pinfa
Phosphorus, Inorganic & Nitrogen Flame Retardants Association

Your newsletter for non-halogen fire safety solutions n° 145 January 2023

EVENTS

pinfa-NA online Lunch & Learn fire and FRs

pinfa North America launches series of free webinars on fire and flame retardants, starting Wed 22 Feb. 11h30-12h30 EST (17h30-18h30 CET). The first webinar will feature Dr. James Zhou, Avient Corporation, on behaviour of polymeric materials in fire and relevant fire test methods. The webinar will include a live questions session with Dr. Zhou and Dr. Anteneh Worku, FR Adviser LLC. The webinar will interest formulators, technical marketing, technical sales, academia, government authorities and other stakeholders.

pinfa-NA's first Lunch & Learn webinar "Back to Basics: Ten Behaviors of Polymeric Materials in a Fire & Understanding Key Test Methods". Registration is free https://www.pinfa-na.org/freewebinar or by contacting dwagner@pinfa-na.org

AMI | Events
Fire Retardants in Plastics

Fire Retardants in Plastics (USA)

The US flame retardants conference, Philadelphia, 26th-27th April 2023, including a panel discussion led by pinfa-NA. The conference covers trends, regulations, new applications, developments in formulation and technology in the fire retardant industry. pinfa-NA will host two panels, with product manufacturers and experts on Impacts on Product Design of Fire Safety Regulatory Developments and Third Party Certifications, and with plastics industry operators on whether PIN FRs meeting evolving use requirements.

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17[2h] AMI Fire Retardants in Plastics, 26-27 April 2023, Philadelphia, USA
https://www.ami-events.com/event/60ee9240-2cf9-4088-a455-e35e259e5b97

PINFA GENERAL ASSEMBLY

Members discussed PIN FRs in products, recycling, chemicals regulations and building fire safety, including with supply-chain organisations and with the European Commission.

In 2023, amongst other projects on PIN FR behaviour, pinfa will launch **further testing of mechanical recycling of PIN FR polymer compounds**, with Fraunhofer LBF. This follows a first testing campaign covering seven different PIN FRs in five polymers with five extrusion cycles (see pinfa Newsletter n°136).

Heikki Väänänen, European Commission (DG GROW) presented the Commission's work on building fire safety. Fire safety is a Member State prerogative (subsidiarity), but the EU plays an important role with harmonised fire performance standards under the Construction Products Regulation (CPR), and by coordinating specific projects on fire safety. Fire safety remains a core objective of the CPR in the revision regulatory proposal. The Commission is pursuing development of a harmonised large-scale fire test method for building façade systems, because there are currently around ten different national tests. Building insulation is growing fast, especially in renovation, in order to achieve energy savings objectives, but can pose considerable fire dangers. Round-robins for the new tests will start in 2023. The reports of the EU FireStat project, on coordinating EU fire statistics, are now published (see below). Work is ongoing with JRC on performance-based design for fire safety, with a report expected soon. Questioned about smoke toxicity, Mr. Väänänen noted that a study for the European Commission (2017, see pinfa Newsletter n°89) concluded that standards on smoke toxicity were currently not needed in the CPR as it seems that the Member States do not have plans to regulate this aspect.

Celia Gryspeirt, Industrial Minerals Europe, discussed regulatory developments in the Chemicals Strategy for Sustainability (part of the Green Deal) which could potentially impact mineral PIN FRs. Nanoparticles will be increasingly subject to regulation. A new JRC Guidance on nanoparticles is expected to exclude natural industrial minerals consisting of crystallites, but not if the materials have been ground to the nanoscale, nor engineered "nano-clays". A new definition of "Poorly Soluble Low Toxicity Particles" (PSLTP, see e.g. Mundt et al. 2022 and ECETOC 2013) may clarify that many minerals have a low "bio-solubility", but could also lead to the question of whether a classification for the inhalation endpoint is needed for widely used minerals (based on read-across from titanium dioxide).

