



Sustainable Flame Retardant for Polystyrene Foams

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TECHNICAL WORKSHOP- III (ALTERNATIVE FRs): March 1th 2024.

Agenda

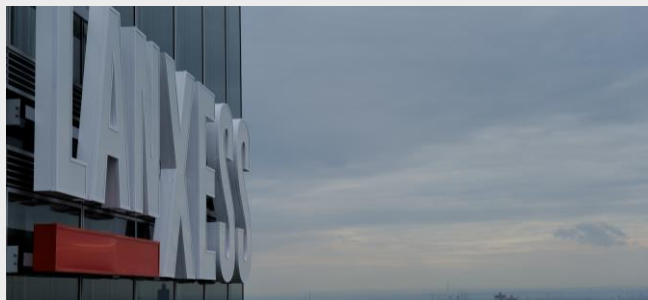
1. Introduction to LANXESS
2. Sustainable Fire Safety Solutions - Polymeric Flame Retardant for Polystyrene
3. Emerald Innovation® 3000: Performance
4. Conclusions

Emerald Innovation is a trademark of LANXESS Deutschland GmbH or one of its affiliates, registered in many countries of the world.

LANXESS – A globally operating specialty chemicals company



Specialty Chemicals Company



- Approximately 13,100 employees in 32 countries
- Global sales of EUR ~8.1 billion in 2022
- 60 sites worldwide

Business Unit Polymer Additives



- Combines all polymer additive activities of LANXESS
- Polymer additives include flame retardants, plasticizers, colorants, hydrolytic stabilizers as well as catalysts, stabilizers and chain extender for PU

Flame Retardants



- A leading global supplier of phosphorus and bromine based flame retardants: Amgard[®], Disflamoll[®], Emerald Innovation[®], Firemaster[®], Levagard[®], and etc
- Technical service worldwide

Flame Retardants for Insulating Materials for Building and Construction

Energy consumption

- Increasing interest in insulation materials is expected in order to reduce the energy consumptions of buildings.
- Polystyrene insulating materials are used as such because of their excellent insulation properties.



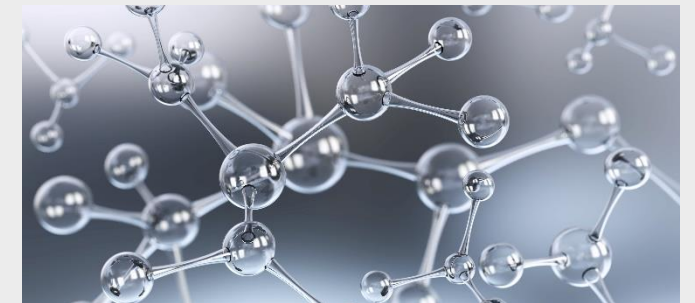
Fire safety

- Fire safety is one important characteristic, among other criteria, that must be fulfilled.
- Fire safety comprises fire standards with different criteria, such as flammability, flame spread and smoke density.



Flame retardants

- Flame retardants help polystyrene foam to meet the required different fire standards.
- Industry is looking for materials with improved toxicity and ecotoxicity profiles. This also implies additives such as flame retardants and is reflected in debates about certain chemicals.



