

Emerald
Innovation™ 1000

Great Lakes
SOLUTIONS 

For a Better Tomorrow

A Chemtura Business

EMERALD INNOVATION™ 1000

*VERSATILE, EFFICIENT, SUSTAINABLE FLAME RETARDANT SOLUTION FOR IGNITION
RESISTANT POLYOLEFINS*

EMERALD INNOVATION™ 1000

- The polymeric structure of Emerald Innovation™ 1000 makes it not readily bioavailable¹, thus addressing the environmental concerns that threaten the sustainability of many current products
- Emerald Innovation™ 1000 is an efficient, sustainable replacement for decabromodiphenyl oxide (DE-83R™) and decabromodiphenyl ethane (Firemaster® 2100R), requiring minimal, if any reformulation
- The high bromine content of Emerald Innovation™ 1000 makes it more efficient than other alternatives to DE-83R™ and Firemaster® 2100R
- Emerald Innovation™ 1000 offers an excellent balance of physical properties, flammability performance and process ability
- Emerald Innovation™ 1000 cost-effectively provides UL-94 V-0 performance in Polyolefin based formulations

1 49 Federal Register 46066 (Nov. 11, 1984), 40 CFR 723.250

EMERALD INNOVATION™ 1000 TYPICAL PROPERTIES

EMERALD INNOVATION™ 1000 IS A POLYMERIC BROMINATED FLAME RETARDANT DESIGNED FOR USE IN A BROAD SPECTRUM OF APPLICATIONS

Property	Emerald Innovation™ 1000
Appearance	Off-white powder
Bromine, %	78
Average particle size, (µm)	5-6
5% wt loss, °C (Thermogravimetric Analysis (@ 10 °C/min under N ₂))	410°C

High bromine content with excellent thermal stability

EMERALD INNOVATION™ 1000 IN HDPE*

Property	Emerald Innovation™ 1000	FR-1	FR-2	FR-4	FR-5
FR Load, %	19.0	19.0	19.0	21.0	22.3
ATO %	6.3	6.3	6.3	6.3	6.3
UL-94, at 1.6 mm	V-0	V-0	V-0	V-0	V-0
Gardner Multi-Axial Impact, J	17.8	17.1	17.7	1.5	15.2
Elongation at Yield, %	8.5	10.1	8.7	5.6	6.9
Whiteness Index, CIE	49.7	55.8	49.5	61.3	46.6

*LYONDELLBASELL PETROTHENE R590005 (0.8MFI)

LABEL DESCRIPTION

- FR-1 DECABROMODIPHENYL OXIDE (DE-83R™)
- FR-2 BIS (PENTABROMOPHENYL) ETHANE (FIREMASTER® 2100R)
- FR-4 POLY(PENTABROMOBENZYL) ACRYLATE
- FR-5 ETHYLENEBIS(TETRABROMOPHTHALIMIDE)