Michael Cassart, Plastics Europe, presented the plastics industry's sustainability objectives. Safety and all forms of recycling (mechanical, chemicals) are key to reach circularity and sustainability goals and require collaboration with the value chain: additives producers, including flame retardants, end-users, collectors, sorting and recyclers. The Green Deal will have important impacts on the plastics industry through the announced obligation of REACH registration of certain polymers (and some form of lightweight notification of all polymers, still under discussion), as well as, for all relevant chemicals, the introduction of Generic Risk Assessment combined with the Essential Use concept.

pinfa General Assembly 22nd November 2022, Brussels. For further information contact: pinfa@cefic.be

FIRE SAFETY

EAPFP says fire safety key to sustainability

Input to the CPR revision says fire performance should be a key performance indicator for building sustainability. The European Association for Passive Fire Protection (EAPFP) welcomes the proposed revised legislative text for the Construction Products Regulation (CPR) as a key tool for ensuring a level playing field and harmonised standards for building materials across Europe. EAPFP's position raises several points about harmonisation, standards implementation and guidance and welcomes the integration of Green Deal sustainability goals into the CPR revision proposal. EAPFP underlines that fire safety is essential for sustainability of buildings and of building materials, and the resistance to fire is essential to restrict fire spread, which reduces the environmental impact of fire incidents.

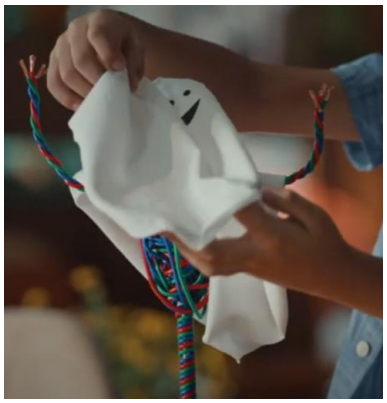
European Commission proposed legislative text for revision of the Construction Products Directive ("Proposal for a Regulation"), 3 April 2022 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12458-Construction-products-review-of-EU-rules_en

EAPFP "The European Association for Passive Fire Protection (EAPFP) position on the Revision of the Construction Product (CPR) regulation", July 2022 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12458-Construction-products-review-of-EU-rules/F3321213_en

New UK group for passive fire safety

The Passive Fire Knowledge Group is set up by the Finishes and Interiors Sector (FIS) federation to change fire culture. Initial members include "tier 1" contractors (large, general works contracting companies), installers, the Association for Specialist Fire Protection and the Building & Engineering Services Association. The aim is to develop and communicate guidance on procedures, systems and products involved in taking fire safety from building design to realisation. Working groups are established on process, fire testing and education.

PFKG Passive Fire Knowledge Group https://pfkg.org/



HFFR fire-safe cables tie paternal love

Ad campaign for Havells India compares HFFR wiring in homes to a father always present to keep his children safe. The 55 second advert by Mullen Lintas (MullenLowe) shows a little boy who puts billow against doors to keep ghosts out and makes a model ghost from electrical wire. The ad then shows his father who keeps him safe, including with HFFR fire-safe wiring in the house, which does not "release black smoke and harmful toxic gases". Havells, a leading electrical goods and equipment supplier in India, says it is promoting halogen-free flame retardant (HFFR) wires and educating customers to their benefits, in line with the company's commitment to electrical safety.

"Havells Wires – Your 24/7 Protection Buddy, 55 second advert (in Indian) https://www.mullenlintas.in/our-work/havells-wires-your-24-7-protection-buddy/

Comparison of railway fire safety standards

Report to federal administration suggests the US should consider material fire performance and smoke toxicity criteria possibly comparable to European railway requirements. The report compares US railroad rolling stock fire safety regulations to those in the EU, Japan and China. The EU standard (EN 45545-2) is considered to be the "most robust and comprehensive", enabling interoperability between railways and ensuring safe travel across national borders. The US leaves risk assessment largely to the railroad operators. The report indicates that the US does not have fire performance and smoke toxicity criteria and should consider integrating these into material performance criteria and should also look at requirements on flammability, gas storage and inspection procedures.

