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PUBLIC CONSULTATIONS



EU consultation on classification of melamine

ECHA (European Chemical Agency) has launched, **open to 7th February 2020**, a [public consultation](#) on a proposal to classify (CLH) melamine as Cat 2 carcinogen (H351 suspected carcinogen) STOT RE1 (specific target organ toxicity, H372 urinary tract), based on possible risks from oral intake.

Melamine is widely mis-known to the public as the veneers on furniture, kitchen surfaces or kitchen utensils – but in fact these are melamine formaldehyde resin, a polymer of melamine. Melamine compounds and melamine itself are used as PIN flame retardants, because they contain nitrogen, which is released to dilute fire gases and which releases nitrous gases which inhibit flames. These compounds are highly compatible with polymers, so that losses from treated plastics are very low. Oral intake is not relevant for flame retardant use.

The proposed classification of melamine is related to oral intake, a consequence of criminal addition of melamine to foods or animal foods in the past, especially in China (the nitrogen falsely simulates higher protein content in standard analysis).

The ECHA consultation is based on a CLH report (Proposal for Harmonised Classification and Labelling) submitted by the German Federal Institute for Occupational Safety and Health (BAuA). This report concludes that “A substantial body of evidence concerning melamine-related toxicity following repeated oral exposure exists”. The data suggests that this is related to generation of crystals / stones (calculi) in kidneys, which may then be related to urinary tract cancer risk, stating that, despite the CLP Guidance which indicates that urinary bladder tumours due to crystals in the bladder is a mechanism that is not relevant for humans, nonetheless “calculus formation as a consequence of melamine exposure poses a carcinogenic risk to humans”. The report also concludes that “Available reliable and relevant ... genotoxicity studies with melamine are negative and do not indicate a mutagenic activity for that substance. Based on conclusive data, classification of melamine as mutagen is not warranted”.

Responses to the public consultation can include new evidence or data, analysis of the data presented by BAuA, information about downstream consequences of the proposed classifications, information about substitutes or any other relevant information. For more information, see the European Melamine Producers Association ([EMPA](#)).

Melamine compounds used as PIN flame retardants include: Melamine itself, Melamine cyanurate, Melamine borate, Melamine phosphate, Melamine polyphosphate, Melamine-poly(aluminium phosphate) – see pinfa Product Selector <https://www.pinfa.eu/product-selector/>

Melamine-poly(zinc phosphate)ECHA public consultation on classification of melamine, open to 7 February 2019 <https://echa.europa.eu/harmonised-classification-and-labelling-consultation/-/substance-rev/24503/term>

“CLH report Proposal for Harmonised Classification and Labelling” for Melamine (1,3,5-triazine-2,4,6-triamine), Federal Institute for Occupational Safety and Health (BAuA), Germany, November 2019 <https://echa.europa.eu/documents/10162/2b381a74-d564-2fde-174a-35fe4eb7368a>

European Melamine Producers Association (EMPA) <https://melamine.cefic.org/>

Consultation on RoHS restrictions for halogenated FRs

The European Commission has a consultation, **open to 30th January 2020**, on restrictions of additional substances under the RoHS Regulation (Restriction of Hazardous Substances in electrical and electronic equipment), with assessments of TBBPA (tetrabromobisphenol-A), MCCPs (medium chain chlorinated paraffins) and ATO (diantimony oxide). The consultation is based on dossiers for each substance prepared for the European Commission by Öko-Institut and Fraunhofer IZM (each 60-80 pages).

For ATO, the dossier concludes that workers in recycling plants are potentially exposed to “a risk exceeding the occupational exposure limits” but that actual data from workplaces shows lower levels. It notes that if ATO is restricted, “regrettable substitution” may occur, with compensation by use of higher doses of halogenated FRs. The report therefore recommends to carry out an assessment of a possible RoHS restriction of the group of all halogenated FRs plus ATO.

