where they can limit FR degradation, improve compatibility (act as a 'sizing agent' effectively coating the FR, improving dispersion and enabling bonding with the nylon polymer) and enhance melt strength. The copolymers offer an economic and performance alternative to solid state polymerisation (SSP) processes. Vertellus is a global speciality chemical and plastic additive producer.

Vertellus ZeMac copolymers https://www.vertellus.com/products/plastics-polymers/zemac-copolymers/

Perspectives for fire retardant treatment of wood

Fire treatment of wood is moving towards PIN FR solutions, with challenges being effects on mechanical properties, FR leaching and water uptake. This short overview paper, intended for the Wood a Fire Safety Conference 2020 (Slovakia, postponed to 1-4 November 2020) outlines the fire chemistry of wood, flame retardant modes of action (in particular accentuation of natural char formation, e.g. by ceramification or dehydration) and summarises different FR families used, either by surface coating or impregnation. Today, most FR treatments are PIN (non-halogenated) with a move away from boron salts because of toxicity questions and low leaching resistance. Developing solutions are based on nitrogen, phosphorus, mineral hydroxides and carbonates or silicates.

"Fire Retardant Treatment of Wood – State of the Art and Future Perspectives", P. Sauerbier et al., International Scientific Conference on Woods & Fire Safety WFS 2020: Wood & Fire Safety pp 97-102 https://doi.org/10.1007/978-3-030-41235-7_14

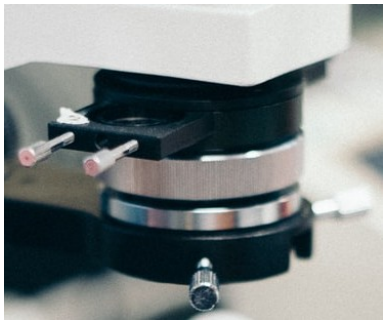
Review of FRs for wood and wood-based products

An update and overview of flame retardant treatments for timber and wood-based products is based on over 110 referenced publications. The significance of wood as a performance, sustainable and aesthetic building material is underlined, but noting that use can be restricted by fire safety concerns. The combustion process of wood is summarised: in the first phase, residual water is evaporated and then low energy is needed to reach 150°C where release of combustible degradation products starts, leading to flame formation. Combustion of volatiles reaches around 800°C and finally exothermic annealing of carbon occurs (hardening due to heating and cooling). Flame retardants act in one or a combination of four ways: modifying pyrolysis (in particular, enhancing the pyrolysis of cellulose to char), isolating the surface layer, changing the wood thermal properties, diluting pyrolysis gases. The authors present different types of flame retardants, noting that there is little new research into halogen-based systems, because of global concerns about impacts on health. PIN FRs used on wood include: phosphorus-based, the main FR solution for wood, generating low

toxic gases and smoke; inorganic salts (hydroxides, phosphates, carbonates, sulfates) which are "environmentally friendly" and reduce smoke release, but pose challenges of water solubility; boron compounds, usually used with other FRs and offering the advantage of also providing fungus and insect protection; nitrogen FRs, such as melamine compounds and ammonia salts, and nitrogen-phosphorus compounds; silicon compounds and nanocomposites including minerals and clays; and PIN intumescent coatings. Innovations cited include polymers including phosphorus and or silicon, which can cross-link into the wood fibres, ensuring a non-leaching, durable FR treatment. Chemical modification of the wood to increase strength can also decrease flammability, e.g. using phenols or acetylate, possibly combined with phosphorus or melamine PIN FRs.

