pinfa
Phosphorus, Inorganic & Nitrogen Flame Retardants Association

Your newsletter for non-halogen fire safety solutions
No. 109 Special Issue
AMI Fire Resistance in Plastics 2019

Gerd Allermann, AMI, opened this 14th Fire Resistance in Plastics, noting that the conference has again brought together **over 160 delegates from across the world**. He identified four key themes for the conference:

- **Technological innovation** opens new needs for fire safety in plastics, for example emobility, increasing digitalization
- Increasingly demanding **fire safety regulation** or industry requirements, worldwide
- Continuing pressure on **environment and health**
- The need to develop **plastics recycling**

The 2020 edition of AMI's Fire Resistance in Plastics conference is announced for Düsseldorf, 30th November – 2nd December 2020 https://www.ami.international/events

AMI's Fire Retardants in Plastics US conference takes place 31 March - 1 April 2020, Cleveland, USA https://www.ami.international/events/event?Code=C1060

NEW FR NEEDS FOR EMOBILITY

Jonathan Crozier, pinfa and Cefic, outlined the new needs for flame retardants in plastics in emobility. Electric vehicles are currently less than 2% of the world automotive market (but nearly 5% in China), but **growth is expected to exceed 70% per year**. Already in Norway, electric vehicles are now over 50% of car sales. New solid-state batteries may accelerate uptake, by offering two times higher energy density, faster charging and longer battery life. Electric cars contain more data cables and connectors than for combustion motor cars, and this will increase with the data transfer requirements of autonomous vehicles. High voltage power transmission inside vehicles, batteries and casings, and charging systems, cables and connectors all imply demanding fire resistance, electrical and mechanical properties. **pinfa workshops on flame retardants and emobility in China, Japan and Europe** over the last year have shown the considerable demand from industry, and the interest to work together on innovation, standards and knowledge transfer between materials suppliers, parts manufacturers and researchers.


Cécile Corriol and Xavier Couillens, Solvay, presented developments in performance **PIN-FR polyamide (Solvay Technyl)** materials responding to new requirements for electric vehicles. Emobility combines performance challenges including electrical characteristics (both power and data management), colour, fire safety specifications, laser markable, thermal resistance and mechanical properties. Plastics offer advantages to automotive design in **replacing metals with lower weight and electrical insulation benefits**. New application areas include high voltage connectors (orange colour requirement), power electronics (AC/DC), and battery systems (batteries, casing, cooling systems). Challenges for Solvay include **finding HFFR (halogen free flame retardant) solutions with higher processing temperatures and with better mechanical performance**, whilst continuing to meet UL94 V0 and Glow Wire fire resistance specifications.
https://www.solvay.com/en/brands/technyl

FRs AND PLASTICS RECYCLING

Lein Tange, ICL-IP, set the scene for the discussion with a summary of the challenges and opportunities for recycling technical plastics and a presentation of several European R&D and pilot industrial recycling projects. **The EU WEEE Directive (Waste Electrical and Electronic Equipment 2012/19/EU) obliges to separate out plastics containing brominated flame retardants**. These can then be recycled if the levels of POP brominated FRs (Penta-, Octa- or Deca-BDE, HBCD) are lower than prescribed limits (1000 ppm for each one separately). However, mechanical recycling of post-consumer plastics poses challenges of scale/logistics (cost of handling and transport), regulatory obstacles to "waste" transport, and quality of analysis and sorting. **Only small levels of sorting failure (2% limit), resulting in mixing of incompatible polymers or additives, can be problematic for mechanical recycling**, leading to "downcycling" to lower grade mixed plastics or incineration. Black colour (carbon black) poses a significant obstacle to sorting. For these reasons, a range of different recycling routes are needed, as part of integrated waste management: mechanical recycling, chemical recycling back to clean polymer, energy recovery as fuel or syngas. The Plast2bCleaned project, with solvent-based physical (dissolution/purification) recycling, shows a carbon footprint close to that of mechanical recycling. The PolyStyreneLoop **industrial demonstration plant under construction at Terneuzen, The Netherlands, will recycle 3 000 t/y of polystyrene**, eliminating the POP brominated FR HBCD and recovering clean polystyrene granules as well as bromine. The carbon footprint is 2-3 times better than incineration. Other EU funded projects include CloseWEEE, MultiCycle.