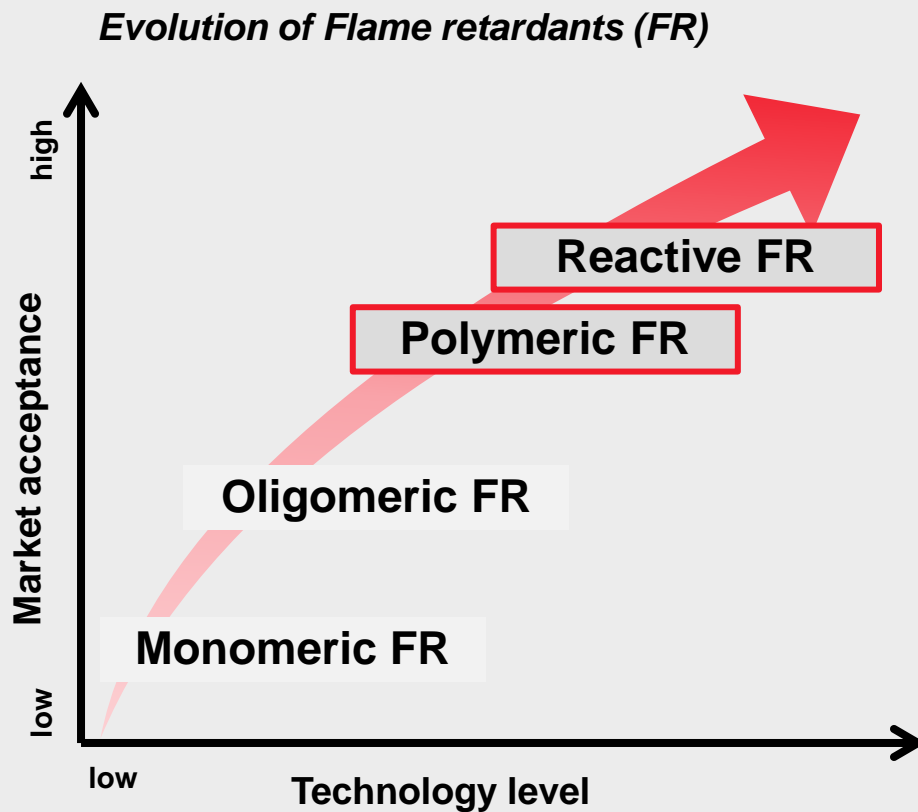
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LANXESS Drives Innovation & Technology Towards Sustainable Flame Retardant Solutions