For MCCPs, the dossier notes that they are suspected PBT (persistent, bioaccumulative, toxic) and vPvB (very persistent, very bioaccumulative) and can contain significant levels of SCCPs (short chain chlorinated paraffins), which are a POP (persistent organic pollutant). The report concludes risks for workers and for the environment, but no evidence of risk to consumers, and recommends an effective RoHS ban (restriction to 0.1% by weight).

For TBBPA, the dossier indicates that it is suspected PBT, and is potentially an endocrine disruptor, reprotox and developmental tox; that workers are exposed by skin, the general population through ingestion and inhalation of dust; and that TBBPA is a long-range environmental pollutant, tending to accumulate and with environmental impact. The report recommends an RoHS limit of 0.1% by weight, which would effectively ban additive use of TBBPA but not reactive use (e.g. in epoxy resins) because such use should leave residual TBBPA levels below this limit.

EU consultation on RoHS restrictions on ATP, MCCPs and TBBPA. Closes 30th January 2020. Input should be relevant technical and scientific information, “not generic statements, not position papers”.

https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_15/4th_Consultation/Guidance_Document_5th_Stakeholder_Consultation_P15_PartIII_Part_III.pdf

Documents should be sent by 30 January 2020 to rohs.exemptions@oeko.de



PINFA GENERAL ASSEMBLY 2019

pinfa 2019 actions and projects 2020



Nearly all of pinfa's 31 members (flame retardant manufacturers and users) were present in Cologne, Germany, for the association's second General Assembly of 2019. pinfa's 2019 activities were discussed, as presented in the Annual Report [here](#). Key activities included communications (pinfa Newsletter, website, [product selector](#)), workshops on fire safety in electromobility (2018: Shanghai; 2019: Tokyo, Darmstadt), study of smoke toxicity effects of PIN FRs in different polymers (see summary below), recycling of FR plastics, proposals to revise the Swedish ecotax on chemicals, fire testing demonstration with the pinfa Advisory Board (see pinfa Newsletter n°106). 2019 also saw active cooperation with a wide range of fire safety stakeholders and organisations in an initiative to promote fire safety research in Europe. pinfa's projects for 2020 include further work on Circular Economy (integrating FRs into research and development of plastics recycling), e-mobility, new FR requirements for 5G, improving understanding of PIN FR impacts on smoke emissions, and the development of a PIN flame retardant information resource package and, in cooperation with pinfa North America, a new PIN FR formulation training course.

pinfa Annual Report 2019 https://www.pinfa.eu/wp-content/uploads/2019/12/PINFA_Annual_Report_2019_web.pdf and <https://www.pinfa.eu/media-events/photo-video/>

Textile FR innovation



Invited participant at the pinfa General Assembly, Thomas Mayer-Gall, DTNW (German Textile Research Centre North-West), presented innovations under development for PIN FRs for textiles, and indicated the institute's interest to associate with pinfa. The creation of a possible associate status for research institutes will be looked into by pinfa. DTNW presented work underway into several new approaches for phosphorus-based FRs for textiles, including biodegradable and bio-sourced FRs, which offer benefits in addressing concerns about microplastics in the environment (resulting from textile wear and abrasion). DTNW is also transferring results from surface finishing/coatings to the field of polymer additives with Hochschule Hamm-Lippstadt and the Kunststoff Institute Lüdenscheid. Possible cooperation was discussed with several pinfa members.

German Textile Research Centre North-West (Deutsche Textilforschungszentrum Nord-West DTNW) <http://www.dtnw.de/en/home/>

REGULATION AND STANDARDS



NFPA fire safety of items "adjacent to buildings"

The NFPA (US National Fire Protection Association) standards committees NFPA 101 and NFPA 5000 (Life Safety Code, Building Construction and Safety Code) have agreed to extend fire safety standards to cover combustible objects "adjacent to buildings", such as furniture and artificial vegetation.