Franky Puype, Institute for Testing and Certification (Czech Republic), presented the analysis of brominated flame retardants in 3 consumer goods made of recycled plastics purchased in the EU (cube toy, kaleidoscope toy, bottle cooler) using the Frontier Laboratories Pyrolysis system. **In all three products, BFRs were detected**, **and in one toy the levels of BFRs exceeded the RoHS limits**. He also presented the application to screen brominated signatures and BFRs by thermal desorption, showing testing on two building foams, one food tray. Other analytical techniques like EGA-MS, heart-cut MS and reactive pyrolysis were addressed as potential screening techniques and strategies for BFR quantification in polymeric material. http://www.frontier-lab.com/





This year's Flame Retardants in Plastics Conference included a **panel discussion on recycling,** moderated by **Isabel de Castro, Flame Retardants Europe**, with **Chris Thornton of pinfa**, **Karen Janssens of Campine**, **Rudolf Pfaendner of Fraunhofer LBF** and **Lein Tange of ICL-IP**.

Isabel de Castro, Flame Retardants Europe, introduced the panel discussion, indicating that EU policymakers are strongly pushing plastics recycling tend to be opposed to "energy valorisation" of end-of-life plastics, be it incineration or other routes such as cement industry or metal smelters. Therefore, it **the FR industry needs to demonstrate that FRs are relevant for and can fit in the circular economy**.

Rudolf Pfaendner, Fraunhofer LBF, summarised the conclusions of the pinfa tests of mechanical recycling of PIN FR plastics. These tests showed that for nearly all the polymer / PIN FR combinations tested, fire performance was maintained after multiple ageing – re-extrusion cycles, but mechanical properties tended to deteriorate because of damage to the polymer and the glass fibres, not because of the flame retardant (see pinfa Newsletter n°105).

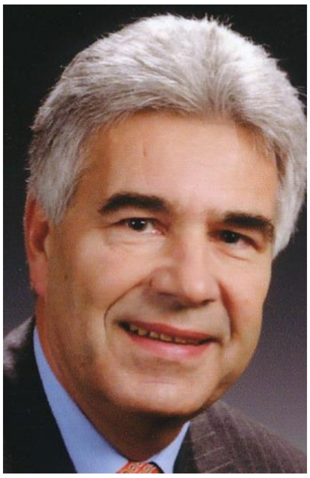
Chris Thornton, pinfa, underlined the opportunities for new business models around plastics recycling, in developing compound formulations to use end-of-life plastics as input materials and **new additives to improve compatibility between recycled polymers** and traces of unintended contaminant polymers or additives resulting from sorting errors (see Compounding World "plastics upcycling" summarised in pinfa Newsletter n°108). He also emphasised that the obligation to recycled end-of-life plastics, sometimes after a decade or longer of produce use, obliges to **develop and use FR chemicals which are recognised as safe** (will not become the "legacy contaminants" of the future).

Active discussion between the panel and conference participants identified challenges in recycling technical plastics, which is more complex than packaging materials: longer use life (distance from producer to end-of-life, problem of "legacy" additives such as POP brominated flame retardants or heavy metal stabilisers), wider variety of polymers and additives, smaller quantities rendering logistics more costly.

Discussion points included:

- Tests show that **most flame retardants are compatible with mechanical recycling**, loss of mechanical properties is generally due to polymer and fibre deterioration not to additives.
- Today already nearly all plastics production scrap is already mechanically recycled. **The challenge is sorting and recycling of post-consumer, end-of-life plastics**.
- Need for stable and coherent regulatory framework, and in particular for adequate **producer responsibility funding to cover the costs of End-of-Life** collection, sorting and recycling.
- Regulation should also oblige "**design for dismantling**", to facilitate separation of different types of plastics.
- Industry needs to work together, with regulators, to implement coherent, long-term and universal **systems of labelling of different plastics** (polymer, additives) to facilitate sorting (see the example of material classification for PET bottles).
- **Business opportunities** for additives, to improve the recycling compatibility of recovered materials and their processing, or tracers and sorting technologies.
- **Cooperation across the industry value chain is essential** to enable end-of-life collection, sorting, logistics and plastics recycling: polymers, additives, compounders, product design, retail, recyclers, regulators and funding.
- If industry fails to come together, to speak with one voice, and to find solutions, then there may be **increasing pressure to "simplify" recycling by reducing the number of polymers and additives used**.