"Treatments and modification to improve the reaction to fire of wood and wood-based products - An overview", C-M. Popescu, Fire and Materials. 2019;1–12 https://doi.org/10.1002/fam.2779

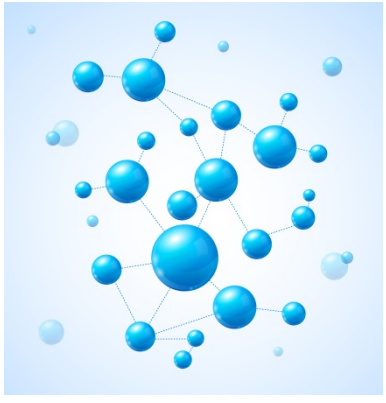
SCIENCE AND RESEARCH



Molybdenum Sulphur Phosphorus FR for PUR foams

DOPO grafted MoS_2 is an effective flame retardant for flexible polyurethane foams: 6% loading reduced heat release and smoke by 30 - 40 %. The phosphorus PIN FR, DOPO (9,10-dihydro-9-oxa-10-phosphaphenanthrene-10-oxide) was grafted onto Molybdenum sulphur nanosheets (both from chemicals suppliers) and mixed into polyurethane foam at the blowing stage at 6% loading. DOPO and MoS_2 were also tested separately at the same loading. Mechanical properties of the foam are modified (e.g. compression set increased from 2.6 to 4.1) but the authors consider this acceptable. Peak heat release rate and maximum smoke density are both reduced by >40% with DOPO - MOS_2. The authors suggest that this is because of good dispersion in the foam, synergy between the minerals and phosphorus, absorption of fire-released hydrocarbons and aromatics by the nanosheets (van der Waals interaction) and enhancement of charring by generated MoO_3 released in fire.

"Novel MoS2−DOPO Hybrid for Effective Enhancements on Flame Retardancy and Smoke Suppression of Flexible Polyurethane Foams", M. Zhi, ACS Omega 2020 5 (6), 2734-2746 https://dx.doi.org/10.1021/acsomega.9b03346



P, N and iron complex as PIN FR in epoxy

A polyphosphazene – iron – nitrogen - organic hybrid at 1% in epoxy passed UL94-V1. The polyphosphazene was combined with iron 2-methylimidazole metal–organic framework (Fe–MOF) then mixed into epoxy (DGEBA). 1% loading of the hybrid PIN FR achieved UL94-V1 @ 3 mm (but 3% achieved only V2 due to poorer dispersion). At 1% loading, LOI (limiting oxygen index) increased from 26 (pure epoxy) to 30 and peak smoke production rate (SPR) was reduced by around one third. The authors suggest that the FR effect is result synergies generating compact ceramified char.

"Polyphosphazene-wrapped Fe–MOF for improving flame retardancy and smoke suppression of epoxy resins", L. Sang et al., J Therm Anal Calorim (2020) https://doi.org/10.1007/s10973-020-09481-6

Publications on FR chemical safety

Several studies look at possible health impacts of flame retardants. Not all are scientifically convincing but pinfa recognises further research is needed. Gaylord 2020, which has obtained media coverage, suggests a link between brominated FRs and loss of IQ in the population. It has been strongly criticised by the US FR industry group NAFRA. This study mentions also phosphorus esters, but seems to in fact concern metabolites which may not be related to FRs. Luo 2020 suggests a link between maternal P-FR metabolite urine concentrations and low infant birth weights (113 cases) but does not correlate out other factors, such as urban living or diet which may be linked to chemical intake and might in fact be the real cause. Liu 2020 tested one P-FR (triphenyl phosphate) showing at oral intake at high doses (> 50 mg/kg body weight/day) crossing of the blood brain barrier and brain modifications.

MARKET STUDIES

Growth for PIN FRs in plastics and wood

Several new market studies, prepared before the COVID crisis, anticipate continuing growth for PIN flame retardants, FR plastics, fire protection materials, fire proofing coatings for wood.

ResearchAndMarkets estimate **global FR market growth of 5.2% per year to 2025**, with environmental concerns pushing a continuing move towards non-halogenated FRs. Growth will be particularly driven by the demand for fire safety in electrical and electronics (E&E), building and construction and automobile. This is reduced from ResearchAndMarkets previous estimate of 6.2% growth from 2019 to 2023 (pinfa Newsletter n°96).

ResearchAndMarkets similarly forecast **growth in the global FR plastics market, at 4% from 2019 to 2024, to reach US$ 55 billion**. Polyurethane is expected to remain the largest FR polymer market, with use of PU foam in construction and transport. FR polyolefins are expected to show the highest growth, driven by halogen-free low-smoke (HFLS) wire and cable.