Source: GBH International "Fire Safety & Technology Bulletin" November 2019
<https://www.gbhint.com/fire-safety-and-technology-bulletin/>



Singapore tightens buildings fire safety regulations

Over 500 buildings will have to upgrade fire safety to respect proposed changes in the Fire Safety Act. The proposals also introduce new offences for contractors and for suppliers of non-compliant materials, with fines up to 100 000 S\$ and two years imprisonment. The new requirements include fire alarms and fire hose reels. A number of buildings in Singapore are also thought to have cladding materials not conform to safety standards. Already in 2018, Singapore made Home Fire Alarm Devices (HFAD) compulsory in all new and upgraded homes. Singapore has reduced fire fatalities from 0.15 per 100 000 in 2014 to 0.07 in 2018, considerably lower than New York or Tokyo.

Singapore “Parliament: Older buildings with high fire risks must have critical safety features under proposed law changes” <https://sso.agc.gov.sg/Bills-Supp/16-2019/Published/20190708?DocDate=20190708>

“Changes to fire safety law passed: MPs call for warning systems in all homes” <http://glbnews.com/url.html?p=https://www.channelnewsasia.com/news/singapore/changes-to-fire-safety-law-passed-mps-call-for-warning-systems-11782860>



US Codes for “Fire Retardant Treated Wood” FRTW

After a number of years of discussion, agreement has been reached to clarify fire safety testing requirements for Fire Retardant Treated Wood (FRTW), that is wood which is impregnated with fire safety products (usually in a pressure treatment). New wording will be introduced into the IBC, IRC and NFPA 5000 building codes specifying for FRTW panels flame spread < index 25 and flame front progression < 3.2 m (ASTM E84 or UL 723 test) and pressure impregnation at ≥ 50 ppi or specified “other means”. Additionally it is added that the tests must be carried out with a longitudinal gap of 3.2 mm (as when panels are installed side-by-side in construction).

Source: GBH International “Fire Safety & Technology Bulletin” November 2019 <https://www.gbhint.com/fire-safety-and-technology-bulletin/>



FAA proposed changes to aircraft fire safety rules

The US Federal Aviation Administration (FAA) is currently considering proposed changes to fire protection regulations for aircraft interiors. On one hand, the proposed changes would extend requirements to materials used in inaccessible portions of the fuselage, not currently clearly covered. On the other hand, prescriptive test requirements would be replaced by performance based standards, and specifications for general categories of components (e.g. large surface area components) rather than specific categories (such as partitions). Standards would be divided into two parts: protection of the airplane and occupants from in-flight fires and protection from post-crash hazards. The objectives are to enable more flexible testing and to avoid individual component materials being subject to multiple different and redundant testing requirements. The proposals were published for consultation until 1st October 2019.

Federal Aviation Administration Notice of Proposed Rulemaking “Interior parts and components fire protection for transport category airplanes” Federal Register, vol. 84, n° 128, 3 July 2019 pp31747 onds. <https://www.govinfo.gov/content/pkg/FR-2019-07-03/pdf/2019-13646.pdf>



Department for
Business, Energy
& Industrial Strategy

Office for Product
Safety & Standards

Updating The Furniture and Furnishings (Fire) (Safety) Regulations 1988

Government response to consultation

UK plans update to Furniture Fire Safety Regulations

The UK Government has published (July 2019) its response to the 2017 public consultation on the updating of the 1988 UK Furniture Fire Safety Regulations (see pinfa Newsletter n°74). The consultation received 126 inputs, of which around 2/3 from business, and the remainder from stakeholders and fire fighters organisations, as well as stakeholder group consultations and input from the Government Scientific Advisers. The Government indicates general support for the proposals on scope, traceability, labelling and enforcement, but mixed views on proposals for revising testing specifications. Respondents questioned the proposed modifications to the match test, and there was opposition, especially from fire services, to the proposed removal of the cigarette test. The Government indicates that “it will focus on safety outcomes such as reduced risk of ignition; reduced risk of fire spread ... underpinned by a set of essential safety requirements which all upholstered furniture placed on the market must meet”. It is proposed to move from prescribed tests to an outcome/criteria based approach, and the Government fixes as the priority to develop this new approach in coming months: defining essential safety requirements and a new legislative framework. This will include working with the British Standards Institution to types of standards to be developed to show compliance with essential safety requirements. The Government has now announced that the updated UK Furniture Fire Safety Regulations should be ready by autumn 2021 (see below).

