

Sustainable Flame Retardant for Polyisocyanurate Insulation Foam

Imran Waseem

Technical Manager Flame Retardants (Europe)

Imran.waseem@icl-group.com

ICL-IP

Koningin Wilhelminaplein 30, 1062 KR, Amsterdam, The Netherlands



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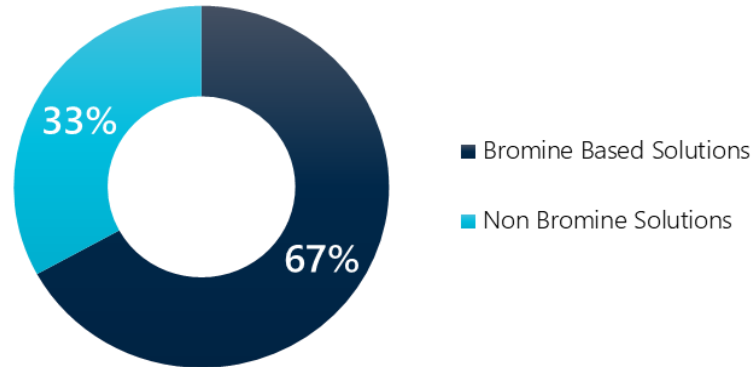
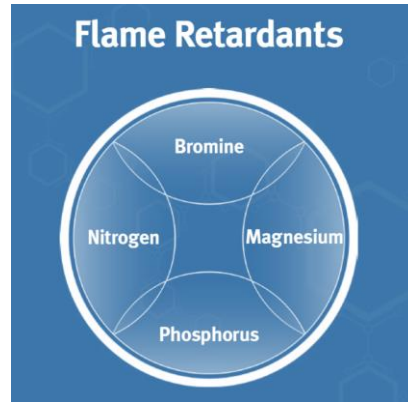
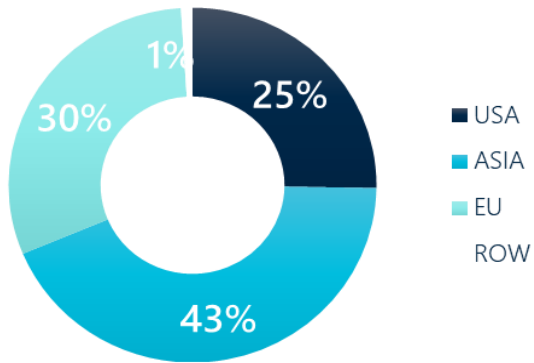
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ICL and ICL-IP brief overview



ICL and ICL-IP brief overview

ICL Industrial Products



Phosphorous Solutions Leader

>100 years of experience with Phosphorous chemistry
Broad PU application development capabilities

