TEGOMER ® and TEGOPREN ® for Polyamide

Evonik Operations GmbH | Interface & Performance

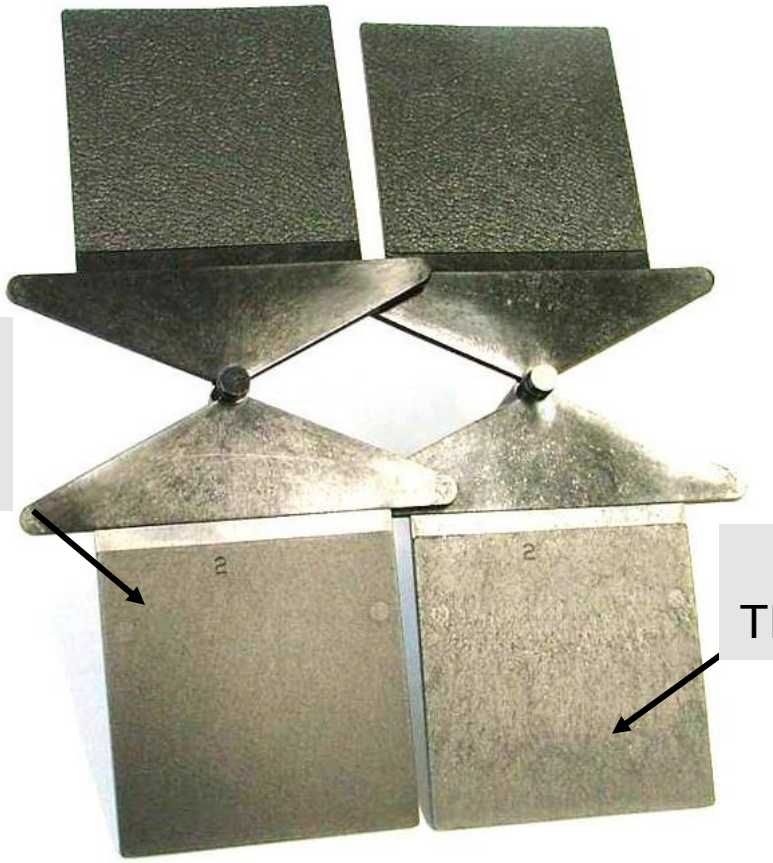
EVONIK
Leading Beyond Chemistry

Embedding of Glass Fibres

TEGOMER® in PA/GF

Improvement of Surface Appearance

Addition of 1-2% TEGOMER® H-Si 6441 P or TEGOMER®AntiScratch L



without TEGOMER®

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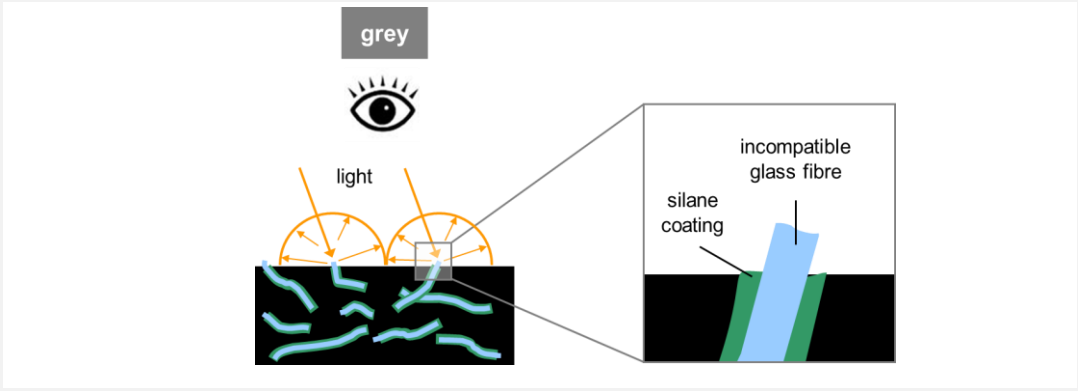
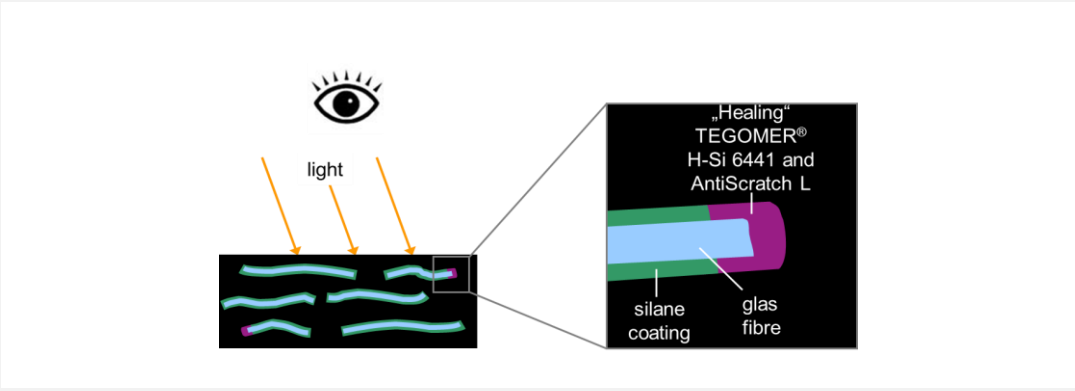
Embedding of Glass Fibres
Mode of Action for TEGOMER® in PA/GF



- Silane coated glass fibres break during processing may appear
- Broken, uncoated fibre ends are incompatible to polymer matrix
- Fibre ends cause scattering & reflection of light

➔**Greyish color of compound instead of black surface**



- Less damages of coated glass fibres during processing
- Uncoated ends of damaged fibre are „healed“ by additive
- Light is absorbed by black dyes or pigments
- No reflection or scattering