INTERVIEWS




Michael Peter and Gotthard Ziegan, Carl Spaeter GmbH

Carl Spaeter supplies different grades of the mineral flame retardant MDH, in particular for cables for different sectors (transport, electrical, construction …), and to applications in construction, such as roofing membranes. Carl Spaeter also offers a range of functional fillers like hollow glass spheres and minerals enhancing heat conductivity. MDH offers inherent advantages of processability and compatibility with Low Smoke Zero Halogen cable formulations. Keys to success are full customer services and competitive total application cost. Carl Spaeter works with customers to define their requirements, both for fire safety and for cable technical performance, and how to optimally achieve these, including both the mineral (PIN) flame retardant, surface coatings, coupling agents to improve cable characteristics and other performance additives. The company sees today increasingly stringent fire resistance requirements, in particular for cables, continuing to be driven by the EU Construction Products Regulation (CPR) specifications. More demanding requirements can also be expected in the future in automotive applications. These changes mean significant market changes towards more technically demanding formulations for tomorrow's cables.

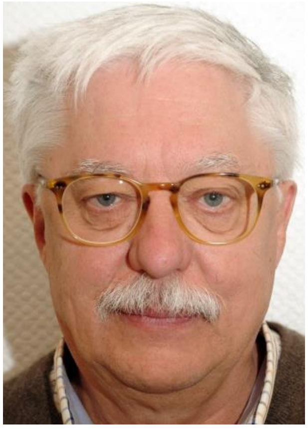
Carl Spaeter (Spaeter Duisburg Group) is both Germany's biggest independent trading company in iron and steel products and a European-level trader in minerals. Carl Spaeter is the exclusive representative in Europe for the company Penoles / Mexico, including a range of flame retardant grades of MDH (magnesium hydroxide) and magnesium oxides. www.spaeter.de

Thomas Menken, De Monchy International

De Monchy centres on providing quality products to customers, ensuring high levels consistent over coming years. Sustainability is a priority for the company, which is moving away from brominated FRs with a developing offer of 'green' and non-toxic FRs. De Monchy is unique distributor in Europe for the phosphorus chemical company Presafer, China, whose objective is to become the world's leading supplier of HFFR APP (ammonium poly phosphate). De Monchy has its own technical expertise, working on synergists and formulations which enable lower FR loadings and improve product material performance. De Monchy has also developed low-dust FR solutions, to improve health and safety in handling and processing. The company is also developing FR solutions for specific challenges such as transparency and long lasting pot life for coatings.

De Monchy is a family owned distributor and trading company based in The Netherlands, with 35 staff and activities in several sectors, including distribution of polymers and of plastics additives in Europe and worldwide. De Monchy's flame retardant offer includes FRs for polyamides, polyolefins and other formulations, flame retardant polystyrenes, intumescent coatings, sealants, composites. https://monchy.com

Bio-based fire safety



Günter Beyer, Fire and Polymers Belgium, summarised possibilities of bio-sourced flame retardants, **Phytic acid** (inositol hexaphosphoric acid), the natural phosphorus storage molecule in plants (especially in seeds), with up to 28% P by weight, has been demonstrated to be an effective flame retardant, and is readily available. The FR efficiency of MDH (magnesium di hydrate) can be improved by a coating with the zinc-salt of phytic acid (Meng 2019). **DNA** (genetic material) is also available (e.g. in fish processing wastes), and contains phosphorus, nitrogen and natural sugar groups. It has been tested as a surface treatment of EVA (Alongi 2014). **Tannic acid** or **lignin**, both natural carbon-containing molecules, are sometimes presented as flame retardants, or they can be modified or functionalised (e.g. by phosphorylation), but in some cases the research does this by using complex, synthetic organic chemicals (Lang 2015, Prieur 2016).

See also Hobbs 2019 review in pinfa Newsletter n°103.

Fouad Laoutid, Materia Nova Research Centre Belgium, presented research into **fire safety functionalisation of polylactide** (PLA, a bio-based polymer) by inserting phosphorus compounds, such as DOPO-diamine, as initiator for lactide ring opening polymerization. A catalyst and an initiator are used to open lactide rings to promote the formation of PLA. The phosphorylated oligomers so obtained are combined with a chain extender to form phosphorylated PLA with higher molecular weight, with the possibility to control the overall polymer chain length and the frequency in the chain of phosphorus molecule insertions. Polylactide modified to contain 4 % P by weight, in a 0.8 mm film, showed a c. 35% reduction in peak heat release rate (PHRR) and in total heat release (THR), and no burning droplets. A 50/50 mix of neat PLA and this modified PLA (overall 2 % P) was self-extinguishing (0.8 mm film) with no burning droplets, and retained transparency.