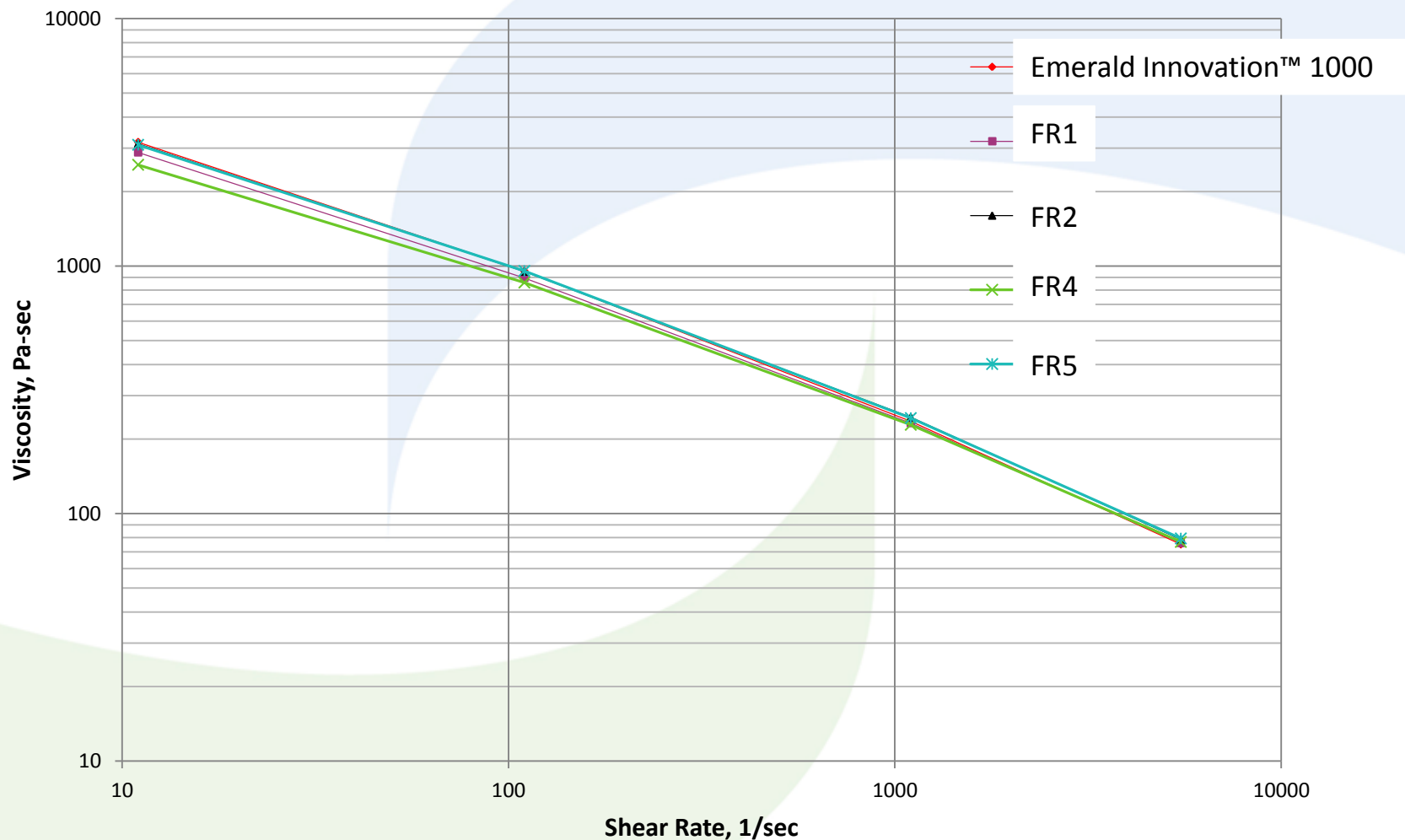
Emerald Innovation™ 1000 offers an excellent balance of efficiency, physical properties and flammability performance in HDPE formulations



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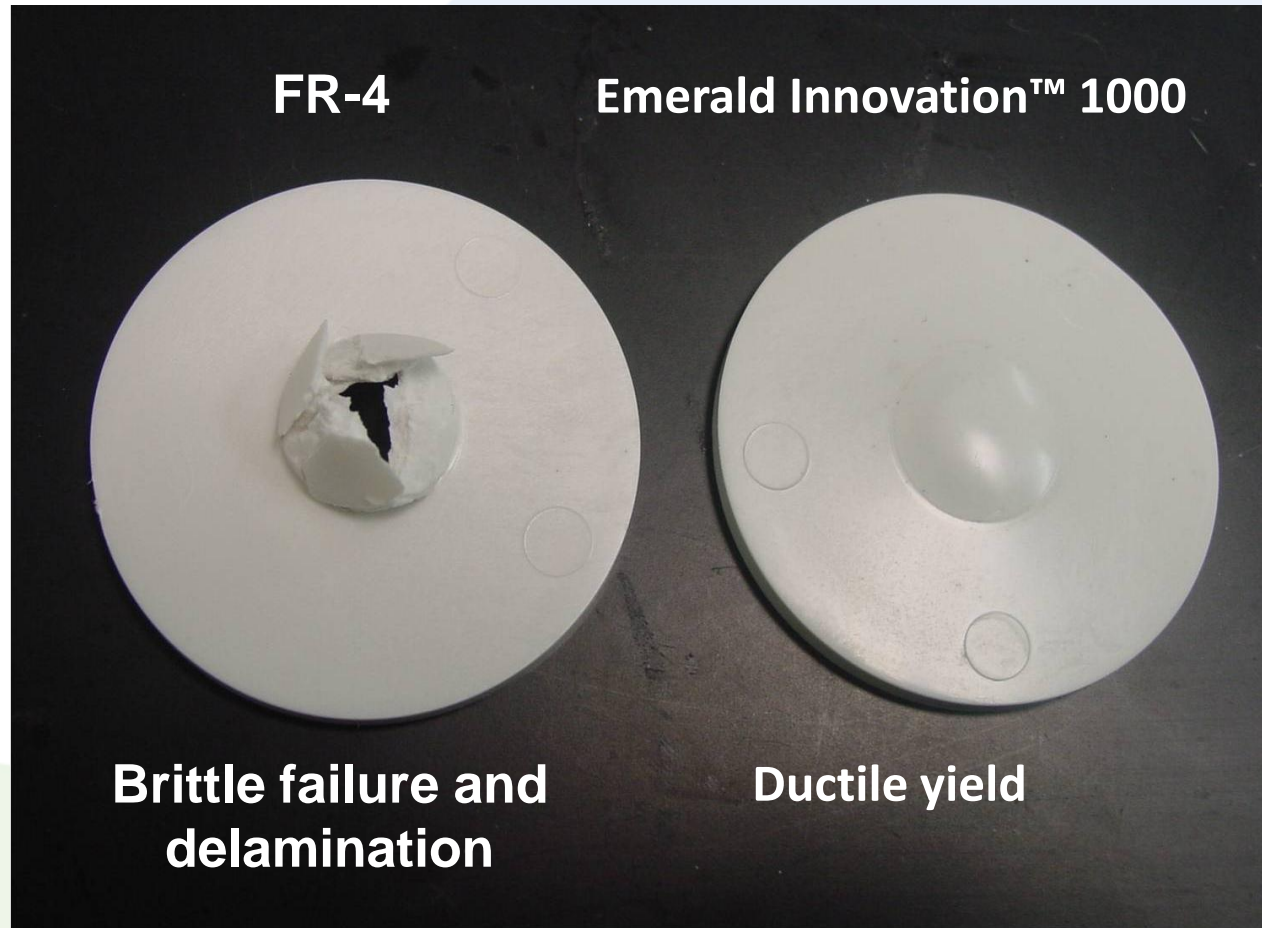
COMPARISON OF MELT VISCOSITIES