➔**Deep black color as desired by the customer**

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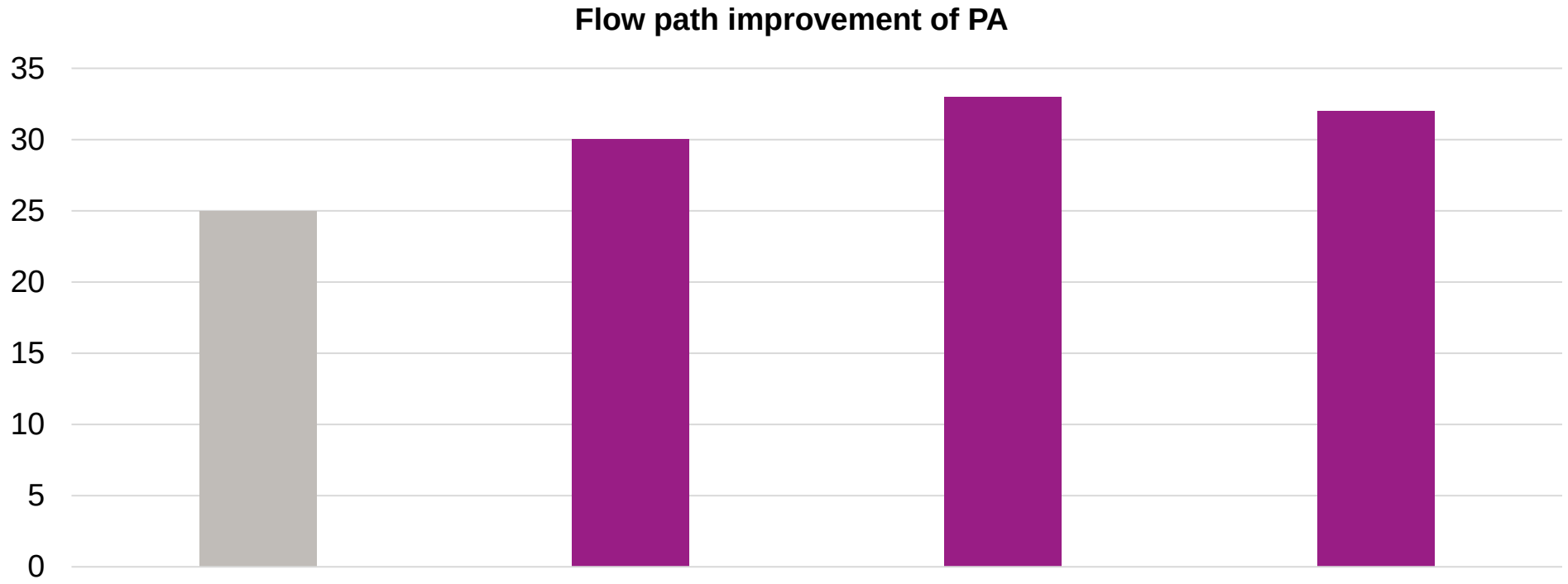
Improvement of Melt Flow
TEGOMER® in PA



Using TEGOMER® AntiScratch L or TEGOMER® H-Si 6441P increases the length of the flow path about ~30%

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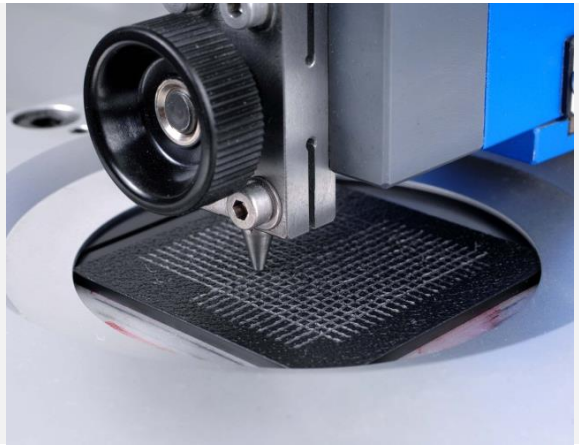
Improvement of Mold Filling
TEGOMER® in PA

- **Improved mold filling**
- **No flow lines**
- **Improved mold release**
- **Ensures dimension stability**

TEGOMER® will help reduce cycling times by improved processing parameters resulting in perfectly shaped parts with excellent surfaces.

Improved Scratch Resistance
TEGOMER® in PA and PA/GF

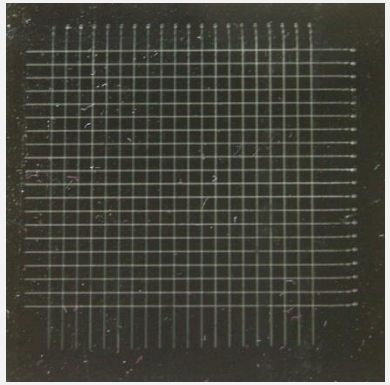
Erichsen Scratch Tester 430 P



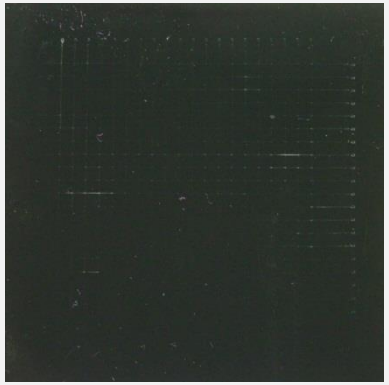
30 N Force

PA, PA/GF

without Additive



with 2% Additive

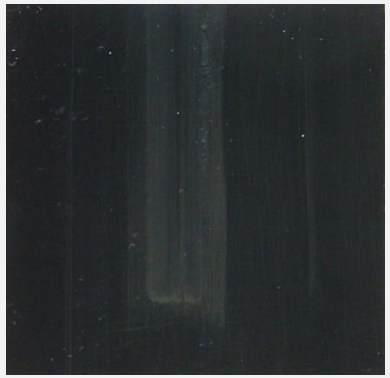


Crockmaster Model 670

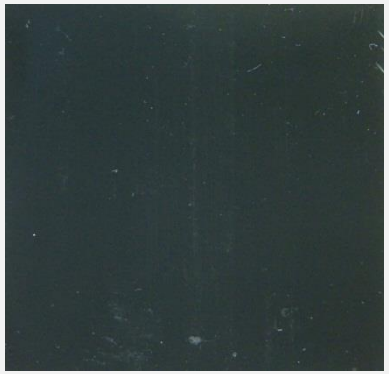
1000 stokes for PA

9 N Force

without Additive



with 2% Additive



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TEGOMER® yields Outstanding Properties in Performance
TEGOMER® vs. Silicone Oil

