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10.02.2020

**RoHS Pack 15 – 4th Stakeholder Consultation
"Substance assessment of Diantimony trioxide" –
Clariant contribution**

Referring to p. 48 of the RoHS Dossier Version 2 on Diantimony trioxide:

Questions for stakeholders participating in the stakeholder consultation:

1.) **Can you confirm the conclusion that the most promising substitution routes for ATO are (a) substituting the halogenated flame retardant together with ATO as synergist ATO, and (b) alternative technologies?**

a) Halogen free approach: We confirm the conclusion from our experience with customers. Electronics brand owners (OEMs) in particular have made pledges and created roadmaps to transition to halogen free technologies. A restriction on ATO and is sole replacement is often not seen as worthwhile – if one has to re-formulate and possibly re-tool, why not go "all the way" to halogen free. An exception were periods in the last years where antimony surged in price and there was an economic incentive to substitute it.
b) Alternative technologies: The selection of a material for a certain part of E&E equipment starts with requirements like mechanical, electrical and appearance properties plus possibly a required flammability rating. These properties together with price determine the selection. Flame retardants are generally avoided where possible because they add cost, production complexity and a detrimental effect on e.g. mechanical properties due to the high loadings (10% … 30% typically). Therefore, alternative technologies have only limited chances where other established solutions exist.

In 2016 DuPont, one of the leading specialty materials companies, published a white paper on non-halogen flame retarded polymers for E&E, demonstrating the wide range of commercially available alternatives (https://www.dupont.com/knowledge/whitepaper-nhfrpolymers-for-electrical-and-electonic-components.html). All major other compounders like BASF, DSM, Solvay, Sabic, EMS, Lanxess, KingFa, and Changchun have similar or related offerings.

2.) The outlined findings indicate that substitution of some components and parts of EEE might still be challenging. If this is the case, please provide evidence for which parts substitution is seen to be difficult. Please provide details on reasons.

Speaking for Clariant's phosphinate based FRs, according to our own test results and our customers' feedback, halogen free solutions are possible and in commercial use for:

- engineering plastics: standard and high temperature polyamides, polybutylene terephthalate (PBT), polyethylene terephthalate (PET), achieving Ul 94 V0 down to 0.4 mm thickness
- epoxy adhesive layers for flexible printed circuit boards (FCCL, base material is polyimide which does not need FR)
- FR4 printed circuit boards (epoxy resin base material), especially in consumer electronics these are commonly used (overall market share ca. 20%), with DOPO[1] and its derivatives being the dominant FR.

The transition to halogen free technologies is a challenge for the E&E industry, but it can be done as demonstrated by OEMs like e.g. Apple and Hewlett Packard. There is a one-time cost of re-formulating and re-tooling, because there are no drop-in solutions where you just exchange the halogenated FR with an alternative. Therefore, sufficient lead time is required for the industry value chain to adopt and build up the required production capacities for alternatives.

3.) Which technical criteria are relevant for substitution?

The selection of a material for a certain part of E&E equipment starts with the requirements like mechanical, electrical and appearance properties plus possibly a required flammability rating. These properties together with price determine the selection. For engineering plastics (where Clariant's phosphinate FRs are used), key technical properties of the flame retarded compounds are: mechanical properties like elongation at break and impact strength, electrical insulation (e.g. dielectric constant, volume resistivity) as well as processing behaviour like viscosity / flowability.

[1] DOPO = 9,10-Dihydro-9-oxa-10-phosphaphenanthrene-10-oxide

Common flammability ratings are UL 94 V0 and the Glow Wire Ignition Temperature. Both are determined and defined for a certain sample thickness. Due to miniaturisation, the requested minimum thickness can go down to 0.4 mm (in some cases even 0.2 mm). Thinner parts are generally more difficult to flame retard (remember than lighting a thin piece of wood is much easier than a thicker one), except for the glow wire test sometimes, where thin samples can melt away quickly from the glowing wire tip. The comparative tracking index (CTI) is a measure of how resistant a material is against electrical arcing on the surface. Here, halogen free FRs have an inherent chemical advantage and reach higher values. This parameter is of increasing interest for electric vehicles where high charging voltages and currents are used.

Brominated flame retardants also have the inherent disadvantage of leading to higher smoke density and formation of more toxic smoke components, because their mode of action is in the gas phase impeding a "clean" combustion. Therefore, brominated FRs have been largely substituted already in areas where smoke toxicity is important and regulated, especially sensitive mass transport like railway and aviation.

4.) To what extent does line density affect substitution, especially regarding power cords, power adapters and display panels?

We can only speak for our Clariant phosphinate product range which goes into connectors, switches etc. and flexible printed circuit boards diverse E&E end applications. Here, current stringent requirements down to 0.4 mm can be met.

5.) Please provide information on actually applied alternatives, especially on the application of inherent flame retardant materials.

The Exolit OP product line based on organic phosphinates is particularly suited for engineering plastics like polyamide and polyesters, as well as adhesive layers in flexible printed circuit boards. Several thousand tons of these flame retardants are used by leading electronic OEMs who have substituted formulations based on brominated flame retardants and diantimony trioxide.

These spider diagrams in fig. 1 and 2 show that Exolit based formulations are on par with brominated / ATO systems. For more detailed technical information please see our product brochure at https://www.clariant.com/en/Business-Units/Additives/Flame-Retardants/Thermoplastics.