"Comparison of International Fire Safety Standards with U.S. Requirements", G. Stillman, Volpe National Transportation Centre, for the US Department of Transportation (DoT), November 2022, 62 pages, DOT/FRA/ORD-22/40 https://rosap.ntl.bts.gov/view/dot/64794

Fire challenges of tomorrow's technologies

Fire expert Jürgen Troitzsch calls for materials fire safety standards for Internet of Things, e-mobility and electronics. Passive fire safety regulations and standards must be adapted to the new technologies and societal megatrends of the 21st century. Numbers of connected electronic devices are expected to grow to over 30 billion and e-vehicles and 2-wheelers to over 300 million by 2025. Fire statistics and produce recall sites show the fire dangers of such electrical equipment. Fire safety standards for electrical and electronic products and for vehicle interiors are too low and need to be tightened. This is the message from fire safety consultant Jürgen Troitzsch in an editorial in Brussels media Euractiv, based on review article published in the Journal of Fire Sciences.

"Electrical applications in IoT and e-vehicles: A fire safety challenge", Euractiv, 15 November 2022
https://www.euractiv.com/section/transport/opinion/electrical-applications-in-iot-and-e-vehicles-a-fire-safety-challenge/

"Electrical applications in Internet of things and e-vehicles: Passive fire safety needs and solutions", J. Troitzsch, J. Fire Sciences 2022
https://doi.org/10.1177/07349041221108643

Global insurer flags warehouse fire problem

Zurich in the UK points to a "dramatic spike" in warehouse fires and in North America flags severe warehouse fire risks. Demand for large warehouses has increased fast with e-commerce, with taller buildings and more densely stored goods. UK Government statistics suggest that warehouse fires increased by nearly 50% in 2019/20 and by a further 20% the year after, with over 320 fires per year. Half of these did not have fire alarms and only 6% had sprinklers. Zurich UK is calling for sprinklers to be obligatory in warehouses over 20 000 m^2. Zurich North America says that larger, taller, denser warehouses are elevating the severity of warehouse fires, with losses reaching 300 million US$ for one 56 000 m^2 warehouse fire in 2020, and says new approaches are needed for sprinklers adapted to new warehouse pile and rack configurations, for firefighting techniques for robotised warehouses and to take into account the dangers of smoke emissions.

"Insurer Zurich issues warning over "dramatic spike" in warehouse fires", Zurich UK, 29 November 2022 https://www.fsmatters.com/Zurich-issues-warning-on-rise-in-warehouse-fires

"Pandemic-led e-commerce boom could spark rise in warehouse blazes", Zurich UK, 29 April 2021 https://www.zurich.co.uk/media-centre/pandemic-led-ecommerce-boom-could-spark-rise-in-warehouse-blazes

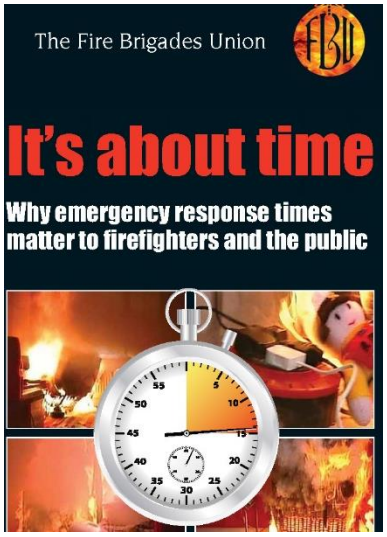
"Storage trends and new technology ignite fire risks for commercial warehouses", Zurich North America, 28 July 2022
https://www.zurichna.com/knowledge/articles/2022/07/storage-trends-and-new-technology-ignite-fire-risks-for-commercial-warehouses

Extension lead blamed for fatal fire

Ten dead in China apartment building fire, Urumqi, Xinjiang, where electrical cable fire is stated to have ignited bedding. The ten dead and nine seriously injured were all victims of toxic smoke, when fire spread from a 15th floor flat up to several higher floors. The fire is stated to have started in power strip, before igniting bedding then spreading out of control. Videos suggesting that building exits were locked under Covid policy have been denied as fakes by official media.