CAPILLARY RHEOLOGY OF HDPE FORMULATION CONTAINING EMERALD INNOVATION™ 1000



Comparable viscosities in HDPE formulations indicate that Emerald Innovation™ 1000 will process under similar conditions as current flame retardant formulations

GARDENER MULTI-AXIAL IMPACT* OF HDPE WITH EMERALD INNOVATION™ 1000 vs. FR-4



** Tested at room temperature*

Superior compatibility of Emerald Innovation™ 1000 with HDPE results in significantly better toughness vs. FR-4 for demanding applications

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EMERALD INNOVATION™ 1000 PERFORMANCE IN TALC-FILLED PP

	Emerald Innovation™ 1000	FR 1	FR 2
Flame retardant %	21	21	21
ATO %	7	7	7
Talc %	20	20	20
UL-94, 1.6 mm	V-0	V-0	V-0
Melt flow index, g/10min 230°C/2.16kg	11.4	12.8	11.9
Notched Izod Impact, J/m	33.6	35.8	41.1
Elongation at Yield %	2.29	2.42	2.38

- Emerald Innovation™ 1000 is an effective replacement for FR 1 or FR 2 for talc-filled PP
- Excellent performance also demonstrated in PP homopolymer and copolymer

LABEL DESCRIPTION

FR-1 DECABROMODIPHENYL OXIDE (DE-83R™)

FR-2 BIS (PENTABROMOPHENYL) ETHANE (FIREMASTER® 2100R)