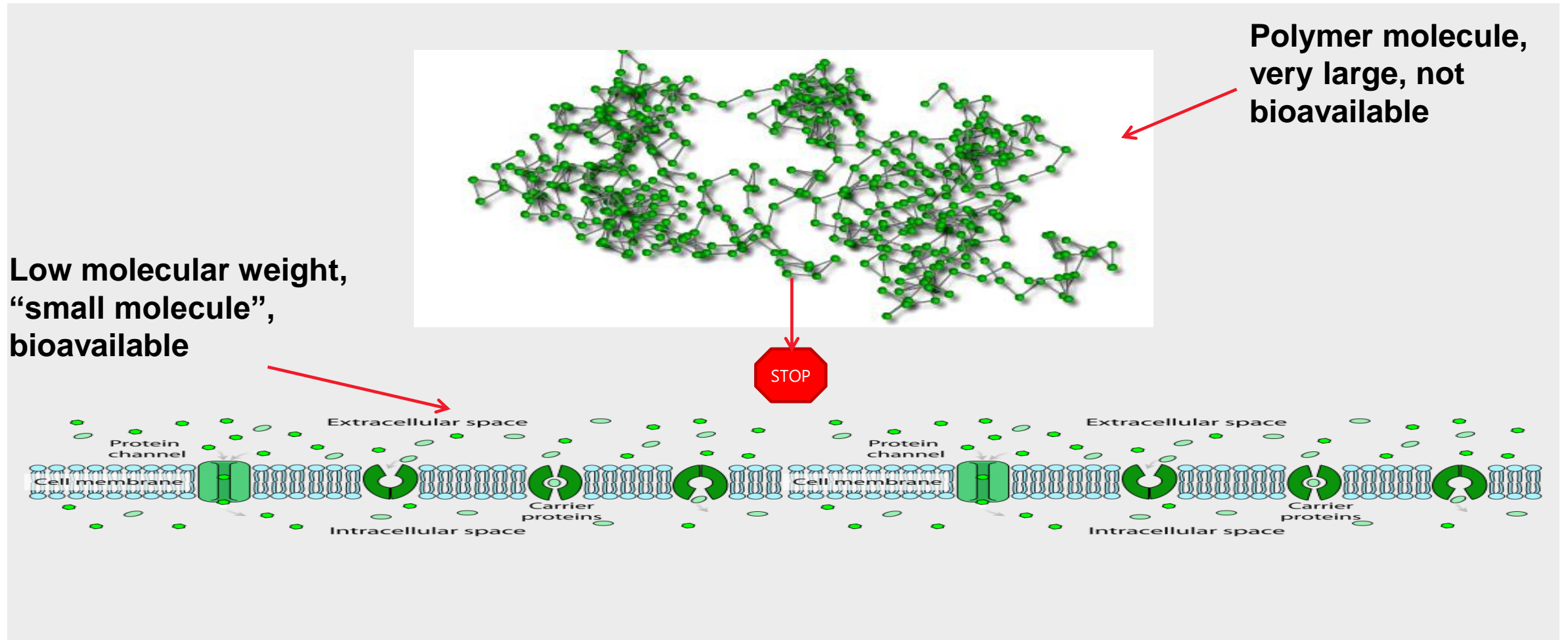
LANXESS strategic focus



Sustainable solutions

- Sustainable solutions are additives that are not bioavailable and not released to the environment.
- The development of reactive, oligomeric and polymeric flame retardants are our solutions for more sustainable flame retardants.
- Reactive flame retardants are incorporated into the polymer chain, where they are covalent-bonded to the polymer and are thereby retained.
- Oligomeric and polymeric additives offer higher migration resistance and are less volatile due to their high molecular weight and resulting immobility.

Bioavailability: Small vs. Polymeric Molecules

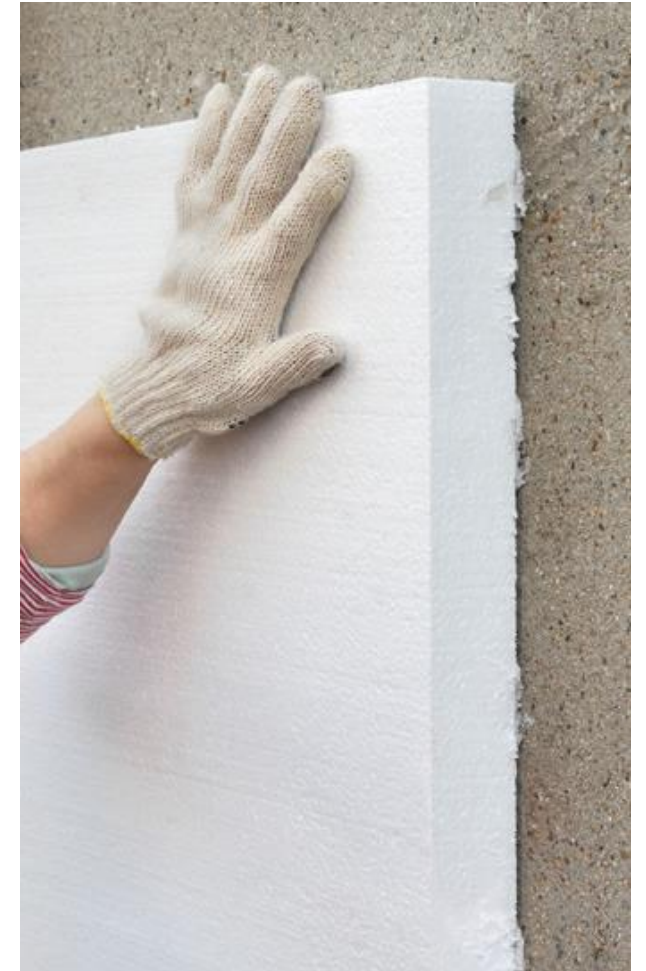


Flame Retardants for PS Insulating Materials in the Building and Construction Industry

Our sustainable answer to growing concerns

- Insulation is an efficient and easy way to save energy.
- EPS and XPS Polystyrene foams are effective and useful insulating materials in building and construction.
- Polystyrene foams are combustible and must be equipped with flame retardants.
- The traditionally used flame retardant additive HBCD (Hexabromocyclododecane) has been identified as a substance raising high concerns.
- The use of HBCD in PS foams is stopped worldwide.
- Sustainable solutions are additives that are not bioavailable and not released to the environment.
- Emerald Innovation[®] 3000 is our answer.