“Updating The Furniture and Furnishings (Fire) (Safety) Regulations 1988. Government response to consultation”, 18th July 2019

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/822072/furniture-fire-regulations-2016-consultation-government-response-july-2019.pdf



UK Government positions on furniture FRs, chemicals

The UK Government has published detailed response to the UK Parliamentary report recommendations on chemicals in consumer products (“Toxic Chemicals in Everyday Life”, see pinfa Newsletter n°104). On flame retardants in furniture, this largely refers to the Government position of 18th July 2019 on updating of the UK Furniture Fire Safety Regulations (see above), underlining a “focus on safety outcomes such as reduced risk of ignition and reduced risk of fire-spread”, whilst allowing for innovation and technological advances. Revised Regulations are announced for autumn 2021. The UK Government essentially rejected the Parliamentary report proposals, in particular the suggestion of labelling products to indicate contained chemicals. The Government indicated that the UK will continue to apply REACH requirements, in particular the SVHC (substances of very high concern) list, after BREXIT, with the only divergence being the possibility for the UK to require additional or tighter constraints.

“Toxic Chemicals in Everyday Life: Government Response to the Committee’s Twentieth Report of Session 2017–19”, 16 September 2019

<https://publications.parliament.uk/pa/cm201920/cmselect/cmenvaud/160/16002.htm>



COMMUNICATIONS

Toxic TV Binge



NGOs attacks FRs in TV brands

A media release from three US environment NGOs claims that “hazardous” flame retardants were found in analysis of casings of six FireTVs (Insignia and Toshiba, purchased from Best Buy and from Amazon in the USA). FireTV is an app for channel access and other functions, not related to fire. The report states that the Insignia TVs contained Deca-BDE, despite this is banned in five US States, including Washington State where these TVs were purchased. The report notes the presence of three other brominated FRs analysed in all six TVs (TTBP-TAZ, 2,4,6-TBP and DBDPE) and also of two phosphorus FRs analysed in some TV sets. It is not clear which phosphorus FRs were analysed and found, because the report states that RDP and BPA-BDPP were analysed but then includes in the table of results BAPP (BAPP stated as found in the three Insignia TVs, and TPhP found in one TV only. The media report emphasises that all brominated FRs will be banned in TV enclosures in Europe from 1st March 2021 (under the EcoDesign [Regulation](#), see pinfa Newsletter n°108).

“Toxic TV Binge: Hazardous flame retardant chemicals found in Best Buy and Amazon TVs” Safer Chemicals Healthy Families, Mind the Store and Toxic-Free Future, 24 October 2019 <https://environmentaldefence.ca/2019/10/24/toxic-tv-binge-hazardous-flame-retardant-chemicals-found-best-buy-amazon-tvs/>

2,4,6-TBP = 2,4,6-tribromophenol
 Deca-BDE = decabromodiphenyl ether
 DBDPE = decabromodiphenyl ethane
 TTBP-TAZ = 2,4,6-tris(2,4,6-tribromophenoxy)-1,3,5-triazine
 RDP = resorcinol bis(diphenylphosphate)
 BPA-BDPP = bisphenol A bis(diphenyl phosphate)
 BAPP and TPhP = acronyms not specified in document