	TEGOMER® H-Si 6441P	TEGOMER® AntiScratch L	Silicone oil Masterbatch
Scratch resistancy 1d / Rt.	++	++	+
Scratch resistancy 7d / 70°C	++	++	O
Mar resistance	++	++	+
Melt flow	++	+	O
Migration	NO	NO	YES
Gloss for non filled PA	++	+	O
Use in molding operations	+	+	-
Demolding	+	+	+
Coloration / Jetness	O	O	-
Dosing in %	0.5-2.0	0.5 – 2.0	2*

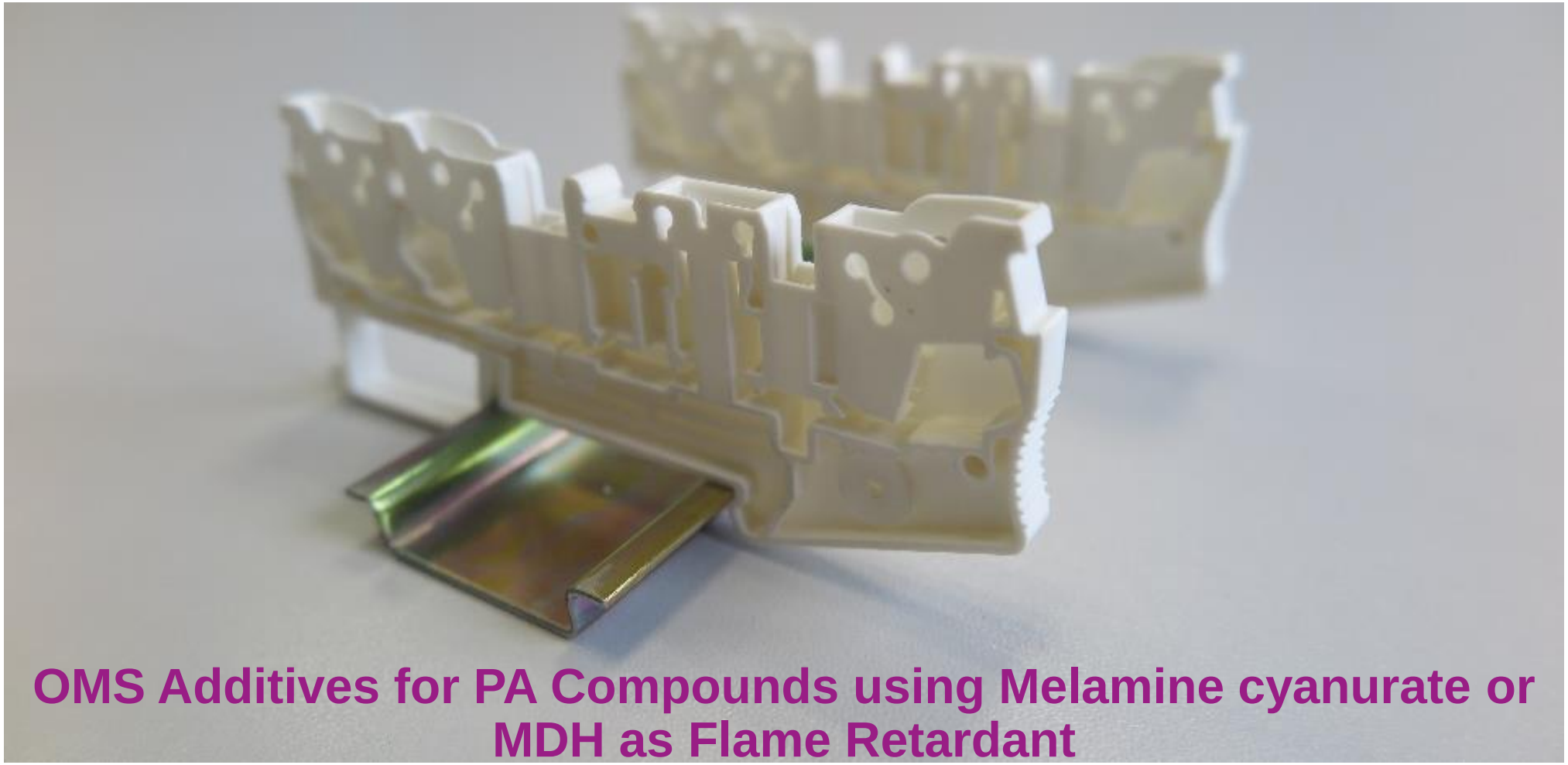
+ first recommendation O second recommendation *Higher dosage results in defects

Improved Scratch Resistance
TEGOMER® AntiScratch Additives for Various Polymers

	TEGOMER® AntiScratch 100	TEGOMER® H-Si 6441P	TEGOMER® M-Si 2650	TEGOMER® AntiScratch L
PP/Talc	+	O		O
PP/TPO/Talc	+	O		O
TPO/TPE	O	+	O	
TPU		+		
PA		+	+	+
PA/GF		+		+
PMMA/ABS		+	O	+
PC/ABS		O	+	O
PET		+	+	O

+ first recommendation O second recommendation

Flame Retardants in PA



Choice of Right Flame Retardant…

…is depending on

- material
- plastics processing
- application
- specification of fire resistance