Interview

Klaus Lederer, POLOPLAST

POLOPLAST's policy is to offer PIN flame retardant solutions, considered to be the future for fire safety. Health and safety, both for POLOPLAST's own staff and for customers, is a priority and leads to prefer PIN FRs which offer benefits and quality technical support from PIN FR suppliers. POLOPLAST has its own plastics chemists, and develops its own performance synergist packages in order to optimise FR loadings in its compounds and to achieve each customer's technical requirements. These are adapted to each country's different standards across Europe in different applications and markets. Challenges and new markets include the need to identify PIN FR solutions which are not water soluble in production cooling, smoke specifications in the Construction Products Regulation, possible future tightening of fire safety requirements in automotive and developing applications (such as use of polypropylene in battery covers) and opportunities to move towards non-halogen FR in pipes and ducting in countries where e.g. PVC is still preferred.

POLOPLAST is a leading European pipe system manufacturer, now expanding into the USA and Europe, with a compounding activity launched in 1998 and specialised in polypropylenes. The company develops and supplies technical plastic compounds to a range of markets including automotive, building & construction and appliances. www.poloplast.com

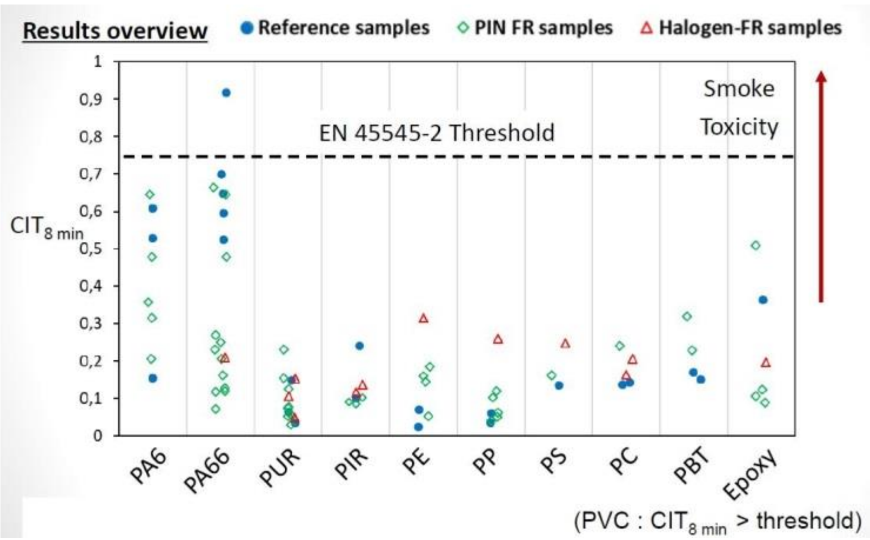
SMOKE TOXICITY

Hervé Feuchter, CREPIM France, presented results of the **comparison of smoke emissions from neat polymers and from polymers with FRs**. This is the first time that such extensive data has been developed under comparable conditions. 94 samples were tested (3 mm plates or 19 mm for foams), provided by 12 pinfa member companies, with 13 different polymers and over 50 different flame retardants (PIN and halogenated).

The FR – polymer combinations were **representative of commercially widespread formulations on the market today**, but without addition of synergists and additives (in order to simplify results). Neat polymers were also tested for comparison. Acute smoke toxicity was determined according to NF X 70-100 (600°C, analysis of 8 toxic gases according to EN 45545-2, which uses the CIT Conventional Index for Toxicity) and smoke density according to ISO 5659-2 + Annex C of EN 45545-2 (50 kW/m^2).

Despite the **variation of smoke emission and toxicity for similar plastics**, these comparative test results do enable some general conclusions to be drawn. These are applicable to all the polymers tested except PVC, which shows inherently high acute toxicity (using this test method):

- Addition of PIN FRs to the polymers generally results in similar smoke emissions and acute toxicity, or lower smoke and toxicity, compared to the neat polymers;
- **PIN FRs show lower smoke density than halogenated FRs**, except in PIR (the PIN FRs show smoke density similar to the neat polymers);
- PIN FRs have no significant impact on the emissions of CO, CO_2, HCl, HBr, HF, HCN, SO_2, NO_x under these test conditions;
- Smoke emission and toxicity is mainly dependent on the type of polymer.