EU Fire Safety Week – Fire Safety of Buildings

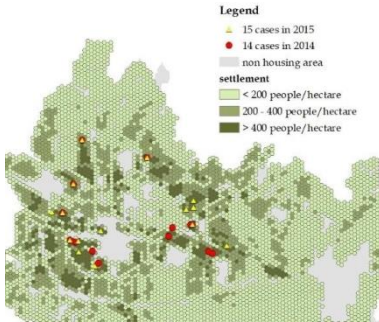
As part of the European Fire Safety Week [2019](#), the Modern Buildings Alliance ([MBA](#)) organised a meeting on building fire safety, with participants from the European Commission and the European Parliament, as well as experts and stakeholders. The meeting addressed in particular how the Building, Installation and Organisation (B.I.O.) framework can improve fire safety in residential buildings. The MBA “Fire Safety Guide” (see pinfa Newsletter n°106) was presented, underlining the seven layers of fire safety: Prevention, Detection, Early Suppression, Evacuation, Compartmentation, Structural Safety and Firefighting. Questions raised included differences in smoke alarm and sprinkler requirements in different European countries, the challenges of smoke emissions from the widespread presence of flammable materials in modern offices and homes, and the need to distinguish between insulation and cladding materials in assessing fire safety of building panels.

Building Fire Safety, Holistic regulatory approach, 19th November 2019, Brussels <https://www.modernbuildingalliance.eu/european-fire-safety-week-2019-agenda-and-registration-for-the-building-day/> See summary video online, with interview of Quentin de Hulst, BASF

European Fire Safety Week, 18-21 November 2019, was organised by the European Fire Safety Alliance (EuroFSA). This day is co-organised by the Modern Building Alliance, Europacable, European Fire Sprinkler Network, European Aluminium, CoGDEM and EuroFSA <https://www.europeanfiresafetyalliance.org/european-fire-safety-week/>

FIRE SAFETY

Urban fire risk in developing countries



A paper from Indonesia underlines the threat of fire for high-density urban areas, with risks of both deaths and injuries, and considerable loss of both residential housing and economic activity. High density urban contexts in developing countries pose high risks both of fires starting (open heat cooking, electrical risks) and of consequences of fire (difficulty of access for fire services and of evacuation). This can lead to catastrophes such as the Nimali area fire, Old Dhaka, Bangladesh, 2020, caused by an electrical transformer, in which over 120 people died. The case of Bandung City, Indonesia, is presented, with nearly 400 fire incidents 2014 – 2016, destroying nearly 3 hectares of city. Damage is limited by active work of community organisations, with nearly 3 000 fire volunteers promoting fire safety, community evacuation plans and fire drills and organisation of contacts with fire service and of first on-site actions against fire by residents.

“Urban Resilience to Fire Disaster in High Density Urban Area”, R. Desriani & P. Samyahardja, in “Equity, Equality and Justice in Urban Housing Development” 2018
https://www.researchgate.net/publication/330674378_Urban_Resilience_to_Fire_Disaster_in_High_Density_Urban_Area



Pilgrims die in train and bus fires

74 people died in a fire on a train in Pakistan, Punjab Province, traveling from Karachi to Rawalpindi, on 31st October. The fire apparently started with a gas explosion in a cooking stove brought on board, in contradiction to railway regulations, by members of the Tablighi Jamaat (Outreach Society or the Society for Spreading Faith, a Muslim missionary movement). Over 50 members of this movement died. In another catastrophe involving pilgrims, 35 people died in a private chartered bus which caught fire after a crash in Saudi Arabia, Medina Province, 16th October. The bus, chartered by the UK travel agency Hashim Travel, was transporting pilgrims from Mecca to Medina. These incidents show the continuing need for both tighter fire safety regulations in buses and trains in many countries, and better implementation of existing safety rules.