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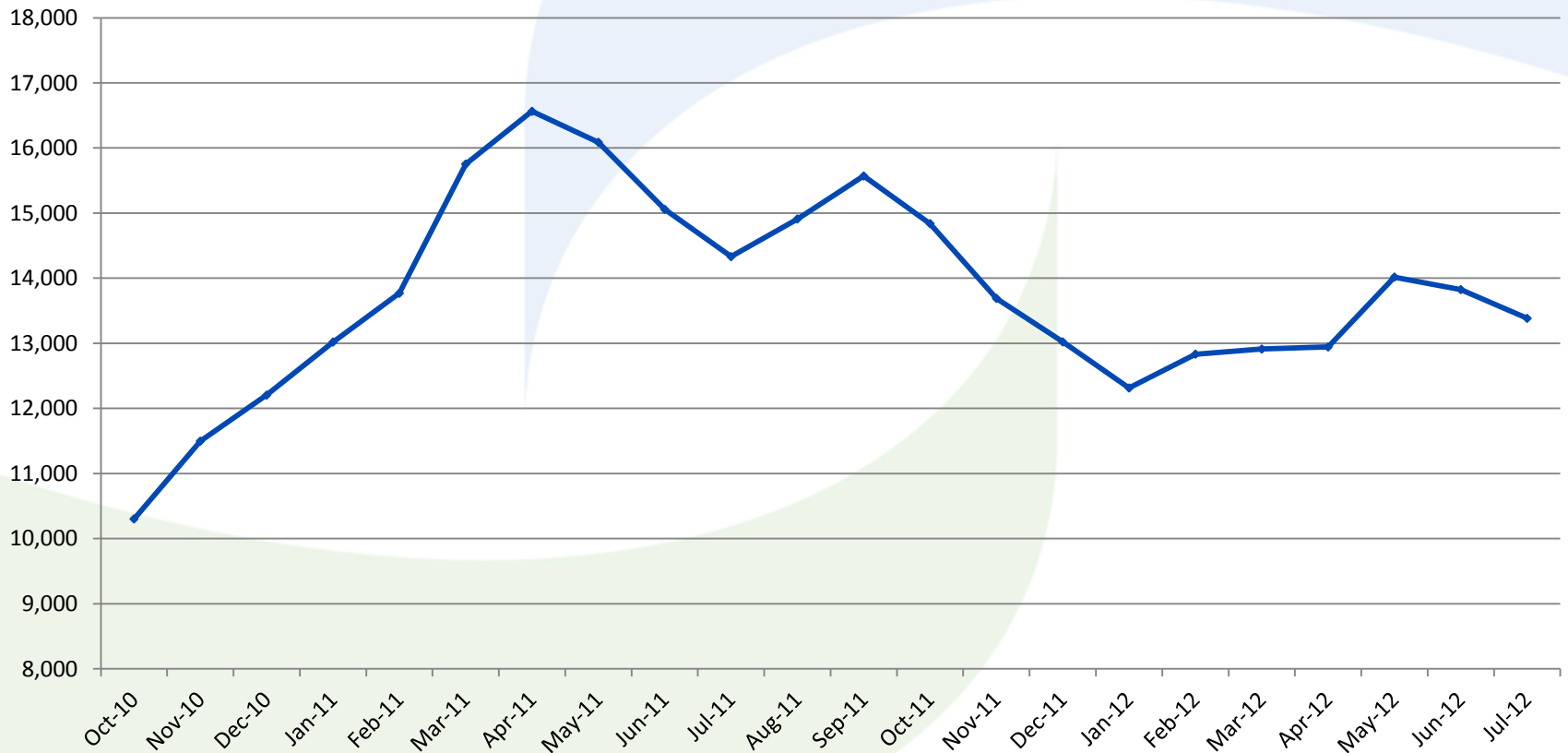
REDUCTION/OPTIMIZATION OF ANTIMONY TRIOXIDE USE

WHY THE NEED FOR ATO ALTERNATIVES?

- Antimony trioxide (ATO) is typically used as a synergist with aromatic brominated flame retardants (BFR) in plastics
- ATO functions via the formation of flame quenching antimony tri-halides through a gas-phase mechanism. It is not absolutely necessary, but makes the system more cost effective
- Alternatives to ATO are sought due to:
 - I. Cost volatility of antimony metal
 - II. Higher cost of ATO

COST VOLATILITY OF ANTIMONY METAL

Monthly average LMB price of Sb metal in \$/MT



METAL SALTS

20% TALC FILLED POLYPROPYLENE (PROFAX 6323)

	1	2	3	4	6
Emerald Innovation 1000, %	21	21	21	21	21
ATO TMS, %	7	2	2	2	2
Zn Borate, %	-	7	3.5	3.5	3.5
Ca/Zn molybdate, %	-	-	3.5	-	-
Zn molybdate, %	-	-	-	3.5	-
Zn phosphate, %	-	-	-	-	3.5
UL-94 @ 1.6 mm	V-0	V-0	V-0	V-0	V-0
Avg. Burn Time	2.9	3.0	3.4	2.6	3.5

ZB 467

Kemgard 981

Kemgard 911A

Kemgard 911B

= Zn Borate

= Zn phosphate

= Ca/Zn molybdate

= Zn molybdate

Significant reduction in ATO content
Potential cost reduction
Reduced smoke emissions?