Participating companies, coordinated by pinfa: Adeka, BASF, Budenheim, Clariant, Dupont, FRX Polymers, GC Green Chemicals, Huber Martinswerk, Lanxess, Nabaltec, SABIC, TOTAL.

Polymers tested: Polyethylene (LLDPE, HDPE), Polypropylene (PP), Polystyrene (PS), Polycarbonates (PC), Polyesters (PBT), Epoxy resins, Polyamides (PA6, PA66, PPA Polyphthalamide), Polyurethanes (PUR, PIR), Polyvinyl chloride (p-PVC, u-PVC).

Flame retardants tested included: Decabromodiphenylethane, Piperazine pyrophosphate, Hinderedamines, N-alkoxy amines, intumescent systems, Melamine polyphosphates, Aluminium polyphosphate, Tetrabromobisphenol A, Diethylphosphinate aluminium salt, Melamine cyanurate or polyphosphate, Magnesium hydroxide, Tris (1-chloro-2-propyl) phosphate, Ammonium Polyphosphate, P-based Polyester Polyol.

PIN FRs FOR PERFORMANCE APPLICATIONS

Christian Battenberg, Clariant, presented **innovations in phosphorus-based PIN flame retardants for demanding applications in E&E and transport**. Clariant offers P-FRs for a wide range of plastics, with strong development in reactive FRs for thermosets, new liquid formulations for improved processing, but also intumescent coatings and thermoplastics. For example, an epoxy formulation with 3% P-content, containing a **reactive liquid P-FR** (no particles) offering very low viscosity and high transparency. Tomorrow's FR formulation challenges include low weight objectives for transport applications, complex composites (such as flexible circuit boards) and high fire safety foams for aviation, railway, maritime, automobile and melamine-free upholstered furniture. **Non-halogen formulations are necessary to achieve smoke emission and smoke toxicity objectives**. Specific solutions presented include a reactive P-FR plus synergists package for polyurethane foams for railway application (EN 45545-2), and optimised APP (ammonium poly phosphate) containing systems using synergists to achieve MARHE HL_2 and HL_3 in epoxy for railways with lower smoke than the neat polymer. Clariant is also developing a range of recycled carbon FRs with NESTE, using hydrocarbons from discarded cooking oils. https://www.clariant.com/en/Business-Units/Additives/Flame-Retardants

Nick Wolter, Fraunhofer IFAM (see pinfa Newsletter n°105 FRPM 2019), presented the Mat4Rail project, developing **innovative composite materials using polybenzoxazine (high performance, low density polymer), basalt fibre reinforcement and phosphorus PIN FRs**. This combination offers low shrinkage and heat release on curing, high service temperature and good mechanical properties, with low weight. Appropriately selected P-FRs have the benefits of improving processing by decreasing viscosity and delaying or catalysing curing, do not deteriorate tensile strength, but can deteriorate interlaminar shear strength – showing the need to work on the fibre – plastic interface. The addition of basalt fibres to the polymer reduce heat release, smoke toxicity and smoke density. The P-FRs tested offer somewhat similar or poorer fire performance and worse smoke density and toxicity than neat polymer with basalt fibres, so further work is needed to find appropriate PIN FR packages. However, PIN FRs can be used in benzoxazine technology to obtain tailored processing properties facilitating market implementation of new high performance polymers.

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Frédéric Roquefeuil, CellMark, presented this group's development into fire safety. The group was founded in 1984 in Sweden with roots in the pulp and paper industry, acquiring **Alcan** International Network in 2012. CellMark has today 700 staff worldwide and a strong **emphasis on developing a safer and more sustainable chemistry.** CellMark's PIN flame retardant portfolio is based around precipitated aluminum hydroxides (mono & tri hydroxides) which are produced by KC Korea. CellMark is also developing and producing specialty mineral additives which work as **synergists to reduce heat release and smoke emission up to 40% while allowing a significant decrease of FR loadings in cable compounds** Current developments aim to further reduce smoke emission with newly designed ATH. CellMark has also developed a ceramifying filler which improves the fire resistance of strategic security parts, whilst remaining compatible with existing processing technologies. www.cellmark.com