BBC “Pakistan train fire: Karachi to Rawalpindi service blaze kills dozens”,
<https://www.bbc.com/news/world-asia-50245090>

BBC “Saudi Arabia bus crash leaves 35 Arab and Asian expatriates dead”
<https://www.bbc.com/news/world-middle-east-50081706>

RECYCLING

FRs compatible with TV plastics recycling



A study (two papers) from Belgium (1), shows that phosphorus flame retardants in LCD TV back covers are compatible with an optimal recycling strategy, identified as dismantling, take-back of the covers and reprocessing to new E&E parts. Tests carried out showed that PC/ABS containing phosphorus FRs could be recycled (melt filtration compounding and injection moulding), showing quality compatible with industrial use in existing E&E parts production (without process redesign), and achieving UL-94V0 at 3.2 mm and V2 at 1.7 mm without addition of FRs. It is concluded “that when a dismantling based recycling for direct reapplication is applied for PC/ABS with phosphorus FRs a high quality recyclate can be produced which is characterized by good processing, mechanical, flammability and aesthetical properties”. The authors

indicate that nearly 400 000 t/y of LCD TVs will reach end-of-life in Europe in 2020, of which 14% by weight is plastic back covers. The paper summarises sorting technologies available today: Fourier Transform InfraRed (FTIR), Raman spectroscopy, X-ray transmission, X-ray fluorescence, sliding spark spectroscopy and laser induced breakdown spectroscopy. Other recycling strategies compared included recycling of the back covers to masterbatch production (tested and shown operational for HIPS containing brominated FRs). This may offer logistic benefits because low recycle quantities can be handled by masterbatchers. Both the above strategies were considered preferable to sorting after shredding of mixed WEEE because higher quality sorting is achieved by dismantling, so enabling economic recovery of “high value of additives, such as FRs”. A key conclusion is the importance of collaboration between WEE recyclers and customers for recycled materials, as well as the need for E&E equipment to be designed for dismantling. The Life Cycle Assessments (LCA) of the different recycling scenarios are compared in a third paper (2) indicating that in this case, WEEE plastics recycling has lower environmental impact than incineration with energy recovery and virgin plastic production. The LCA is above all driven by quantities of plastic recycled, rather than by recycle quality. Recycling of FRs has no significant impact on the LCA, because the impact of their production (per kg) is considered similar to that of polymers.

1 = “Towards a more circular economy for WEEE plastics – Part A: Development of innovative recycling strategies” and “Towards a more circular economy for WEEE plastics – Part B: Assessment of the technical feasibility of recycling strategies”, F. Wagner et al., *Waste Management* 100 (2019) 269–277 <https://doi.org/10.1016/j.wasman.2019.09.026> and *Waste Management* 96 (2019) 206–214, <https://doi.org/10.1016/j.wasman.2019.07.035> funded by the Flemish Environmental Technology Platform (MIP) and the Flanders Innovation & Entrepreneurship (VLAIO) in the Next Level Plastics Recycling project and with Bertin Technologies, Belgium.

Photo: light switch internal part injection molded from recycled PIN flame retardant PC/ABS

2 = “Diversified recycling strategies for high-end plastics: Technical feasibility and impact assessment”, W. Dewulf et al., *CIRP Annals - Manufacturing Technology* 68 (2019) 29–32 <https://doi.org/10.1016/j.cirp.2019.04.004>



Overview of plastics recycling

A review from Australia summarises different routes for plastics recycling and current technology developments. Plastics recycling is characterised as: Primary = mechanical recycling into an equivalent plastic; Secondary = mechanical down-cycling to a plastic with lower properties or quality; Tertiary = recovery of chemical constituents; Quaternary = waste to energy. New recycling routes however fall outside this categorisation, when contained metals or other elements are recovered at the same time as the organic carbon content: e.g. car tires as fuel for steel production, e-waste as input to metal smelters, use in silicon carbide production. Other innovative recycling routes cited include upcycling e-waste to 3D-printing filaments, to carbon fibre products, to composite panels or to activated carbon for superconductor production.