- **Halogens** emit toxic decompositions products e.g. HCl
- Phosphorous has disadvantages regarding the plastics processing due to its **corrosive** behavior
- **Nitrogen flame retardants** like melamine cyanurate are an alternative for engineering polymers
- **Inorganic flame retardants** are limited by the processing temperatures of the polymer

Flame Retardants used in PA

HFFR System		Dosage of FR in PA 6	Dosage of FR in PA 66
red-P	Red Phosphorous		
MC	Melamine Cyanurate	8 %	12 %
MPP	Melamine Polyphosphate	30 %	25 %
MeHp	Metal Hypophosphite	15 %	25 %
MDH	Magnesium Hydroxide	55 %	55 %
AlO(OH)	Boehmite	55 %	55 %
Mel-Me-P	Melamine Poly Aluminum and Zinc Phosphates		

Performance break-down when using 55% MDH in PA

- Reduced flow behavior
- Tensile strength: PA 6: ~75MPa, PA66: ~65MPa, benchmark: 85MPa
- Elongation at Break: PA 6: ~4 %, PA66: ~3 %, benchmark: 6-12%
- Surface looks marble-like

Improvements when using OMS in-situ during compounding or for surface treatment

- Improved processing due to reduced amperage draw when additive is used during compounding
- Improved flow behavior and improved demolding during injection molding
- Surface looks not longer marble-like but homogeneous and smooth
- Burning time is reduced due to a better dispersion of flame retardant

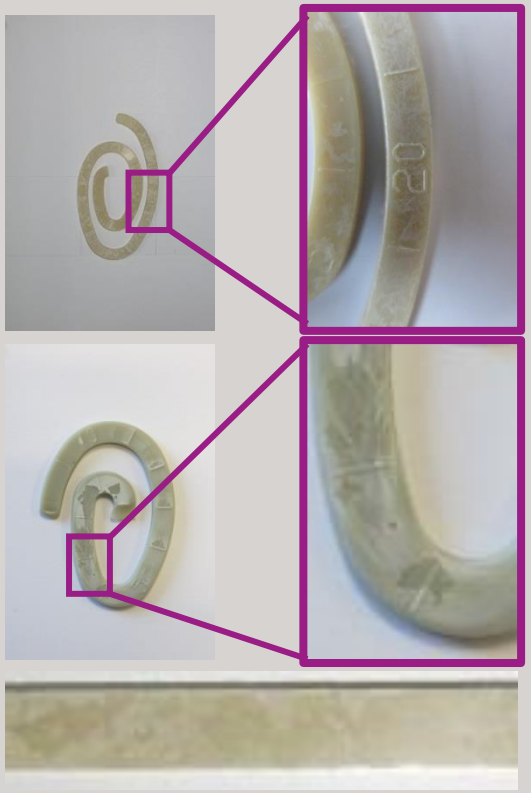
Influence of Different Flame Retardants on PA

	halogen-containing FR	P-containing FR	N-containing FR	MDH
Acting in phase	gaseous	condensation/ gaseous	condensation/ gaseous	condensation/ gaseous
Working principle	chemical	chemical / physical	chemical / physical	physical
Efficiency	+	+	+	-
Compatibility	+	0	0	0
Side effects	-	+	+	+
Price/performance	0	0	0	0
PRO	Low dosage necessary	synergy when combining		cheap
CON	toxic smoke corrosive gas	corrosivity	e.g. legislations do not allow a high MC content	High loading necessary → reduced flow behavior
Potential of OMS	▪ Improved flow behavior → better surface appearance ▪ Hydrophobicity → better electrical properties (CTI) ▪ Improved char formation → lower burning time ▪ Compatibilizing effect improves mechanical properties like elongation and impact strength			

Property Improvement of High Filled Polyamide
TEGOMER® H-Si 6441P in PA 66

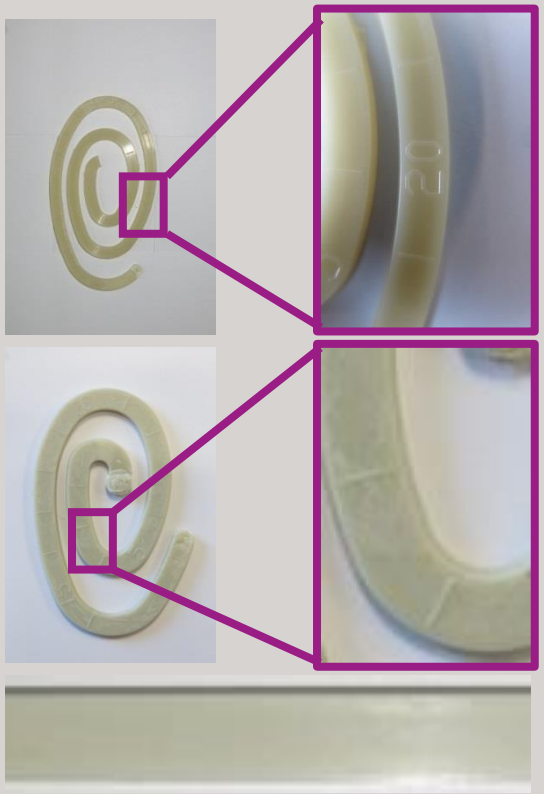
PA66 + 55 % MDH

PA66 + 40 % alumiasilica filler



Without additive

- Marble-like surface
- Poor flow behavior
- Poor impact strength
- Low elongation at break



+ 2% TEGOMER® H-Si 6441P

- Smooth surface
- Good flow behavior
- Improved impact strength
- Increased elongation at break

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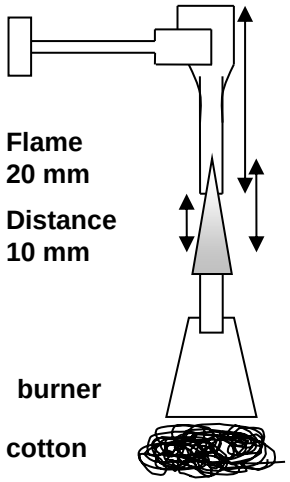
Evaluation of Flame Resistance according to UL 94