Apartment block fire, Urumqi, Xingiang, China, 24th November 2022
https://asianews.network/epidemic-control-not-related-to-fire-deaths-in-urumqi-govt/

FIRE STATISTICS



UK fire response times continue to worsen

Primary fire response times in the UK have increased by nearly a minute over the last decade, to nearly nine minutes. This is the time between a call being made and fire services arriving at a fire, for "primary" fires (fires susceptible to impact people or property). Response times have been increasing gradually since 1995, except for during Covid. Average fire response time increased 15 seconds 2021 to 2022, principally because of increased driving times. For comparison, Yeoman et al. 2011 indicate fire response times from 7 ½ minutes (urban areas) to 10 ½ minutes in South East USA. Claridge & Spearpoint 2016 indicate 90% achievement of 7 ½ minutes for permanent fire stations and 90% x 10 minutes for volunteer-staffed fire stations in New Zealand. The UK Fire Brigades Union ("It's About Time", Wrack, 2010, cited in Jusoh 2022) suggest that after around 9 minutes a fire often cannot be extinguished by the first firefighting team to arrive, requiring a full team and equipment, and after 10 minutes risks leading to further physical injuries, worse property damage and difficulty to control the fire.

"Detailed analysis of response times to fires attended by fire and rescue services: England, April 2021 to March 2022", UK Government, 2022
https://www.gov.uk/government/statistics/detailed-analysis-of-response-times-to-fires-england-april-2021-to-march-2022/detailed-analysis-of-response-times-to-fires-attended-by-fire-and-rescue-services-england-april-2021-to-march-2022

"Average fire response times in England rise by 15 seconds", International Fire Safety Journal, 28 December 2022
https://internationalfireandsafetyjournal.com/average-fire-response-times-in-england-rise-by-15-seconds/

254 000 fires in France in 2021

France's fire services were called to over 254 000 fires in 2021, of which around 80 000 in buildings (+7% from 2020) and around 45 000 fires in vehicles (the remainder in vegetation or other). These fires resulted in nearly 280 deaths (+11% from 2020) and around 22 000 injuries. The official annual statistics report also provides detailed information on firefighters numbers and budgets. Data for previous years is available back to 2002.

"Les statistiques des services d'incendie et de secours", Edition 2022
https://mobile.interieur.gouv.fr/Publications/Statistiques/Securite-civile

Analysis of UK fire fatality statistics

Nearly 300 victims die each year in UK fires, with nearly 8 000 injuries. Old age, smoking and heating devices are key factors. The UK Government statistical analysis 2011-2019 shows a reduction in fire deaths of over 50% since 1997 and a similar reduction in fire injuries. This report reminds that ongoing work is still needed to understand why thousands of people continue to die in fires each year. Statistics show that older people are more likely to die in fires, as well as other vulnerable people, and underlines the importance of alcohol, smoking and of fires caused by misused heating devices.

"An in-depth review of fire-related fatalities and severe casualties in England, 2010/11 to 2018/19"
https://www.gov.uk/government/publications/an-in-depth-review-of-fire-related-fatalities-and-severe-casualties-in-england-2010-to-201819/an-in-depth-review-of-fire-related-fatalities-and-severe-casualties-in-england-201011-to-201819

EU Firestat project report

Report underlines importance of fire statistics to define policies to reduce fire risks and proposes standards for data. The Firestat project was requested by the European Parliament and engaged by the Commission. Information on fire statistics was collected from the 27 EU Member States and from 8 other countries (selected as having structured fire statistics systems). A literature review shows that fire data systems are important in reducing building fires and their consequences. Report recommendations concern identifying non-reporting in fire data, defining realistic data collection (not burdensome), sensitivity analysis related to data uncertainty, cost benefit analysis of fire safety policies, collection of data at the EU level and standardisation of definitions and data methodologies. A simple set of 14 information elements to include in fire data collection is proposed.

"EU Firestat project: closing data gaps and paving the way for pan-European fire safety efforts. Final Report", Efectis, for the European Commission, 2022 https://dx.doi.org/10.2873/778991 See summaries of Firestat sub-reports on flame retardants in TV sets, upholstered furniture, sprinklers, combustible cladding in pinfa Newsletter n°141.