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MODIFIED CLAYS

UNFILLED PP HOMOPOLYMER PROFAX 6323

Emerald Innovation 1000, %	30	27	27	27	27
ATO, %	10	4.25	4.0	4.0	3.0
Modified clay* %	-	4.25	4.0	4.5	4.5
Avg. Burn time, sec		4.2/1.8	4.2/1.8	1.8/3.0	3.4/4.2
Total Burn time, sec	39	30	30	24	38
UL-94 @1.6 mm	V-0	V-0	V-0	V-0	V-0

*Modified clay:
quaternary ammonium and siloxane treated
montmorillonite clay.
Charex 44PSS
Amcol/Nanocor

*Total FR loading can be reduced
ATO loading significantly reduced
Reduced smoke emissions possible?*



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MODIFIED CLAYS

UNFILLED PP COPOLYMER SG702 18MFI

Emerald Innovation 1000, %	26	26	26	26	26	26
ATO, %	8.7	7.7	6.7	5.7	4.7	3.7
Modified clay*, %	-	1	2	3	3	4
Avg. Burn time, sec	0/1.5	1.8/0.6	1.4/2.2	0.8/1	2/0.8	2/5.2
Total Burn time, sec	15	12	18	9	18	36
UL-94 @ 1.6 mm	V-0	V-0	V-0	V-0	V-0	V-0
MFI, g/10min	20.0	21.2	20.7	21.0	22.08	19.19

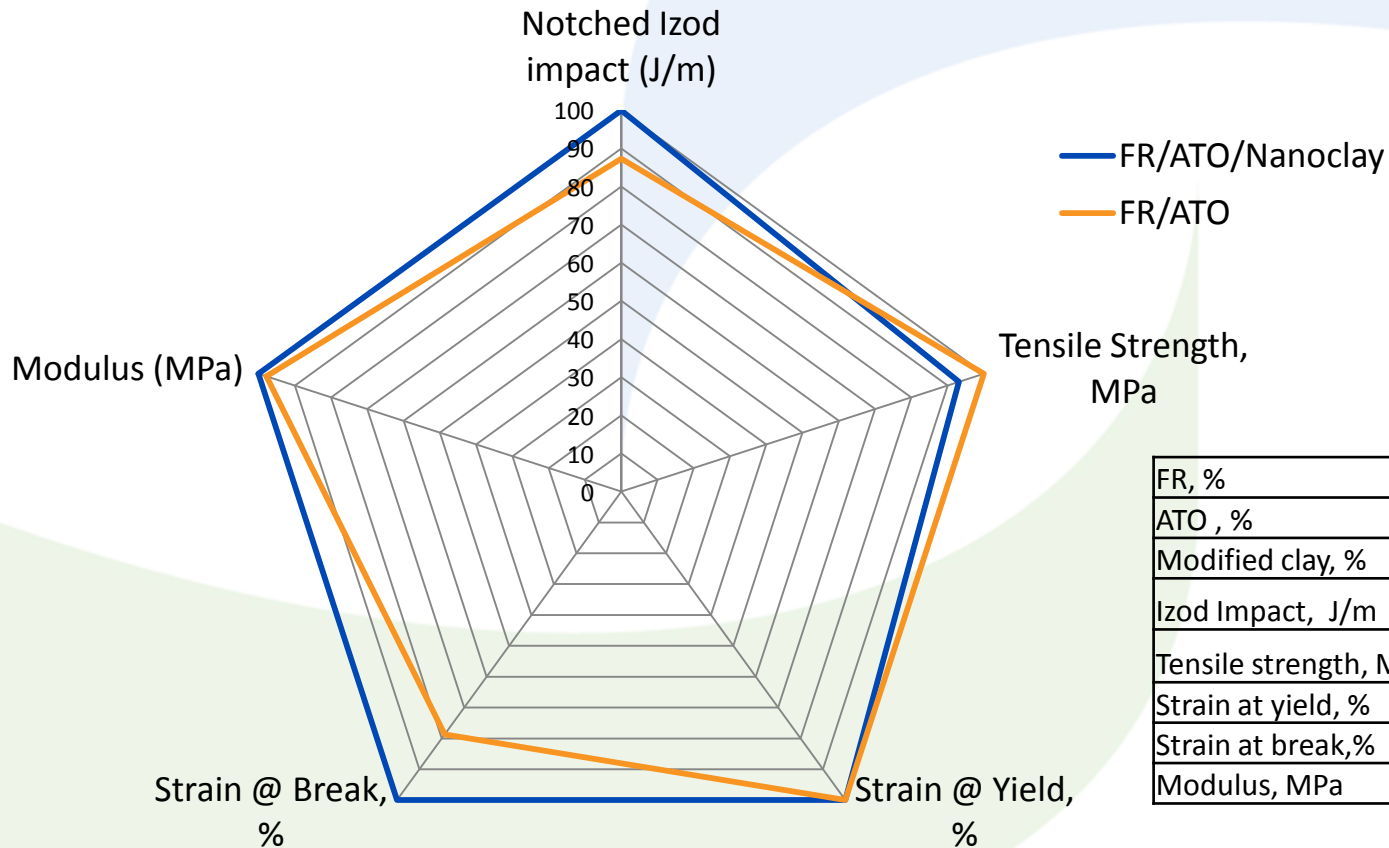
*Modified clay effectively replaces up to about 50% ATO
Cost saving potential
Minimum effect on flow*