Conditioning of 5 specimen, which are each evaluated in the following way

after 1st flame application (10 sec)
count afterflame time (t_1)

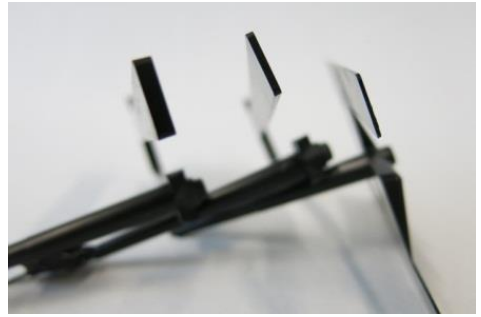
after 2nd flame application (10 sec)
count afterflame time (t_2) and afterglow time (t_3)

Determine classification according to the values from the table



Specimen dimensions:

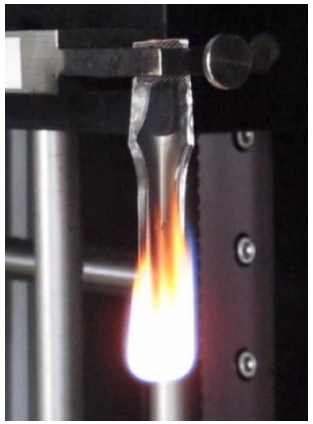
Length:	125 ± 5 mm
Width:	13 ± 0.5 mm
Thickness:	0.025…13 mm



Material Classification according to UL 94 V (Vertical Burning Test)	V-0	V-1	V-2
Afterflame time for each individual specimen (t_1 or t_2)	≤10s	≤30s	≤30s
Total afterflame time for any condition set (t_1 + t_2)	≤50s	≤250s	≤250s
Afterflame plus afterglow time for each individual specimen after second flame application (t_2 + t_3)	≤30s	≤60s	≤60s
Afterflame or afterglow of any specimen up to the holding clamp	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

Improved Flame Resistance by using a Surface Treatment
Polyamide with 8% Melamine Cyanurate (MC)

		PA + 8% MC	PA + 8% MC+ 1% TEGOPREN® 6875
Processing	Current [%]	65	57
	Pressure [bar]	25	21
Tensile Test	Tensile modulus [MPa]	3350	3360
	Tensile strength [MPa]	69	68
	Elongation at break [%]	32	31
Flame Resistance according to UL 94	Afterflame time for each individual specimen (t1 or t2) [s]	10	5
	Total afterflame time for any condition set (t1 + t2) [s]	28	14
	Afterflame + afterglow time for each individual specimen after second flame application (t2 + t3) [s]	12	2
	UL 94 classification	V-1	V-0



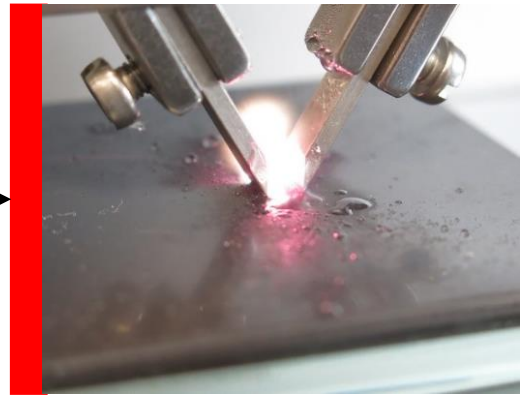
The surface treatment of melamine cyanurate results in better processing conditions and an improved flame retardance.

CTI Method for Polyamide E&E Application

50 drops are applied to specimen at a specific voltage

no flame or overcurrent after 50 drops (low voltage)

CTI, determination of erosion depth
CTI= 600V–2,1 mm



arc appears, test failed (high voltage)

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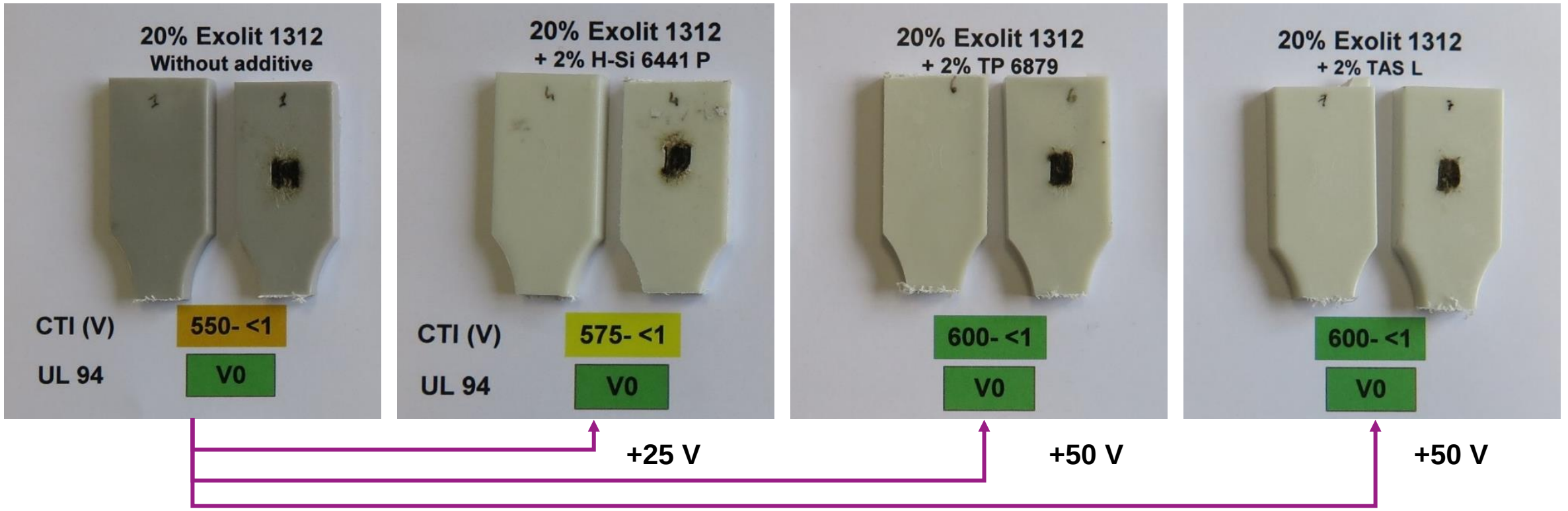
Improvement of CTI without loosing UL 94 V-0