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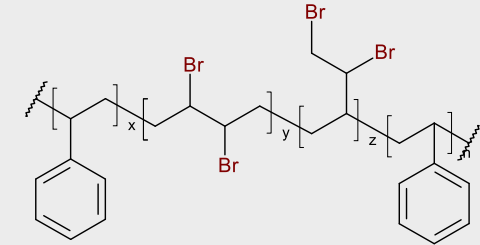


Polymeric Flame Retardant for Polystyrene Foams

Emerald Innovation[®] 3000

Description

- Brominated Styrene-Butadiene polymer
- High molecular weight > 100,000 g/mol
- Bromine content: 65%
- Product based on licensed technology from Dow Chemical Company



Application

- Flame retardant for polystyrene foam
- Expanded polystyrene (EPS) foam products
- Extruded polystyrene (XPS) foam products
- Building insulation

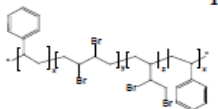


Properties

- Effective. Provides comparable fire performance in polystyrene foam to standard flame retardants at equivalent bromine levels
- Polymeric structure overcomes concerns compared to small molecule flame retardants

Sustainable Fire Safety Solutions: Hazard Summary of Emerald Innovation® 3000

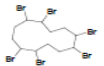
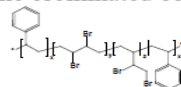
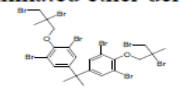
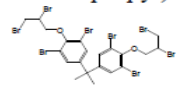
The hazard profile of the brominated SBS is anticipated to be safer than HBCD

Chemical	CASRN	Human Health Effects											Aquatic Toxicity		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization ¹	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Butadiene styrene brominated copolymer ² 	1195978-93-8	L	L	L	L	L	L	L ^d	L		M	L	L	L	VH	L

VL = Very Low hazard **L** = Low hazard **M** = Moderate hazard **H** = High hazard **VH** = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from predictive models and/or professional judgment.

- Due to its large size, lack of low molecular weight (MW) components, and un-reactive functional groups, human health and ecotoxicity hazard for this polymer are measured or predicted to be low.
- The exposure potential to the butadiene styrene brominated copolymer is expected to be lower than HBCD because it is a large polymer and is unlikely to be released from the polystyrene.

Hazard Summary of Flame Retardants For PS Insulation.

Chemical For full chemical name and relevant trade names see the hazard profiles in Section 4.8	CASRN	Human Health Effects											Aquatic Toxicity		Environmental Fate		
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization ¹	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation	
Hexabromocyclododecane (HBCD) 	25637-99-4; 3194-55-6	L	M	L	M	H	M	M	L			VL	VL	VH	VH	H	VH
Butadiene styrene brominated copolymer ² 	1195978-93-8	L	L	L	L	L	L	L ^d	L			M	L	L	L	VH	L
TBBPA-bis brominated ether derivative ³ 	97416-84-7	L ^s	M ^s	M ^s	M ^s	M ^s	L	M ^s	L ^s			L	L	L	L	H	H
TBBPA bis(2,3-dibromopropyl) ether ³ 	21850-44-2	L	M	M	M	M	L	M	L			L	L	L	L	VH	H

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from predictive models and/or professional judgment.