*Modified clay:
quaternary ammonium and siloxane
treated montmorillonite clay.
Charex 44PSS
Amcol/Nanocor



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MECHANICAL PROPERTIES OF UNFILLED PP COPOLYMER CONTAINING MODIFIED CLAY



FR, %	26	26
ATO, %	8.7	6.7
Modified clay, %		2
Izod Impact, J/m	118	135.2
Tensile strength, MPa	18.2	17.0
Strain at yield, %	2.5	2.5
Strain at break, %	4.8	6.1
Modulus, MPa	1588.0	1623.4

Mechanical properties slightly better

CONCLUSIONS

- Performance comparisons for Emerald Innovation™ 1000 in polyolefins demonstrate comparable efficiency at similar load levels over DE-83R™ and Firemaster® 2100R
- Emerald Innovation™ 1000 provides higher multi-axial impact strength than other polymeric brominated flame retardants tested
- Similar compounding and molding conditions used with DE-83R™ and Firemaster® 2100R
- Evaluation of metal salts and modified clays show great potential to significantly reduce the use of high-cost ATO in polyolefins whilst maintaining flammability performance

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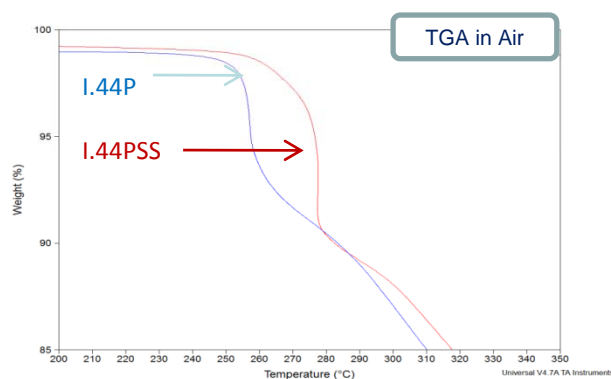
Charex® New Generation Organoclay Products for the use of Flame Retardant Additives

General Description:

Charex 44PSS is a newly developed bentonite based organoclay for the use as flame retardant additives. In addition to traditional inner gallery cation exchange modification, Charex 44PSS uses organo-modified siloxane chemistry as edge treatment agent to reduced moisture adsorption and enhance dispersion in polymer resins.

Product Data*:

Surface Modifier	Di-methyl, di-hydrogenated tallow ammonium/Siloxane
Appearance	Off white free flowing powder
Surface Modifier (%)	34-36 wt%
Bulk Density	250-300 kg/m ³
Particle Size (Mean)	14-18 Micron
Specific Gravity	1.7 g/cm ³
X-ray (d ₀₀₁)	22-25 Å
Product Package**	20-kg paper bag or 400-kg bulk bag



* These data are for reference use only. Certificate of Analysis will come with each commercial shipment.

High Performance:

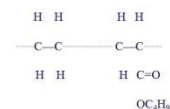
With enhanced ion exchange and cleaning process, Charex 44PSS has significant heat stability comparing with standard I.44P organoclay. TGA (air) results show more than 20°C higher decomposition temperature.

Charex MBEBA:

Charex MBEBA is a new generation of clay masterbatch in the nanoMax® family based on EBA, a copolymer of ethylene and butyl acrylate. Comparing to EVA, EBA has enhanced heat stability and better moisture resistance.

Charex MBEBA contains 50 wt% Charex 44PSS and is manufactured with proprietary processing technology. 44PSS was fully dispersed in EBA. This grade is suitable for new LSOH FR compound development with enhanced char forming and wet electrical stability. It can be used in EVA, EMA, PE, TPE or blends. Typical loading level is 4-8% with 2-4 clay level.

EBA (ethylene butyl acrylate)



Our TDS P801, P802 and P804 provide formulation and processing references.