“The present and future of e-waste plastics recycling”, V. Sahajwalla & V. Gaikwad, *Current Opinion in Green and Sustainable Chemistry* 2018, 13:102–107 <https://doi.org/10.1016/j.cogsc.2018.06.006>



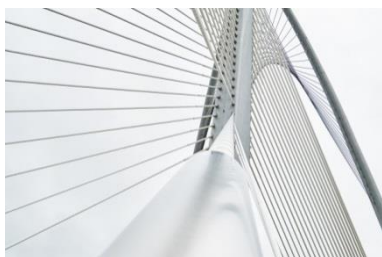
Neste, Ravago & Remondis to recycle plastics

Neste, a leader in renewables, has announced plans to chemically recycle 200 000 t/y of waste plastics back to chemicals feedstock. Remondis, leader in Germany in waste management, will collect plastics for recycling. Ravago, world leader in polymer distribution and recycling, will bring expertise in plastics chemistry. The objective is to produce raw materials for the chemicals industry (for production of new plastics, chemicals and fuels) from post-consumer plastic waste, enabling upcycling to high quality plastics applications, such as food contact. Neste's objective by 2030 is to process one million tonnes of plastics per year, that is c. 2% of EU total plastic use, or c. 4% of EU post-consumer plastic waste.

"Remondis and Neste to cooperate on chemical plastics recycling", 24/10/2019

<https://www.euwid-recycling.com/news/business/single/Artikel/remondis-and-neste-to-cooperate-on-chemical-plastics-recycling.html> *"Ravago and Neste to advance chemical recycling", 13/11/2019* <https://www.euwid-recycling.com/news/business/single/Artikel/ravago-and-neste-to-advance-chemical-recycling.html>

FIRE SAFETY PRODUCTS



Ceramifying polymer coating

Finnester Coatings has launched a fire protection coating HybridRED which offers external weather resistance, low smoke and toxicity, fire performance and exceptional aesthetic quality. This is the first composite coating to combine all of these properties. It is applied like a paint and is based on proprietary ceramifying polymer, which produce a nearly non-combustible protection in fire. To improve heat protection of substrate, it can be combined with an intumescent, with only a slight resulting reduction in the gloss appearance. HybridRED has been selected for fire-safing of a railway footbridge in the UK, as it was able to achieve protection against surface spread of flame, low smoke and toxicity, and durability outdoors. See also pinfa Newsletter n°67.

"HybridRED makes FRP footbridge over railway fire resistant", 14/10/2019

<http://www.finnester.com/cms/en/news/215-hybridred-makes-frp-footbridge-over-railway-fire-resistant> *"Composite coating creates fire resistance for decorative outdoor applications"* 3/10/2019 <https://energynorthern.com/2019/10/03/composite-coating-creates-fire-resistance-for-decorative-outdoor-applications/>

RESEARCH



Bio-based reactive phosphorus FR for epoxy

Furfural is a natural aldehyde chemical found in or derived from non-food, lignocellulose materials such as wheat bran, corn cobs and sawdust (*furfur* = latin for bran). A Schiff base (nitrogen containing, imine structure) was derived from furfuran, then reacted with DOPO (9,10-dihydro-9-oxa-10-phosphaphenanthrene-10-oxide), generating a reactive phosphorus-containing flame retardant. At 5% loading in epoxy (DGEBA/DDM 4,4' -diaminodiphenylmethane), resin impact strength was improved and UL94-V0 (3.2mm) and 37.5% LOI (limiting oxygen index) fire performance were achieved. The P-FR was shown to reduce the release of volatiles gases from the epoxy in fire, acting in both the solid phase (char formation) and in the gas phase.

"Flame retardant and toughening behaviors of bio-based DOPO containing curing agent in epoxy thermoset", Z. Yao et al., Polym Adv Technol. 2019;1-11