INTERVIEWS


Shinichi Ikoma and Shinji Sakaguchi, Daihachi

Daihachi sees phosphorus as the key to fire safety in the future as users look for alternative solutions to halogenated chemicals. Phosphorus PIN FRs, especially phosphorus esters, provide flexibility, fire performance and compatibility with technical material requirements. A challenge however, for the longer term, is sustainable supply of yellow phosphorus (P4), because the world is dependent on a very limited number of suppliers. Daihachi is therefore cooperating with the Japan Council for Circular Phosphorus to look at possible production from recycling. Daihachi is currently proposing innovations in phosphorus FRs for electronics, engineering plastics and for timber / wood. Significant growth and demand for new fire safety solutions, compatible with demanding performance, are expected in emobility and 5G, with the latter requiring specific electronic material properties. For engineering plastics, such as PBT, Daihachi is developing phosphorus FRs to meet specific processing requirements for temperature and hydrolysis resistance, and with electrical performance (CTI > 600). New phosphorus flame retardants for wood, without boric acid, for pressure-immersion application, offer moisture resistance (exterior use), durability, transparency and no white traces during ageing.

Daihachi Chemical Industry Co. was established in 1919 and today produces flame retardants, plasticisers, resin modifiers and other additives, as well as metal extractants, with over 260 staff. https://www.daihachi-chem.co.jp

Obituary: Mr Ikoma passed away on 4th January 2020. pinfa publishes this interview in respect and with thoughts for his family and colleagues.

Kostas Gatos, TERNA MAG

TERNA MAG expects that the prospects of market growth for flame retardants will induce new developments in relevant materials and polymeric recipes, on the basis of optimum (technically and cost wise) solutions. This will be driven in particular by stringent regulatory fire safety requirements. Non-halgenated compounds will extend their applications in constructions and transportation, supported by new developments in polymer resins and in manufacturing processes. Future trends towards smart materials and 3D printing will drive PIN FR technologies in these fields. Conventional applications will be served by suitable combinations of PIN FRs, to reduce costs whilst maintaining physical properties. These developments require R&D activities into functional fillers and investment in new equipment. TERNA MAG carries out in-house testing and supports customers in implementation. For post-use recycling, challenges are compatibility between different synergists and polymers, and cooperation is needed between recyclers, resin producers, additive suppliers and compounders to develop operational processes.

TERNA MAG S.A. is part of the GEK TERNA Group, which operates worldwide with 5 000 staff and has a leading position in Greece in construction and infrastructure, renewable energy resources, clean energy production & supply and industrial minerals. TERNA MAG S.A. is active the production and supply of various magnesium products, exploiting the magnesite deposits on the island of Euboea, Greece. www.ternamag.com

INTERVIEWS

Muhammad Waseem, Gabriel Chemie

Polyolefins in general, and polyproylene in particular, are one of Gabriel Chemie's specialist sectors for halogen free flame retardants, providing masterbatches for extrusion and injection moulding applications with demanding fire safety and technical specifications such as stadium seats (see pinfa Newsletter n°44), films for aviation transport, construction, mining industry. PIN flame retardants, combined with specific recipes of other additives, need to offer performance such as anti-UV, colour stability under ageing or transparency, and the masterbatcher has to guarantee to the customer that requirements will be fulfilled. Specific additives are also selected to improve processing. A challenge for PIN FRs can be cost compared to legacy halogenated FRs. Gabriel Chemie is already processing recycled plastics granules, and interest is today developing with customers. The overall wide variety and number of different additives is a challenge for masterbatchers. PIN FRs can be sensitive to the presence of other additives, so that an FR which is effective in virgin material may achieve the same fire performance in post-consumer recycled granules. The quality of sorting of recycled plastics is thus critical.

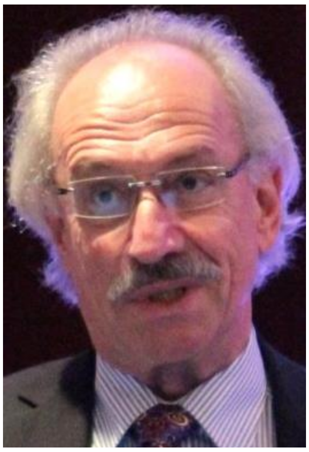
Gabriel Chemie, founded in 1956, offers masterbatches for plastics, including both colours and functional additives such as fillers, anti-flame, antistatic, processing and performance additives and laser marking, with services including formulation advice, production support, compound production laboratory testing. The company has operations in ten countries in Europe and in Russia and customers worldwide. http://www.gabriel-chemie.com