Emerald Innovation[®] 3000 is anticipated to be safer than HBCD and the two other alternatives

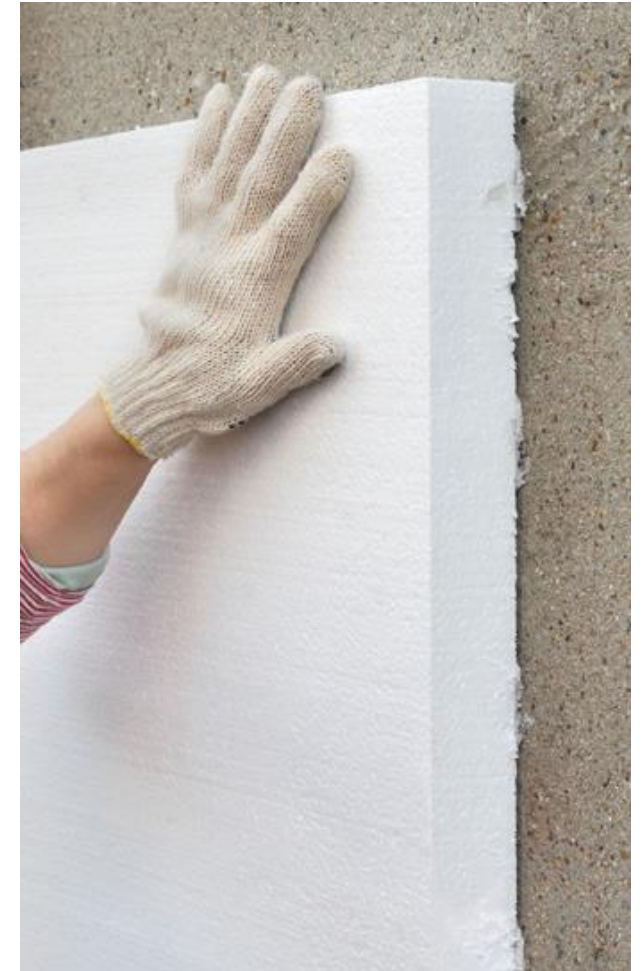
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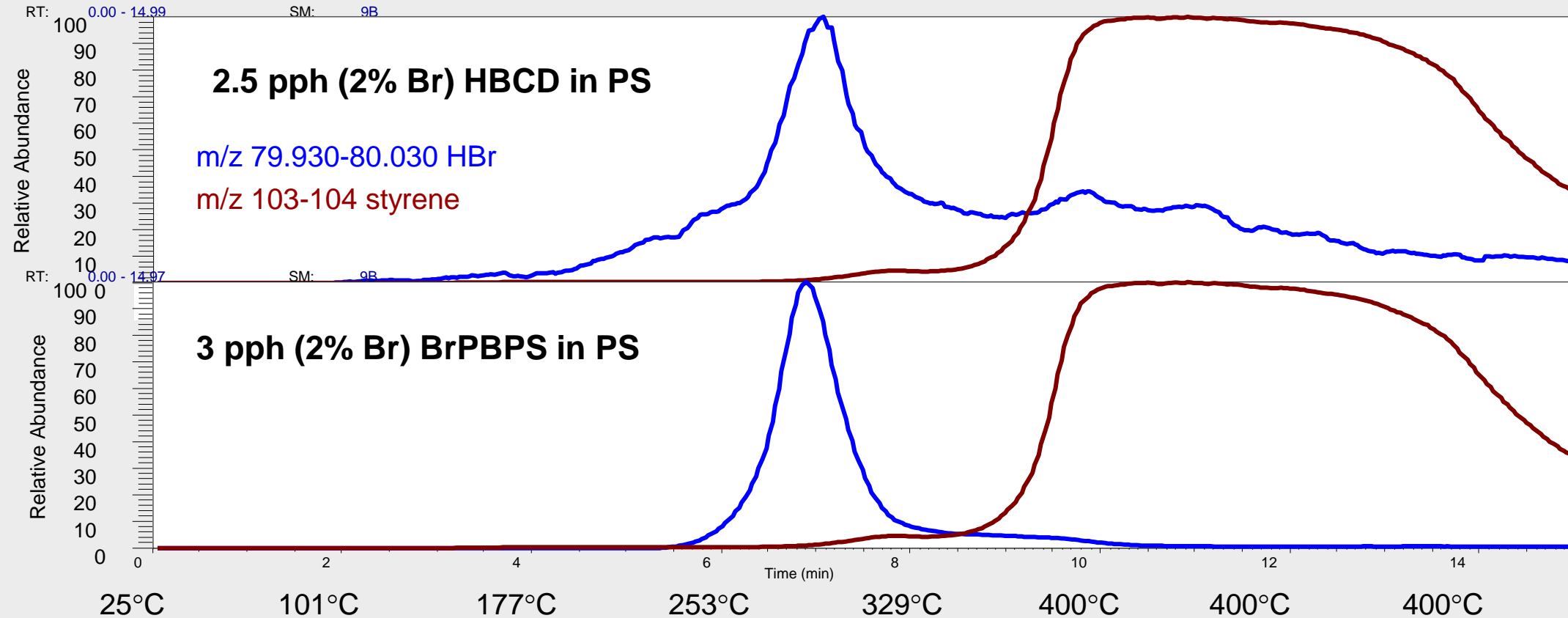
Our sustainable answer to growing concerns