PIN FR DEVELOPMENTS

Advances in polyurethane fire safety are PIN

A review of flame retardants for rigid and flexible polyurethane (PU) foams shows that progress is centred on PIN solutions. The authors underline the high fire risks of PU foams, the consequent need for flame retardants to inhibit ignition and reduce flammability, and the "the serious health hazards and environmental concerns of halogen compounds". 270 references are reviewed showing the extent of research into PIN FR solutions. Chemical decomposition and fire reaction of PU are discussed. FR solutions presented in detail include phosphorus-based PIN FRs, phosphorus-nitrogen PIN FRs, carbon-based (e.g. expandable graphite EG, EG + hypophosphite), inorganic PIN FRs (including synergists such as boron compounds), organically modified nanoclays, siloxanes. Reactive PIN FRs solutions (such as modified urea formaldehyde or reactive phosphorus polyols) can have lower impacts on foam processing and mechanical performance. Post-processing foam PIN FR application (Layer-By-Layer LBL, sol-gel, freeze drying) are outlined. The conclusions underline the need to move away from halogenated FRs and the interest of synergistic PIN FR combinations.

"Recent Advancements in Flame-Retardant Polyurethane Foams: A Review", A. Yadav et al., Ind. Eng. Chem. Res. 2022, 61, 15046−15065
https://doi.org/10.1021/acs.iecr.2c02670

Xeriant non-halogenated fire safety

Aerospace specialist Xeriant has developed a low-toxicity, low-smoke PIN FR for textiles, constructions and polymers. The non-halogen, bulk additive can be used in compounding, applied to textiles or used with cellulosic materials. Applications to date include ensuring fire safety of construction panels from recycled cardboard fibre and recycled plastics and surface treatment by spray-application to synthetic textile fibres. Work is underway to adapt the product for inclusion in polymer compounding. The PIN FR includes minerals and phosphorus compounds to ensure fire performance and smoke inhibition.

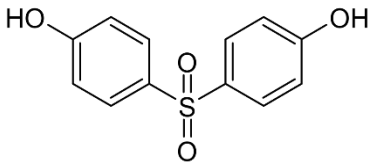
"Xeriant develops Retacell composite panel", 8th June 2022
https://www.recyclingtoday.com/article/xeriant-announces-new-retacell-composite-panel/

PIN FR systems: high rate of development

Compounding World's annual review of flame retardants notes high interest and development of all types of PIN FR systems. New grades of phosphonates and other PIN chemistries, with specific PIN synergists, aim to achieve both UL 94 V-0 for thin wall sections and demanding Glow Wire Ignition requirements, e.g. in polyamides, including with glass fibres. An objective is to improve fire safety of unattended electronic equipment. New polycarbonate grades aim to replace use of perfluorinated sulphates in polycarbonate sheets and films and other polymers. Phosphorus-nitrogen PIN FRs are particularly effective in reducing smoke emissions, essential in e.g. railway applications, and can also prevent dripping. Developments in mineral PIN FRs achieve increasingly demanding fire safety specifications, e.g. for electric vehicles, whilst improving processing and mechanical properties. PIN synergists, such as performance clays, can be combined with mineral PIN FRs. Other PIN innovations proposed include graphene, silsesquioxanes, ionic liquids. New carrier polymers or PIN FRs or copolymers offer promising developments in fire and material performance, and specific additives are being developed to facilitate recycling of plastics, including with PIN FRs, by repairing polymer structure damaged by reprocessing.

"Flame retardant focus turns to green gains", Compounding World (AMI CW) December 2022 www.compoundingworld.com and direct link to article.