Bernd Hönig, Constab

Constab optimises formulations to achieve customers' needs for specific and often demanding applications. PIN FRs are now available which offer heat stability in processing, are melt blendable, easy to process and can be transparent or colour-compatible. However, in some cases, halogenated FRs can enable lower FR loadings or lower costs. Specific expertise can be necessary to ensure processing of some PIN FR compounds (viscosity, temperature). If legislation changes to require low smoke emission in applications such as construction then this would drive a further move towards PIN FR solutions. Another driver could be the increasing customer rejection of antimony, perceived as facing regulatory uncertainty. In particular, PIN FR solutions are not mainstream today for XPS (expanded polystyrene) insulation materials, and polymeric brominated FRs are the preferred flame retardant solution. PIN FRs are today the optimal choice in electrical and electronic applications, including cables, conduits for cables, polycarbonate sheets. Growth is expected in particular in E&E and in cables, with innovation and new requirements for emobility and for smart devices. Recycling of "clean" streams of well identified post production compounds at customers is known to Constab. Recycling of post-consumer plastic waste is much more complex. Very effective sorting is necessary and respecting processing temperature limits for PIN FRs can be a challenge.

Constab (Kafrit Group) is a leading masterbatcher and compounder, with five production plants across the world, integrating R&D, testing, compound design and production support. The company develops and supplies for sectors including packaging films, agricultural films, pipes, insulation foams, construction barriers, fibres, nonwovens …Constab is a world leader in BOPP (biaxially orientated polypropylene) but also supplies compounds of polystyrene, polyethylene, polycarbonate … www.constab.com

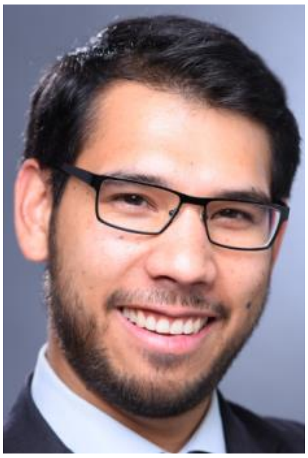
FIRE SAFETY TRENDS



Jürgen Troitzsch, consultant, summarised trends in fire safety standards. Increasingly, standards are designed to allow fire safety to be achieved by different approaches: use of inherently fire resistant materials, fire barriers or flame retardants. **Key sectors where standards developments are ongoing are construction, furniture and cars and buses**. In construction, fire safety requirements in tall buildings are being tightened following the Grenfell fire: e.g. the ban on combustible façade materials in buildings > 18 m in the UK (see pinfa Newsletter n°108) The EU is currently developing a new large-scale test for façade materials and the US (via the IBC, International Building Code) is expected to amend its NFPA 285 large-scale façade test in light of the lessons learnt from the Grenfell fire.. For furniture, discussions are still underway in the UK (see pinfa Newsletter n°109) but the recent room tests funded by the North American Fire Retardant Association show that FRs are effective, delaying flashover from 4-5 to 17 minutes, and delaying the time before smoke emission and reducing total smoke emission and smoke toxicity (Blais et al. 2019, see pinfa Newsletter n°104). For automotive, the **NHTSA SwRI study** (see Hennessey 2017) on possible revision of FMVSS 302 (1972, vertical burning requirement for automotive interiors) is expected in coming months. For buses and coaches, UNECE R118 is applicable worldwide since 2014, and although slightly more demanding than previous standards, is still considerably weaker than fire safety requirements for railways (but UNECE R118 does allow the more stringent ISO 5658-2 test to be used on a voluntary basis).

Marc Leifer, ICL, summarised trends and perspectives in fire safety, as seen by his company. **Civilisation has been marked by great fires, from Rome in 64 BC to San Francisco in 1906**. Considerable improvements have been made in preventive fire safety, at least in developed countries, especially by design for safety and by the use of flame retardants in combustible materials. Challenges today are the need to address health and environmental concerns, be they scientific or irrational. Standards are moving towards rationalisation and flexibility to enable innovative fire safety technologies, and inclusion of smoke emission and smoke toxicity criteria. A key message is that flame retardants are largely a success and are a key to lower fire deaths and injuries: "**No ignition, no fire**". See video here https://www.youtube.com/watch?v=pPakvDIaa_E

