Who is afraid of brominated flame retardants?

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AMI Fire Resistance in Plastics
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ICL is a leading global Fertilizers and specialty minerals company

- $5.3bn sales in 2019
- Manufacturing sites spread around the world
- ~13,000 Employees
- 20 R&D centers with 500 researchers
- Newly included in the FTSE4 Good index for sustainability efforts
Leading Positions in Our Markets

Market Leadership

Number 1 Market Positions
- #1 in Bromine capacity
- #1 in Bromine Iso-tank fleet
- #1 in Brominated biocides
- #1 in Phosphorus FRs
- #1 in Clear Brine Fluids
- #1 Self-extinguishing Hydraulic fluids

Leading Market Positions
- Flame Retardants
- Specialty Magnesia
- Magnesium Chloride

R&D Leadership
- R&D in Israel, USA
- Developing next-generation polymeric, reactive products
- New FR Product Pipeline: SaFRon®, TexFRon®, VeriQuel®, PolyQuel®
- ZnBr Energy Storage complexing agent for Energy storage Batteries
- Additional attractive bromine applications under R&D

Environmental Leadership
- Responsible Care
- VECAP® (Voluntary Emissions Control Action Program)
- Greenhouse gas reduction
- SAFR® – Scientific Assessment for Flame Retardants
Brominated Flame Retardants & critical fire safe uses

- Communication
- Electronics
- Automotive
- Servers
- Smart Manufacturing

- Internet of Things & Big Data
- Electric & Autonomous Vehicles
- Medical Devices
- Solar Panels
- Smart Roads

(AICL Industrial Products)
Brominated Flame Retardants & fire safety standards

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<td>IEC 60335 (International); EN 60065 (Europe)</td>
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Brominated Flame Retardants contribution to fire safety

A steady reduction in lethal fires and fire deaths


USA Civilian Home Fire Deaths/million - normalized (1977-2018)

Source: NFPA Survey of fire Department 1977-2018; UK National statistics
Global flame retardants market split

2010

- Br: 6%
- Cl: 3%
- Inorganic: 16%
- Others: 19%
- Total: 940,000 MT

2020

- Br: 5%
- Cl: 3%
- Inorganic: 15%
- Others: 18%
- Total: 1,460,000 MT

2025

- Br: 5%
- Cl: 3%
- Inorganic: 15%
- Others: 18%
- Total: 1,790,000 MT

Source: ICL internal market survey
Can we imagine a world without Brominated Flame Retardants in critical uses?
Can we imagine a world without Brominated Flame Retardants in critical uses?

A steady increase in lethal fires and fire deaths?

Source: NFPA Survey of fire Department 1977-2018; UK National statistics
Can we imagine a world without Brominated Flame Retardants in critical uses?

Brominated Flame Retardants are essential for meeting fire safety standards. Let’s not make them the scapegoat of public chemophobia!
The truth on Brominated Flame Retardants

❖ All commercial BFRs are approved for unrestricted use regulatory wise;
   Polymeric FRs are registration exempted

❖ BFRs exhibit high cost/efficiency ratio in the vast majority of thermoplastic applications; in most applications, the required BFRs loading is lower compared to alternatives, for reaching same fire safety standards

❖ BFRs are solid, free-flow, easy to handle materials and exhibit excellent processing performances
The truth on Brominated Flame Retardants

- BFRs show excellent hydrolytic stability in thermal processes and end-uses, even under harsh conditions. BFRs are thermally stable in all thermoplastic transformation processes.

- BFRs maintain mechanical and rheological properties and have little impact on the initial polymer performances.

- Flame retarded polymers with BFRs are fully recyclable, keep properties resilience and meet circular economy requirements.
WEEE/ELV plastics part of a circular Economy
Limitations mechanical recycling due to legacy contaminants

Challenges for all recycling activities and all plastics:

• Collection and sorting system
• Substances of concern and change of POP limits
• Scale of Economy
• Constant changing of legislation/notification
• Demand of recyclate
• Low oil price compared to virgin polymers
Recycling technologies

Today material/mechanical recycling:
• Sorting and Mechanical processing

Physical recycling:
• Dissolution/purification: (separating additives & recycling polymer)

Chemical recycling:
• Depolymerisation into monomer
• Gasification/pyrolysis
• Solvolysis

Pre-sorting is nearly always needed! Improving sorting technologies – more efficient recycling!
Sorting technologies development

For all recycling technologies a certain sorting step plus purification is needed:

• Plastics with BFRs separation using density separation

• XRF-NIR technologies are used to separate bromine/halogens containing plastics

• Near and Mid Infra Red Sorting even becoming possible for black plastics

• Tomra technology, Steinert and others to be used to separate different polymer type

• Challenge for WEEE/ELV (automotive) plastics sorting efficiency >98% → quality issue
Innovative recycling technologies for Styrenics, ABS and HIPS containing BFRs

- Focus is on physical/chemical recycling methods that allow separation of BFRs and recycling in dedicated streams including destruction of POPs and bromine recovery.