- A similar temperature profile of Br release when the flame retardant decomposes.
- Good thermal stability.
- Flammability testing showed similar behavior at equal bromine level for all building and construction worldwide mandatory fire tests.
- Proven commercially viable solution for all PS insulation material.



Temperature-Dependent Release of Active FR Species

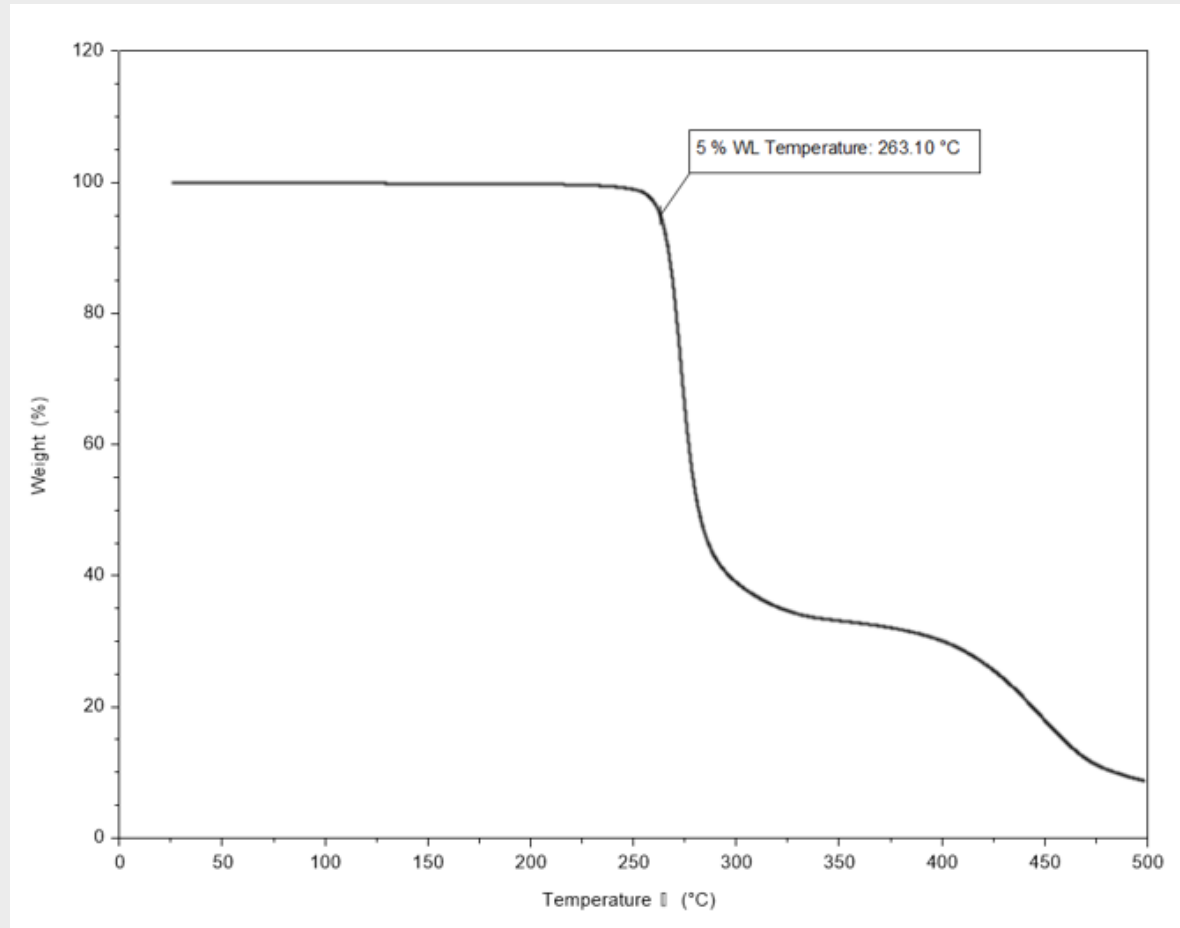
Direct Insertion Probe-Mass Spec.: 25 to 400°C at 38°C/min of FR/PS blends