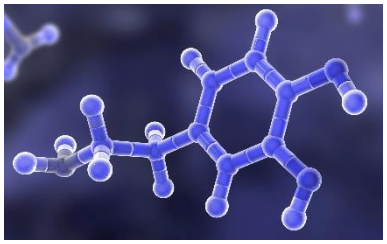
RESEARCH AND INNOVATION



Polymeric phosphorus sulphur PIN FR

Researchers tested a sulphur polyphosphonate PIN flame retardant in PET achieving UL 94 V-0 (3.2 mm) at 8% loading but with dripping. The polysulfonyldiphenylene phenylphosphonate (PSPPP, a polyphosphonate) was synthesised by reacting phenylphosphonic dichloride with a sulfonyldiphenol (bisphenol S – BPS), then catalysing polymerisation. An 8% loading of PSPPP in PET (polyethylene terephthalate) increased LOI from 20.5% to 29.7% and improved UL 94 rating (3.2 mm) from V-2 to V-0 (no ignition, but with dripping). Inclusion of PSPPP reduced smoke release and increased char. The fire protection effect is considered to be a combination of char formation, transesterification reactions between PSPPP and PET increasing char barrier effect and gas phase actions of phosphorus radicals. It is not clear what if any contribution to fire performance was brought by the sulphur.

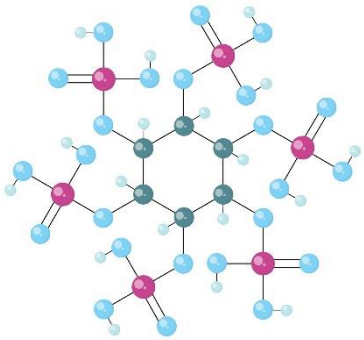
"A Sulfur-Containing Polyphosphonate Flame Retardant for Polyethylene Terephthalate", X. Bo et al., Combustion Science & Technology, 2022, https://doi.org/10.1080/00102202.2022.2109153 Chemical diagram of BPS: Wikipedia.



PIN functionalised mineral FRs for epoxy

Magnesium hydroxide (MDH) treated with polydopamine and metal ions showed improved fire performance effect in epoxy. Polydopamine, a bio-inspired polymeric coating material, was polymerised in the presence of the well-recognised mineral PIN flame retardant MDH and of different transition metal ions (iron, cobalt, copper, nickel, at ratio of approx. 1:1:0.12 w/w). This resulted in a coated MDH – metal ion particles. These were cured, mixed into epoxy resin (EP-44), then cured at 30% w/w loading. The PDA coating of the MDH is considered to have improved fire performance effectiveness both because of breakdown of MDH agglomerates during the processing (smaller MDH particles) and better dispersion in the epoxy. Mechanical properties were improved compared to pure epoxy. Non-treated MDH increased the LOI of the epoxy by nearly +30%, and achieved UL 94 V-1 (3 mm), compared to pure epoxy not rated. Inclusion of the metal ions further improved fire performance, in particular with iron which enable +42% LOI (vs. pure epoxy) and UL 94 V-0. Smoke release was very considerably reduced by untreated MDH, and was even further reduced by inclusion of copper ions.

"Investigation of magnesium hydroxide functionalized by polydopamine/transition metal ions on flame retardancy of epoxy resin", D. Zhu et al., J. Thermal Analysis and Calorimetry 2022
https://doi.org/10.1007/s10973-022-11467-5 Image = dopamine.



Phytic acid, melamine, peanut shell PIN FR

Biobased PIN flame retardant reduces heat and smoke release from epoxy by over one third. Waste peanut shells were pyrolysed at 700°C, to produce biochar, which was then combined with phytic acid (a natural phosphorus rich molecule widely present in plant seeds) and melamine (a nitrogen compound). This bio-based PIN FR was then fixed into bisphenol epoxy resin by curing with diaminodiphenylmethane, at 3% PIN FR loading. The PIN FR did not significantly deteriorate epoxy brittleness and increased tensile strength. Peak heat release rate and total smoke release were reduced by 37% and 31%. Flame retardant effect is considered to result from inert gas release and structured char formation. The authors conclude that the phosphorus – melamine – peanut shell biochar material could be an effective, environmentally friendly PIN flame retardant for epoxy.