Lucintel estimate **the E&E flame retardant resin market to grow by 4.6% to US$ 2.2 billion by 2025**, covering epoxies, phenolic, polyesters and others in enclosures, circuit boards, electrical components etc. Growth is expected to be driven by increasing demand for FR laminates and by fire regulations.

TransparencyMarketResearch estimate that the **global market for non-halogenated FRs for all polymers will grow at 8% from 2019 to 2027, from US$ 2 billion in 2018**. Drivers are identified as end-user demand to move away from halogenated FRs, increasing polymer use and fire safety regulations. Polyolefins are estimated to represent 26% of the non-halogenated FR market for polymers and are expected to grow.

Digitsnmarkets estimate that the **non-halogenated FR market will grow at 4.4% from 2018 to 2025 (from 4.33 billion US$ 2018),** driven particularly by E&E and automotive, pushed by tightening fire safety regulations. ATH (aluminium tri hydroxide)

is expected to continue to hold the biggest market share, because of low toxicity, cost-effectiveness and action as a smoke suppressant.

MarketsandMarkets estimate the **fire protection materials market at US$ 2.7 billion in 2019, with expected growth of 8.5% to 2024**. This covers coatings, mortar, sealants, sheets/boards, sprays, etc. Drivers indicated are growth of construction, especially of commercial buildings, and increasing emphasis on passive fire protection.

Mordor Intelligence predict that the **global market for fire coatings for wood will grow a 5.1% from 2019 to 2024**. Demand will be driven mainly by wood use in construction, in particular in China where fire safety regulations are put into place, but also by wood in furniture. Development of UV-cured fire coatings will bring opportunities.

MarketStudyReport estimate that the **world market for fire treated wood will grow at 3.1% from 2019 to 2024, to reach US$ 1.3 billion in 2024**. This covers both FR treated plywood and timber, with FR treatment usually consisting of pressure impregnation of organic or inorganic salts.

ResarchAndMarkets: Flame Retardant Market Forecasts, Worldwide, 2019 to 2025 - Growing Demand of Fire Retardant Chemicals in Automotive and Building & Construction https://www.prnewswire.com/news-releases/flame-retardant-market-forecasts-worldwide-2019-to-2025---growing-demand-of-fire-retardant-chemicals-in-automotive-and-building--construction-300984925.html

ResearchAndMarkets: Flame Retardant Plastics Market Report: Trends, Forecast and Competitive Analysis https://www.researchandmarkets.com/reports/4895522/flame-retardant-plastics-market-report-trends

Lucintel: Flame Retardant Resin in E&E Composites Market Report: Trends, Forecast and Competitive Analysis https://www.reportlinker.com/p05843516/Flame-Retardant-Resin-in-E-E-Composites-Market-Report-Trends-Forecast-and-Competitive-Analysis.html

TransparencyMarket Research: Non-halogenated Flame Retardants Market for Polymers to Reach a Valuation of ~US$ 4 Bn by 2027 https://www.transparencymarketresearch.com/pressrelease/non-halogenated-flame-retardants.htm

Digitsnmarkets: Global Halogen Free Flame Retardant Market Industry Trends, Estimation & Forecast, 2018 – 2025 https://www.openpr.com/news/1903736/global-halogen-free-flame-retardant-market-industry-trends

MarketsandMarkets: Fire Protection Materials Market Worth $4.0 Billion by 2024 https://finance.yahoo.com/news/fire-protection-materials-market-worth-103000516.html

Mordor Intelligence: Fireproofing Coatings for Wood Market - Growth, Trends, and Forecast (2019 - 2024) https://www.reportlinker.com/p05778203/Fireproofing-Coatings-for-Wood-Market-Growth-Trends-and-Forecast.html

Market Study Report LLC: Fire Retardant Treated Wood Market Report 2019 Global Industry Growth, Key Manufacturers, Opportunities and Forecast to 2024 https://www.marketwatch.com/press-release/fire-retardant-treated-wood-market-report-2019-global-industry-growth-key-manufacturers-opportunities-and-forecast-to-2024-2019-03-13

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