PA 6 + 30% GF + 20% Exolit 1312 (OMS in-situ)



2% TEGOMER® H-Si 6441 P, 2% TEGOPREN® 6879 or 2% TEGOMER® AntiScratch L

improve CTI of a flame retardant and glass fibre reinforced polyamide 6 by 25V / 50V without loosing UL 94!

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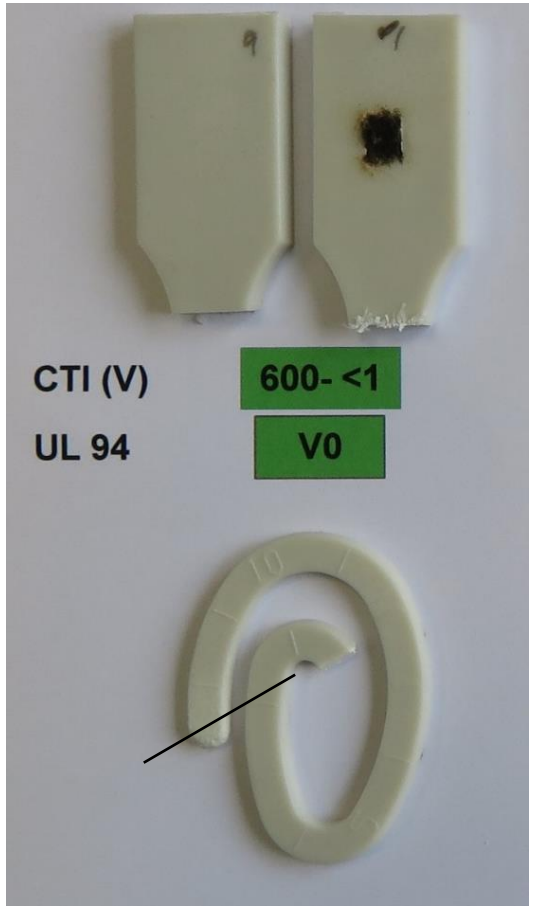
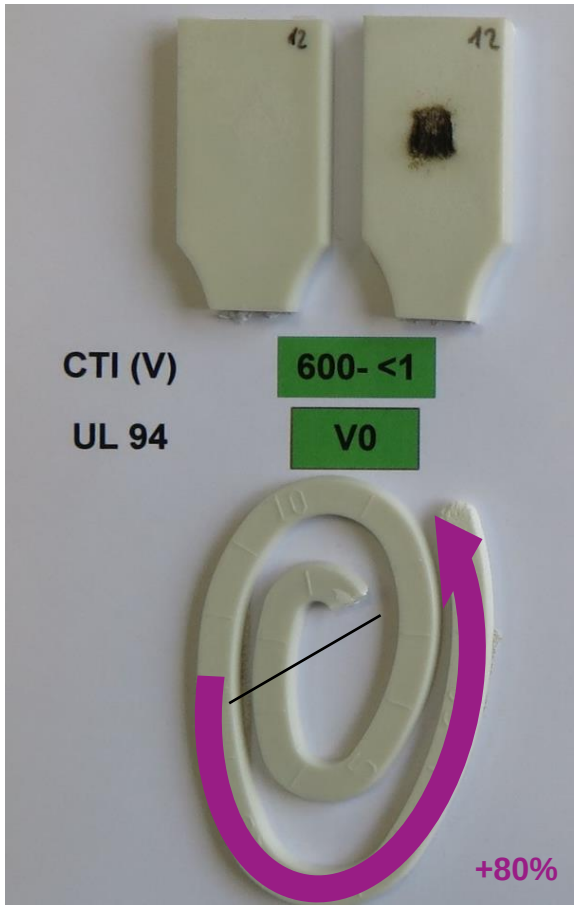
Improvement of flow behavior without loosing CTI and UL 94 V-0

PA 6.6 + 30% GF + 20% Exolit 1312





2% TEGOMER® H-Si 6441 P

improves flow behavior of a flame retardant and glass fiber reinforced polyamide 6.6 by 80% without loosing UL 94 and CTI!

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Designed for Colorizing Technical Polymers:
TEGOMER® P 121 / P 122