- Certain projects of relevance
  - PolyStyreneLoop handling EPS with HBCD (insulation foam) waste
  - NONTOX handling WEEE, ELV, and CDW plastics with BFRs
  - PLAST2bCLEANED: using super heated solvent with Br and ATO recovery and focus on E&E and automotive plastics with BFRs
  - PWB precious metal recycling
  - SMX project, tracing BFRs for recycling (BSEF/NAFRA study)
NONTOX project : Successor of CCloseWEEE

A H2020 funded project:
Removal of BFRs and contaminants from WEEE/ELV/C&D plastics
Using CreaSolv® Technology and Extruclean
A potential process for scaling up to a Demoplant similar to PSLoop

Aim:
✓ Optimise and demonstrate the efficacy of different technologies to extract functional additives like ATO and bromine from the polymer
✓ Develop and improve techniques for efficient characterisation and pre-treatment of contaminated plastic waste
✓ Boost the market uptake of plastic recycling technologies and recycled products by a systematic evaluation of potential techniques to upgrade recyclates towards potential wider applications range
A H2020 funded project

WEEE/ELV recycling: recovery of ABS, HIPS, BFR and ATO

Started June 2018. Main partners: Elix Polymers, TNO, Coolrec, ICL, Campine

Using superheated solvent with physical removal of ATO and BFRs

Aim:

• Improved sorting of HIPS and ABS containing BFRs and ATO from other polystyrene and ABS fractions
• Dissolution of WEEE plastics in heated solvents
• Separation of additives to concentrate bromine flame retardants and antimony trioxide fractions for recycling
• Using technologies like active carbon, ultra-filtration with ceramic filters
• Energy efficient recovery of solvent and of polymer.
CONSORTIUM

Industry/SME

Recycling Company
- Coolrec

Engineering company
- JUCHHEIM

Bromine fraction

Antimony fraction

Research Institutes

Coordinator
- TNO
- Fraunhofer ICT
- GAÏKER

Polymer
- Plastics producer
- End user
- Chemical industry

Dissemination and exploitation
- Sustainable INNOVATIONS
PolyStyreneLoop Demoplant 3000 mt/y with Bromine recycling under construction next to ICL Terneuzen, start up Q2 2021

- PolyStyreneLoop handling EPS containing HBCD
- It includes XPS containing CFCs and falls under the Montreal Protocol plus for HBCD under the Basel Convention
- Planned in 2021 to handle 500 mtons of EPS/10 mtons XPS
- The HBCD sludge is treated in the BRU of IPT where the bromine is recovered and reused back into polymeric FR for X-EPS/XPS
- Official opening scheduled June 2021

3300 mtons of EPS/XPS waste /y
Budget 14 million euro
PS-foam and Bromine recycling; closing the loop

FROM DEMOLITION SITE TO RECOVERING BROMINE AND POLYSTYRENE

PS-foam is treated in the PolyStyreneLoop demonstration plant in Terneuzen, Netherlands

Demolition

Compaction

HBCD-sludge is being treated in the Bromine Recovery Unit, safely destructing HBCD

Bromine is recovered and can be used in new flame retardants (Poly-FR)

GPPS can be used for new XPS or X-EPS

From PS-foam new GPPS is made
PSLoop Demoplant next to ICL

Progress construction 2021 Start up June 2021
Technical readiness and CO₂/LCA

- Mechanical recycling has the lowest carbon footprint (CFP) and highest Technical Readiness (>TR8*)
- Dissolution processes are from TR 1 to TR 4 and <50% CFP of virgin plastics
- CreaSolv© Technology TR 4-6 a demoplant built by Unilever Indonesia at TR6-7
- PSLoop 3300 mtons/y demoplant and start up June2021 TR 6-8
- PLAST2bCLEANED: TR 2-4: very good carbon footprint close to mechanical recycling
- Chemical recycling depolymerisation TR 3-6 pre-sorting/process/polimerisation → LCA CO₂
- Feedstock recycling TR3-TR6 Carbon footprint versus R1 incineration

*TR1 = idea; TR2 – 3 = Lab scale; TR 4 = pilot scale; TR 5-7 = demoplant industrial environment; >TR8 = full proven technology
Conclusions

- Certain plastics need a fire safety function AND be part of a circular Economy
- For E&E/automotive plastics, means often polymers with FRs and other additives
- BFR’s are often the best *technical* solution
- E&E plastic waste – very diverse, relatively small volumes
- Complete sorting of waste - technically/economically not possible yet
- Substances of High Concern hinder mechanical recycling
- Emerging technologies are the option: dissolution processes and solvolysis
  - The SoC is isolated and converted into new resources being bromine
  - Real material efficiency, recovery of ALL materials at virgin quality
  - Good progress on the technical developments for new technologies
  - Scale-up possible and ongoing into direction of demo plants ➔ full scale plants
  - This year first PSLoop Demoplant to be started up and could lead to next ones
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