<http://dx.doi.org/10.1002/pat.4782>



Gas phase FR effects of aluminium – phosphorus FRs

A research study analyses the differing gas phase fire-inhibition effects of two different aluminium – phosphorus PIN FRs (AHP aluminium hypophosphite, from Qingzhou Yichao Chemicals, and AlPi aluminium diethylphosphinate, from pinfa member Clariant) at 10% loading in PBT (polybutylene terephthalate). PBT is a widely used, high performance thermoplastic polymer used in applications such as electronics, automotive, fibres, in this case supplied by BASF (a pinfa member company). Volatiles emitted from controlled pyrolysis of the plastics at 400 - 600°C were collected and analysed by photoionization, after removal of particles < 1.2 µm (PY-PI-TFOMS). Fire tests were carried out (LOI, cone calorimeter, UL94 vertical burn @ 3 mm). The authors conclude that the better fire performance of the AlPi-PBT (e.g. peak heat release rate around a half that of AHP-PBT and around a quarter of neat PBT) reflected “much better gas phase action of AlPi. They suggest that this results from release of $C_2H_5-(O=P^*-OH)$ and diethylphosphinic acid which effectively generate PO type radicals.

“An insight into gas phase flame retardant mechanisms of AHP versus AlPi in PBT: Online pyrolysis vacuum ultraviolet photoionization time-of-flight mass spectrometry”, Ma et al., *Combustion & Flame* 209 (2019) 467–477 <https://doi.org/10.1016/j.combustflame.2019.08.020>

Magnesium – AlPi synergy in polyamide

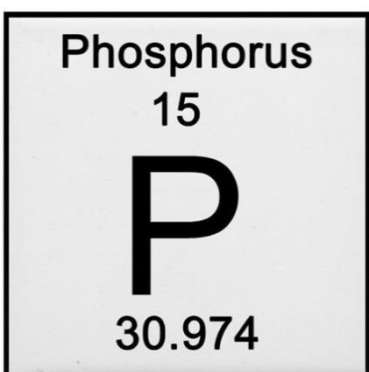
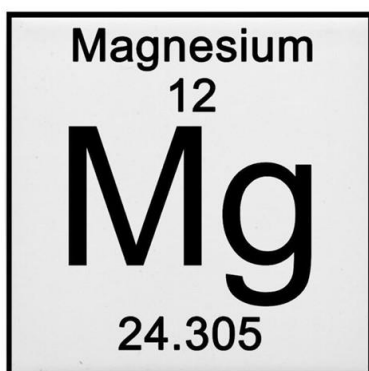
Micron-sized magnesium oxide (MgO <75 µm) at 0 – 0.5 % loading, and AlPi (aluminium diethylphosphinate) at 0 – 14 % loading, were tested as synergistic PIN FRs in polyamide PA66, after extrusion and injection. A combination of 0.3% MgO and 9.7% AlPi achieved fire performance (LOI, heat release) similar to 12 – 14 % AlPi (without MgO), including UL94-V0 at 1.6 mm. The authors indicate that MgO reacts with diethylphosphinic acid, produced by AlPi in burning, to create magnesium phosphates which improve char yield, giving a compact and homogeneous char.

“The study on flame retardancy synergetic mechanism of magnesium oxide for PA66/AlPi composite”, Z. Zhan et al., *Materials Res. Express* 6 (2019) 115317 <https://doi.org/10.1088/2053-1591/ab4737>

AlPi as PIN FR for rigid polyurethane foam

Aluminium diethylphosphinate was tested at 0 – 11 % loading in rigid polyurethane foam (PUR), produced by one-step mixing, water blowing. Fire performance and combustion behaviour were analysed. Dosing of AlPi was noted to deteriorate the foam cell structure. AlPi improved fire behaviour, for example reducing by nearly 50% burning time in the UL94 vertical burn test (achieving UL94-V1 even with low AlPi loading), increasing LOI by nearly one quarter and decreasing peak heat release rate by one fifth (compared to neat PUR). AlPi also reduced hydrocarbons and carbon monoxide emissions during burning. Analysis showed that AlPi caused PUR to form aromatic and aromatic heterocyclic structures in heat decomposition, so improving the strength and compactness of char, in addition to acting to inhibit fire in the gas phase.

“Effect of aluminum diethylphosphinate on flame retardant and thermal properties of rigid polyurethane foam composites”, G. Tang et al., *Journal of Thermal Analysis and Calorimetry* <https://doi.org/10.1007/s10973-019-08897-z>



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