→ Mass dyeing of Polyamide Fibers

TEGOMER® P 121 / 122

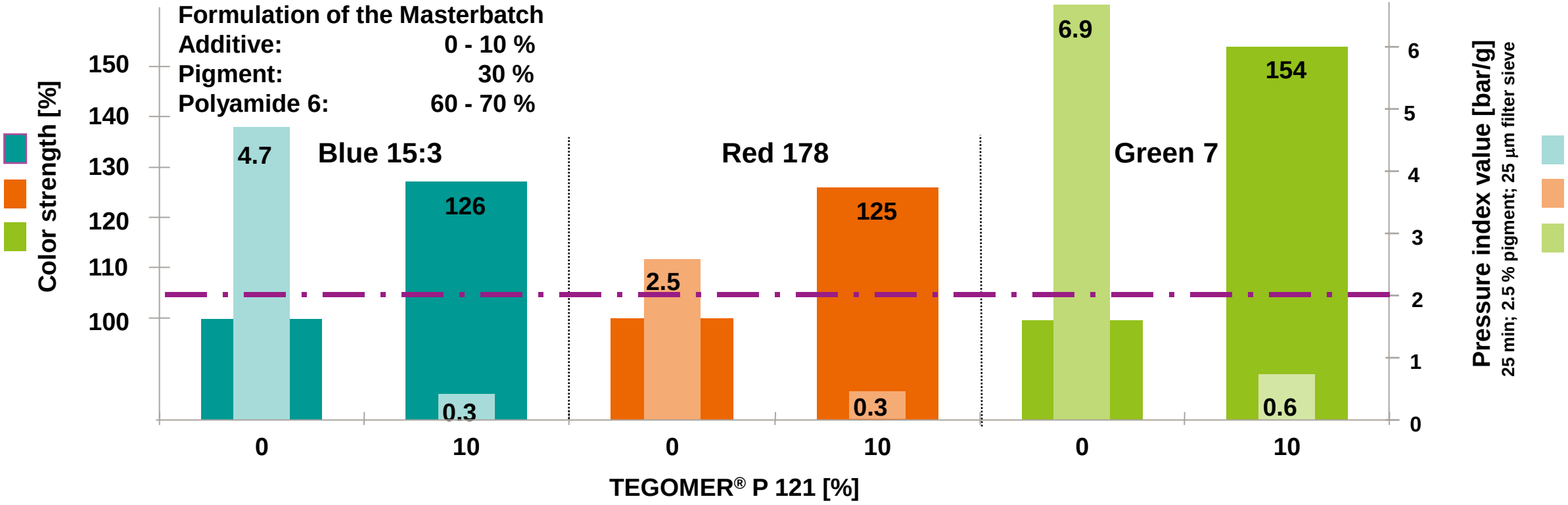
- Improved color strength
- Reduced fiber fracture
- Low pressure index values

→ Production of PA Masterbatches

- High color yield
- Higher throughput
- Easy to dilute in injection extrusion and injection molding
- Agglomerate free from the first passage

TEGOMER® P 121 / P 122 is the first choice for PA and all kinds of technical polymers in high demanding applications, where a superior pigment dispersion is essential.

TEGOMER® P 121
Colorizing PA 6



By using **TEGOMER® P 121** a tremendous reduction of the pressure index value (< 2 bar/g for fiber grades) and a significant increased color strength is obtained

Concentrate was heightened with TiO_2 to determine the color strength Pigment:TiO_2–ratio 1:10

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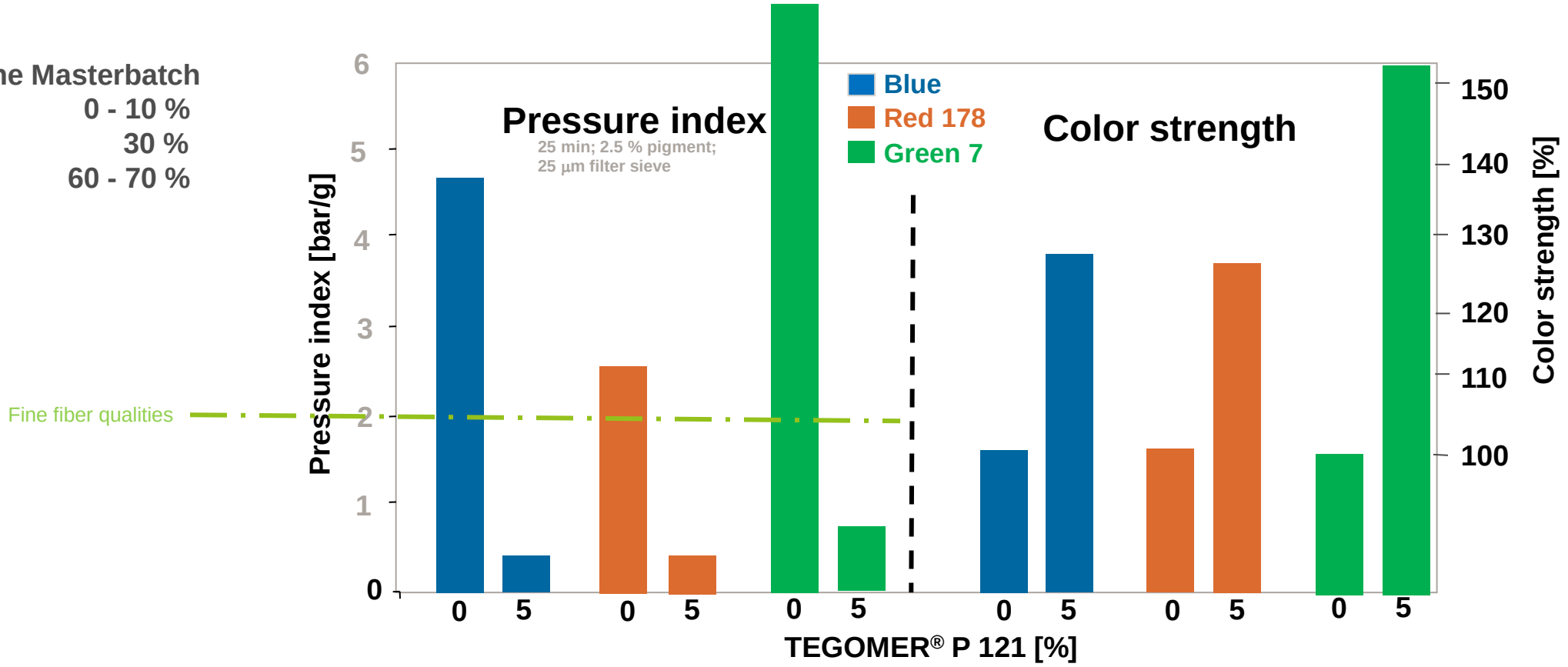
TEGOMER® P 121

Case – Different Pigments in PA 6 with TEGOMER® P 121

Formulation of the Masterbatch

Additive:	**0 - 10 %**
Pigment:	**30 %**
Polyamide 6:	**60 - 70 %**



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TEGO® Sorb PY 88 T.Q.
One Example with Recycled PA 6