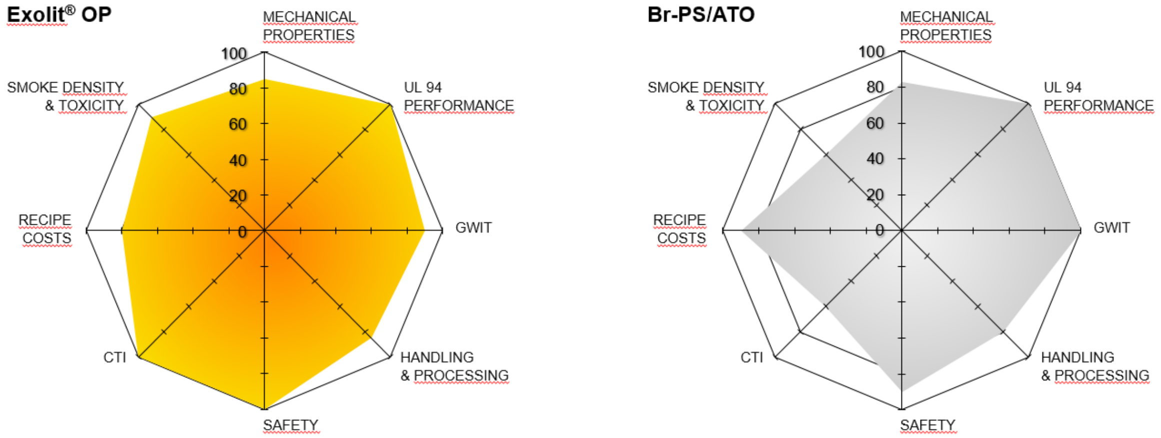

Fig. 1: Performance diagram of polyamide 66 (30% glass fibre reinforced) formulations containing Exolit OP vs. brominated / ATO. The halogen free formulation is technically and economically competitive.

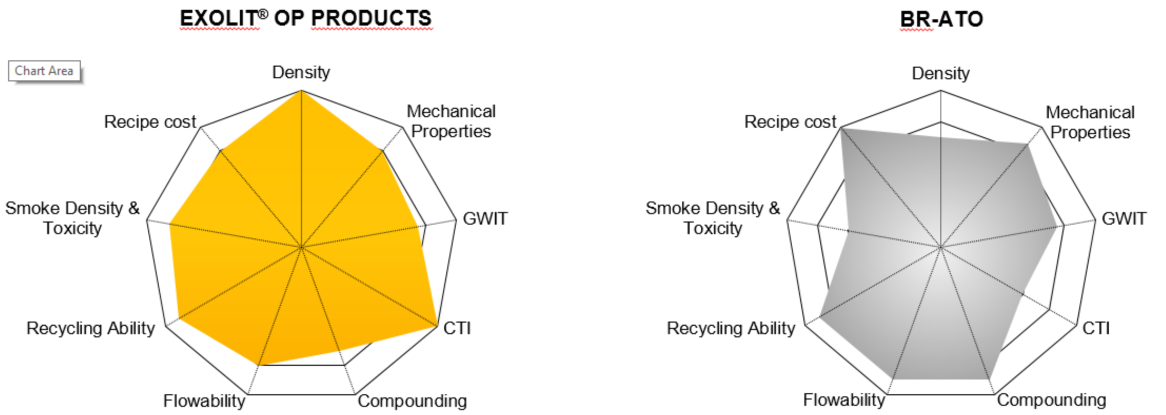

Fig. 2: Performance diagram of polybutylene terephthalate (PBT, 30% glass fibre reinforced) formulations containing Exolit OP vs. brominated / ATO. The halogen free formulation is technically and economically competitive.

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Other comments - p. 50 table 8.3:

a) Aluminium Diethyl-phosphinate (DEPAL): this product (is the key ingredient in Clariant's Exolit OP products and) has received a GreenScreen Benchmark of 3, an independent, very positive rating for environmental and health profile: https://www.clariant.com/en/Corporate/Case-Studies/Flame-Retardants/Clariants-phosphinate-flame-retardant-receives-excellent-GreenScreen-Benchmark-3-rating

b) the "Human Health and Environmental Concerns" given for red phosphorus are factually wrong and refer to yellow (also called white) phosphorus = P_4. This confusion has happened many times in the past, because there is no clear distinction in CAS numbers between white and red phosphorus (both are elemental phosphorus in different allotrophs). Whereas P_4 is highly toxic as you indicate, red phosphorus is far less so. The Clariant product (Exolit RP 607) is labelled as:
   a. H228 Flammable solid.
   b. H317 May cause an allergic skin reaction.
   c. H412 Harmful to aquatic life with long lasting effects.

   In addition, in humid environments and at higher temperatures phosphine (PH_3) gas may be formed which is toxic.

About Clariant

Clariant's non-halogenated flame retardants provide environmentally more compatible protection for buildings, electric and electronic equipment as well as textiles and other materials used in airplanes, trains, busses and ships. Clariant's portfolio is based on phosphorus chemistry, with production sites in Knapsack, Germany, Muttenz, Switzerland and Lufeng, China. Clariant's flame retardants are all marketed under the trade name Exolit® (www.exolit.com).

Clariant is a focused and innovative specialty chemical company, based in Muttenz near Basel/Switzerland. On 31 December 2018 the company employed a total workforce of 17 901. In the financial year 2018, Clariant recorded sales of CHF 4 404 billion for its continuing businesses. The company reports in three business areas: Care Chemicals, Catalysis and Natural Resources. Clariant's corporate strategy is based on five pillars: focus on innovation and R&D, add value with sustainability, reposition portfolio, intensify growth, and increase profitability. Clariant's has recently introduced its EcoCircle, supporting the transition from a one-way plastics value chain to a circular plastics economy. For more information visit www.clariant.com/en/Sustainability/EcoCircle.