HBr evolution is similar to HBCD

Source: The Dow Chemical Company

Thermal stability of Emerald Innovation[®] 3000

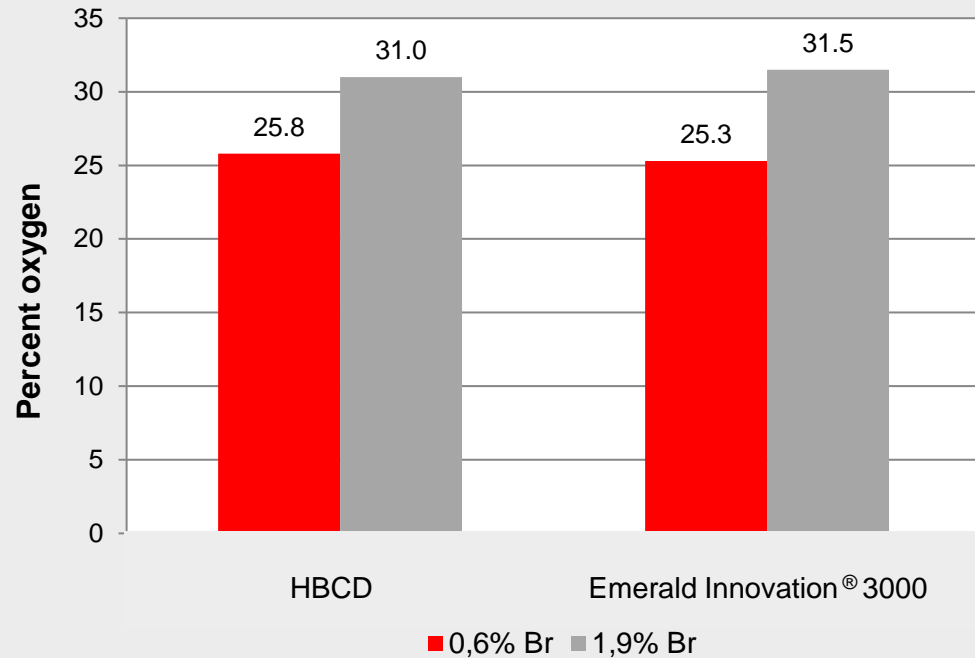


10°C/min in N₂

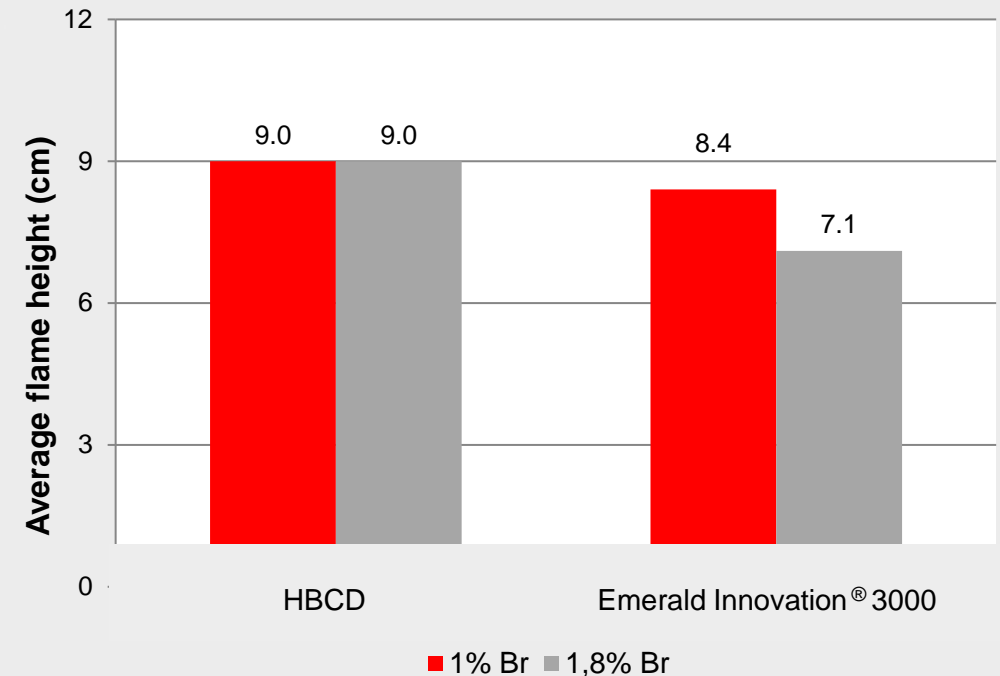
Fire Testing Performance in XPS Foams

HBCD and Emerald Innovation® 3000

LOI (lowest oxygen index)



Small burner test



Emerald Innovation® 3000 is an efficient flame retardant for polystyrene

Production Trial: XPS with Emerald Innovation® 3000



XPS production line



XPS finished product

Fire Standard: GB 8624-2012



Classification Criteria for class C

- SBI test for building materials (GB/T 20284)
 - Total Heat Release (THR):
THR600s - total heat release of 600s $\leq 15\text{MJ}$
 - Fire Growth Rate (FIGRA)
FIGRA0.4MJ - the fire growth rate index when the released heat of sample burning reaches at 0.4 MJ $\leq 250\text{W/s}$
- Small burner test (GB/T 8626) for combustible building material

Fire Standard: GB 8624-2012

Jiangsu Product Quality Testing & Inspection Institute

Test results of an Oriental Yuhong XPS foam sample flame retarded with 2,5% Emerald Innovation® 3000

Standard GB8624-2012 Burning Behavior Class C				
Test method	Property	Class Criteria	Test result	Passed
GB/T 20284	THR600	≤ 15 MJ	9 MJ	✓
	FIGRA0.4MJ	≤ 250 W/s	197 W/s	✓
GB/T 8626	Flame height 60 s	≤ 150 mm	55	✓
	Flaming droplets within 60s	No flaming droplets igniting filter paper	No flaming droplets	✓

The XPS foam meets the GB8624-2012 C classification

Conclusions

- ✓ Emerald Innovation[®] 3000 is confirmed by US EPA to have an improved environmental profile.
- ✓ Emerald Innovation[®] 3000 provides the same fire safety as the legacy products meeting all the global existing flammability requirements.
- ✓ Emerald Innovation[®] 3000 is suitable for all different processes.
- ✓ Emerald Innovation[®] 3000 containing polystyrene insulation material provides similar high-quality insulating materials.
- ✓ Emerald Innovation[®] 3000 is an economically viable solution.



Thank you for your attention!

Disclaimer

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Unless specified to the contrary, the values given have been established on standardized test specimens at room temperature. The figures should be regarded as guide values only and not as binding minimum values. Kindly note that the results refer exclusively to the specimens tested. Under certain conditions, the test results established can be affected to a considerable extent by the processing conditions and manufacturing process.

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LANXESS Deutschland GmbH, D-50569 Köln

Business Unit Polymer Additives

LANXESS

Energizing Chemistry