The benefits of TEGO® SORB PY 88 can be identified in the following manufacturing steps

- During compounding to guarantee a malodor free production
- For reduced odor of the final product
- Especially effective for eliminating odors in recycling of thermoplastics and rubber production

Example

- Recycled grade of PA 6 containing mercapto-sulfur components which generate odor
- Addition of 1 % **TEGO® SORB PY 88** leads to reduction of smelling components by 25 to 50 %
- characterization of VOC by thermo-desorption (GC-MS 90°C) VDA-Norm 278

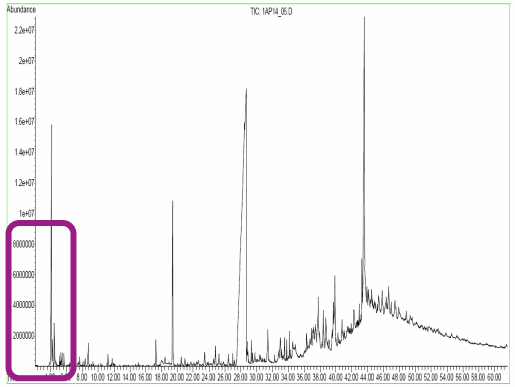
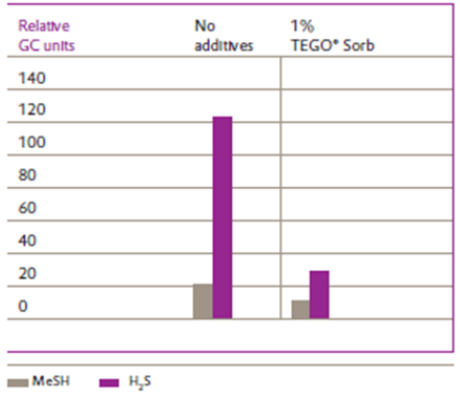


Figure 19: Reduction of hydrogen sulfide and mercapto methane by TEGO® Sorb



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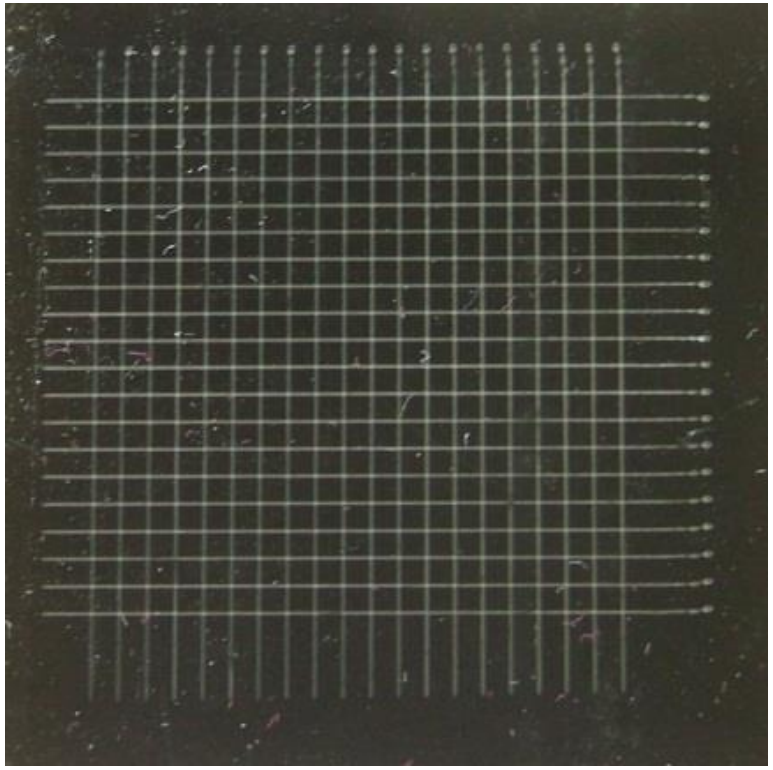
TEGOMER®

Summary of Properties

TEGOMER® / TEGOPREN®

- Improves the mechanical properties of PA glass fiber filled systems
- Improves flame retardant properties of HFFR compounds
- Operates as a permanent slip enhancer
- Does not show migration
- Improves mold release
- Reduces the melt viscosity
- Enables outstanding mold filling property



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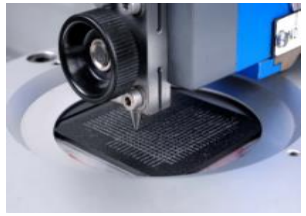
Benfits of TEGOMER® and TEGOPREN® in PA

For processing, improving the melt flow, mold filling and de-molding, to enable high filler loadings and easy incorporation of GF

- **TEGOMER H-Si 6441P**
- **TEGOMER M-Si 2650**
- **TEGOMER E 525**

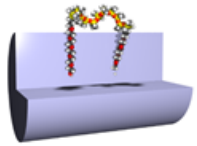
For improved hydrophobicity and reduced water up take

- **TEGOMER M-Si 2650**
- **TEGOPREN 6875**



To optimize surface appearance and scratch resistance

- **TEGOMER H-Si 6441P**
- **TEGOMER AntiScratch L**
- **TEGOMER M-Si 2650**



As material properties enhancer to improve impact, tensile strength and to increase E@B

- **TEGOMER M-Si 2650**
- **TEGOMER H-Si 6441P**

To improve the dispersion of flame retardants and boost their efficiency with optimized mechanical properties

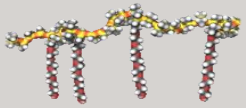
- **TEGOPREN 6875**
- **TEGOPREN 6879**
- **TEGOMER H-Si 6441 P**

As odor absorber in virgin, filled, colorized and recycled PA

- **TEGO SORB PY 88**

For colorizing and masterbatches

- **TEGOMER P 121**
- **TEGOMER P 122**



For the syntheses of PA 6

- **TEGO Antifoam N**
- **TEGOMER H-Si 2315**

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