Diverse End-Use Markets

Diversified product portfolio and strong customer base

Engineering, R&D, Innovation

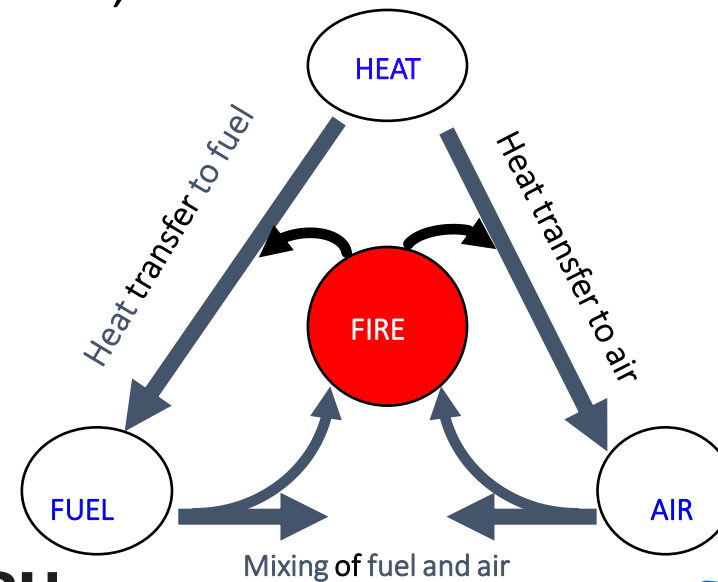
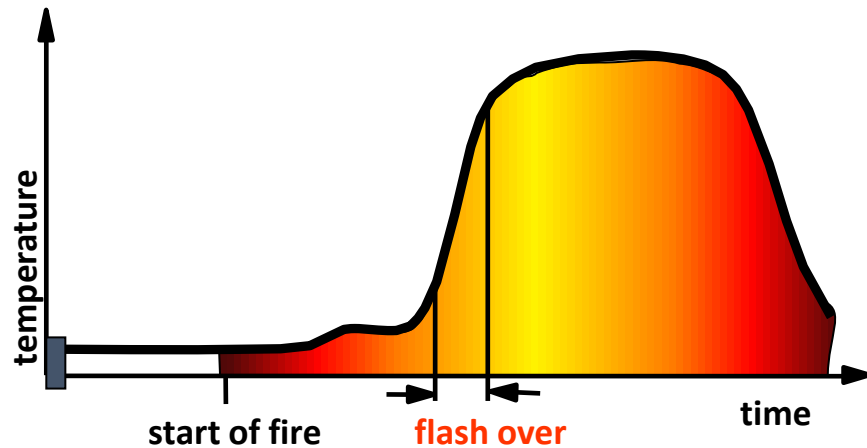
Vast engineering experience, three R&D centers, innovation supported by AI & collaboration with external partners

Growth Fundamentals

Solid demand supported by long term market trends (EV, digitalization, electronics, other)

Need for flame retardants

- Safeguarding the life and property by preventing ignition of insulation
- FRs interfere in the combustion cycle of polymer either by radical scavenging or by creating a thermal barrier
- In addition to physical, mechanical and thermal requirements PIR boards also need to meet regional flammability requirements
- DIN 4102 Class B2, EN 13501 Class E, ASTM E-84, UL-790 and UL-263 etc. need to be fulfilled in Europe and USA



TCPP in PIR Boards

- Tris (2-chloroisopropyl) phosphate (TCPP) is an efficient, robust, low viscosity, hydrolytically stable and all-round flame retardant for PU foam for 30 + years
- Most of TCPP (around 80 %) is used in rigid foam applications
- TCPP work via gas phase by quenching and replacing high energy free radicals produced within the system, particularly; H, OH and O that are needed to sustain flaming. It fulfills most technical and flammability requirements for PIR foam
- TCPP has gone through various HSE risk assessments in previous years. A recent two years long study by National Toxicology Program (NTP) USA concluded potential carcinogenic activity of TCPP
- Based on this study the hazard classification was changed to category 2 and H351 (suspected carcinogenic). This may lead to additional obligations under other regulations

VeriQuel R-100 as TCPP replacement

- Due to regulatory challenges faced by TCPP, it is necessary to implement new sustainable flame retardants as replacement
- To replace TCPP in PIR foams ICL developed a halogen-free, phosphorous rich and reactive flame retardant
- The flame retardant contains hydroxyl group which can react with the isocyanate component in the formulation hence it becomes part of PIR chain

Typical properties of VeriQuel R-100 are as follows:

Appearance	Clear, transparent liquid
Color APHA	<50
Hydroxyl Number (mg KOH/g)	270
Acid Number (mg KOH/g)	<6.0
Viscosity @ 25°C (cps)	17
Water Content (wt%)	<0.20
Specific Gravity @ 25°C	1.16

Lab scale comparison with TCPP

- Following generic formulation was used to compare VeriQuel R100 with TCPP in PIR continuous insulation board for roofing foam