OTHER FR PRESENTATIONS



Alexander Battig, BAM (German Federal Institute for Materials Research and Testing), presented research into development of **hyperbranched polymeric FRs, containing phosphorus, nitrogen and sulphur** (phosphorus esters, amidates, diamidates, amides). The polymer molecules may be functionalised both at molecule ends and within the polymer backbone. The hyperbranched polymers have the advantage of being non crystalline, so improving immobilisation in the polymer matrix, and compatibility with mechanical properties, particularly in epoxy resins. A systematic variation of P-O and P-N content highlighted the change in fire performance of the FRs. Low thermal stability of low molar mass variants was improved with hyperbranching and may be further improved by inclusion of aromatic groups. Sulphur showed to act to improve fire resistance both in the gas phase (radical generator) and the solid phase (char enhancer). The results illuminate the multifunctional qualities of hyperbranched polymers as effective FRs.

Klaus Rathberger, Georg H. Luh, Germany, outlined the benefits of his company's **expanded graphite as a PIN flame retardant system component**. Applications include EPS, foams in transport applications (automotive, aircraft), compounding for thermoplastics, rubber, silicones, roof bitumen, intumescent fire seals and gaskets. Quality of product is essential to achieve processing and fire performance objectives, for example: particle size (although expanded graphite seems to be effective with somewhat larger particle size than some other mineral PIN FRs), presence of impurities, balance between fast fire reaction at lower temperatures and compatibility with higher processing temperatures (today, the upper processing limit is around 230°C, but products enabling higher temperature processing are being researched). Thermal conductivity both contributes to reduce fire ignition and can improve heat dispersion in applications. Low dusting masterbatches are now available for cleaner processing. A limit to application remains the black colour.

Sinikka Freidhof, Lubrizol, presented **CPVC, in which the chlorine content of PVC is increased from around 55% to around 67%** through a post chlorination process. The modified polymer offers improved rigidity and fire performance following the increase in chlorine content. Typical applications for CPVC have been in piping such as fire sprinkler water pipes, demanding industrial applications, plumbing systems for hot and cold water or - more recently - as an additive in PVC. **Lubrizol is actively working on take-back and recycling of CPVC materials**. Challenges are to assure correct sorting, so that returning materials are compatible and of homogenous quality. This poses labelling problems: even if pipes are marked, cut-offs may lose the marking. Another challenge is 'legacy' additives, such as heavy metals like tin or zinc used as stabilisers in CPVC. Recycling requires to develop collaboration throughout the value chain, including installers, end-users, dismantlers and recyclers, and to propose common solutions, including to regulators.

Daniel De Schryver, Albemarle, presented **new polymeric brominated flame retardants for thermoplastic resins (styrenic polymers ABS/HIPS).** Advantages include thermal stability (compatible with injection molding), melt blending, aesthetic quality (gloss), colour stability (with temperature, time) and mechanical properties better than current FR solutions. Mechanical recycling tests (injection molding, grind, re-melt, re-inject) showed no deterioration after six cycles (more stable than the neat polymer).

Caroline Braibant, International Antimony Association (I2A) presented the “hazards” of antimony and stewardship measures engaged to enable safe use of antimony trioxide (ATO). The known hazards are lung toxicity, lung cancer, delayed ossification and maternal toxicity. GHS classifications are H351 potential carcinogen class 2 and H373 STOT RE lung (voluntary listing, STOT = specific target organ toxicity). Sales of antimony products in 2018 were worth 300 million € in the European Economic Area. Antimony is the most used synergist with halogenated flame retardants. The 31 members and associate members of have engaged actions to reduce “risk”, based on exposure assessment, risk characterisation, risk determination and risk management measures.

Karen Janssens, Campine, presented an assessment of antimony use as an FR synergist, using the **ICL SAFR methodology** (see pinfa Newsletter n°79), including testing blooming of antimony in plastics (migration to the surface). In most polymers tested blooming was not detectable (<1 $\mu gSbO_3/cm^2$). In LDPE and PA6 blooming after accelerated ageing, representing 2.5 years room temperature exposure, was < 2,5 $\mu gSb_2O_3/cm^2$. For a 55 inch television, this would be 500 000 times lower than the European regulation on Sb_2O_3 dust and is considered not to pose a significant risk of inhalation. The presence of antimony does not impact bromine blooming. Risk reduction measures for ATO users include using small bags, wetting, non-respirable masterbatches.

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