"A novel green IFR system: Design of a self-assembled peanut shell-based flame retardant and its fire performance in EP", J. Liang et al., Progress in Organic Coatings 174 (2023) 107277
https://doi.org/10.1016/j.porgcoat.2022.107277

PIN FRs act as indoor air improver

Mineral nitrogen FR flame retardants in wood function as indoor air purifier, removing oxygen ions. The natural mineral tourmaline (an acyclic silicate containing metals such as Na, Ca, K, Mg, Fe, Al, Li) and KH550 (a silane: 3-aminopropyl-triethoxysilane) were vacuum impregnated into balsa wood. The balsa had been partially delignified by soaking in acetate then in sodium hydroxide; to increase specific surface area and improve impregnation. The PIN FR increased LOI (Limiting Oxygen Index) from 21 (untreated balsa wood) to 25, reduced peak heat release rate by nearly 50% and smoke production rate by over 80%, achieving UL 94 V-1. The treated balsa showed a capacity to purify indoor air by releasing negative ions (1000 pcs/cm^3/20s). This was also demonstrated visually by reduction of cigarette smoke from air.

"Wooden "Air Purifiers" with Fire-Retardancy and Smoke-Suppression Properties", X. Sun et al., Adv. Sustainable Syst. 2022, 2200346 https://doi.org/10.1002/adsu.202200346

OTHER NEWS

Phosphorus FRs and smoke toxicity. Lab tests of six aryl phosphate FRs in PC/ABS show reduced fire hazard but increased smoke emission and fire gas toxicity. Six different aryl phosphate PIN FRs (TPP, CDP, RDP, BTPP, BDP and Sol-DP) were tested at 10% w/w loading in 8:1 PC/ABS, with also PTFE anti-drip agent. UL94 fire testing, cone calorimeter, NBS smoke chamber with FTIR and thermal decomposition (TGA) tests were carried out. The PIN FRs reduced fire hazard by preventing flame spread, reducing heat release (-13% to -25%) and delaying ignition. UL 94 V-0 (1.6 mm) was achieved in all but one case. However, smoke production, smoke opacity and emissions of toxic gases (CO, HCN, NO_x) were increased with all six aryl phosphates. More stable aryl phosphates (e.g. RDP) tend to result in somewhat lower smoke toxicity than less stable molecules (e.g. TPP). The authors conclude that these aryl phosphate PIN FRs act in the gas phase, are thus effective in reducing fire hazard, but lead to release of incomplete combustion products, so smoke and toxic gases.

TPP = triphenyl phosphate. CDP = cresyl diPhenyl phosphate. RDP = resorcinol bis (diphenyl) phosphate. BTPP = butylated triphenyl phosphate. BDP = bisphenol A bis (diphenyl) phosphate. Sol-DP = fyroflex aryl phosphate.

"Effect of aryl phosphates on toxicity of combustion gases of flame-retardant polycarbonate/acrylonitrile butadiene styrene blends according to EN 45545 railway standard", A. Sánchez & S. Villanueva, Fire and Materials, 2022, 1–11 https://doi.org/10.1002/fam.3062

Review article by over 40 scientists suggests that chemical exposure increases susceptibility to obesity. Chemicals cited include phthalates, bisphenols, PFAS, pesticides, tributyltins, parabens and brominated and organophosphorus flame retardants (OPFRs). The non-halogenated OPFRs cited are TPhP, EHDPHP and TPP, suggesting possible impacts on lipid and glucose metabolism and on adipose cells, based on around ten human epidemiology and animal studies (from a total of over 700 studies referenced for all chemicals). A summary of the study published by the European Commission indicates organophosphorus FRs as amongst "some 50 chemicals and classes of chemicals that can be classified as obesogens".

"Exposure to chemicals from plastic and other sources: a possible causal factor in obesity?", "Science for Environment Policy" n°590, European Commission DG Environment, 30/11/2022
https://environment.ec.europa.eu/news/exposure-chemicals-plastic-and-other-sources-possible-causal-factor-obesity-2022-11-30_en

"Obesity II: Establishing causal links between chemical exposures and obesity", J. Heindel et al., Biochemical Pharmacology, Elsevier, 2022, 199, pp.115015. https://dx.doi.org/10.1016/j.bcp.2022.115015

PUBLISHER INFORMATION

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