Ingredients	pbw	
	TCPP	VeriQuel R100
Aromatic Polyester Polyol	100	100
Flame Retardants	12.0	12.0
Surfactant	2.5	2.5
Amine catalyst - 1	4	4
Amine catalyst - 2	0.9	0.9
Amine catalyst - 3	0.3	0.3
Water	0.5	0.5
Pentane	20.5	20.5
NCO Index	300	300

- Polymeric MDI was used to react with the formulation blend shared above. Mixing weight ratio of Polymeric MDI to the formulation blend is calculated at 300 Index. Due to reactive nature (-OH value) of VeriQuel R100 higher amount of MDI used in formulation

Lab scale comparison with TCPP

The following tables show the comparative results of VeriQuel R-100 with TCPP

Reactivity Profile		
	TCPP	VeriQuel R100
Cream time (sec)	16	19
Gel time (sec)	35	26
Rise time (sec)	50	55
Tack-free time (sec)	65	75
Density (Kg/m3)	31	31

Dimensional Stability @ 95% R.H. and 70°C		
	TCPP	VeriQuel R100
1 Day (%)	3.30	0.80
7 Day (%)	1.88	5.26
14 Day (%)	1.07	2.25

Fire Performance Test		
	TCPP	VeriQuel R100
Cone Calorimeter Test		
Total Heat Release (MJ/m ²)	6	6
Total Smoke (m ² /m ²)	118	90
DIN 4102**		
Flame Height	B2	B2
	10.2	9.0

**Per DIN 4102 test, flame height less than 15 cm is rated as B2 class.

Further evaluation of VeriQuel R100 in PIR board manufacturing has shown that VeriQuel R100 based formulation meets requirements per ASTM-E84, UL-790, UL-263 and FM Calorimeter test for roofing application

Evaluation in PIR Boardstock

Discontinuous Board Evaluation:

Formulation shown in earlier slide was used to make discontinuous boards. Foam samples from these boards were used in various testings related to PIR Insulation boards



	TCP	VeriQuel R100
Compressive Strength (psi)	25	33
Closed cell content (%)	97.3	96.1
R value at 24 °C (ft ² .hr.°F/Btu.in)	6.8	7.0
Cone Calorimeter Test		
Total Heat Release (MJ/m ²)	3.2	3.9
Total Smoke (m ² / m ²)	118	98
Hot Plate test		
Weight loss (%)	35.0	36.5
Thickness retention (%)*	+1.0	-2.0
DIN 4102**	B2	B2

* Positive thickness retention means expansion of the foam

**Per DIN 4102 test, flame height less than 15 cm is rated as B2 class

Evaluation in PIR Boardstock

Discontinuous Board Evaluation:

The following table shows comparison of the test results for full scale Fire tests carried out externally.

	TCPP	VeriQuel R100
ASTM E-84 test (4" thick foam panel)	Class 1	Class 1
SBI Test *		
FIGRA (W/s)	3572	4242
THR (MJ)	7.5	8.5
SMOGRA (m ² /s ²)	1238	1133
TSP (m ²)	180	159



SBI test



ASTM E-84 test



*SBI test is carried out on foam panels without any type of facer on it

Conclusions

- VeriQuel R100 provides a viable alternative to traditionally used TCPP for PIR foams produced by continuous or discontinues processes
- When compared with TCPP, VeriQuel R100 provides similar reactivity profile and dimensional stability though minor adjustments in catalyst and surfactant package might be needed.
- VeriQuel R-100 showed comparable fire performances with TCPP in cone calorimeter and other small-scale tests like DIN4102 B2 as well as large-scale fire tests e.g. E-84 (tunnel test) and SBI
- The foam samples made with VeriQuel R-100 showed good thermal, physical and mechanical properties

Due to these reasons, it can be considered as technically viable and sustainable alternative to TCPP for insulation foam boards. Being reactive in nature, it becomes the part of PIR chains and there are negligible chances of emission or leaching into the environment.

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Thanks a lot

Questions ?