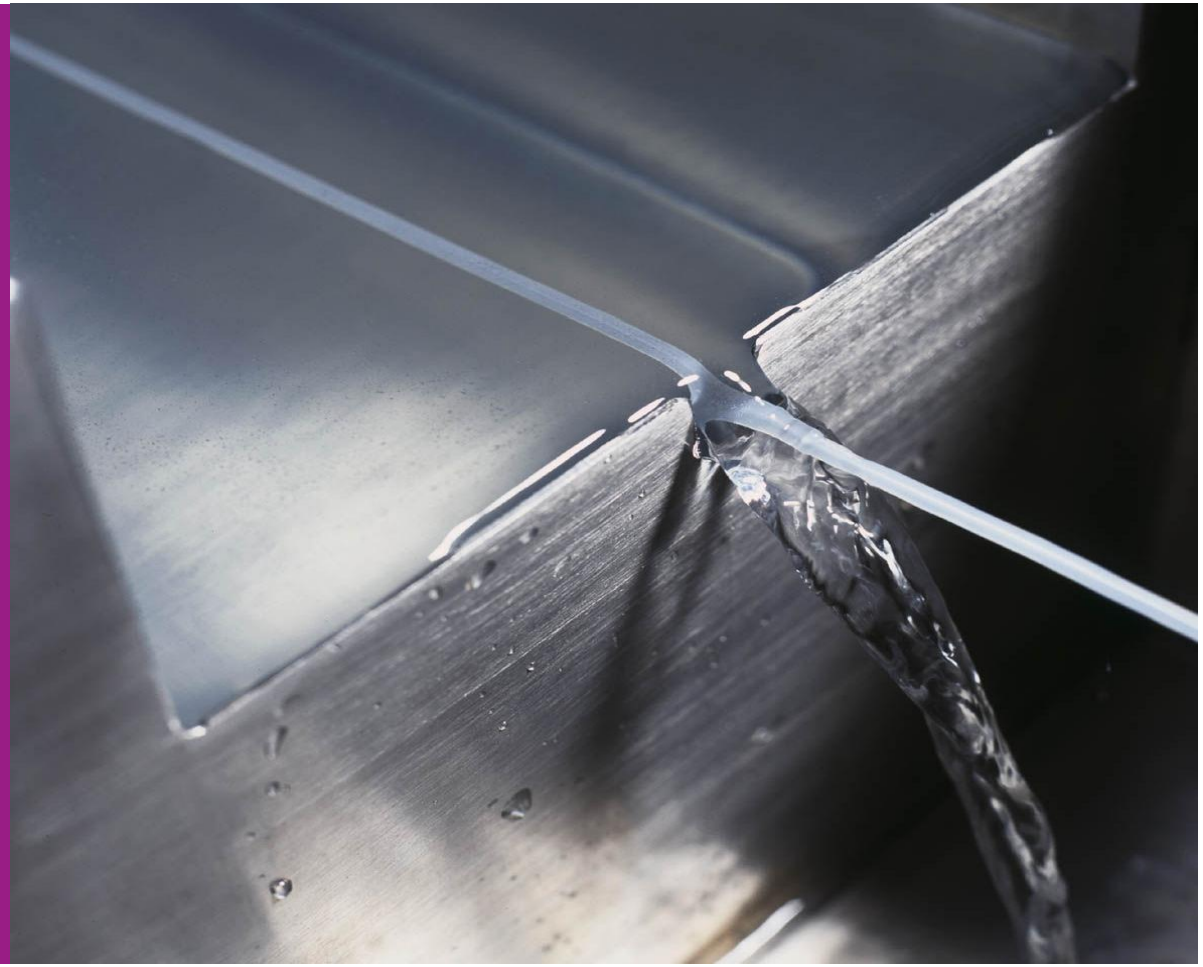
Dynasylan® Silanes for PE crosslinking



August 2025

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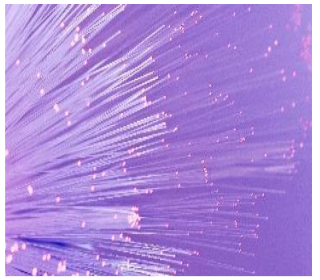
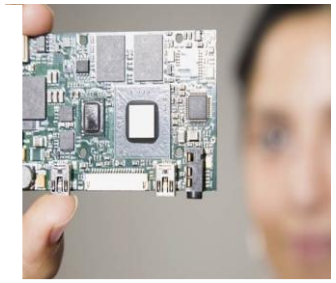
Leading Beyond Chemistry

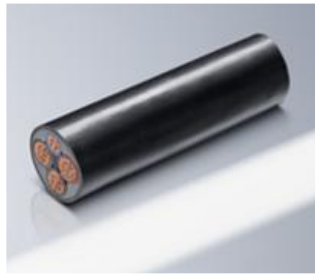




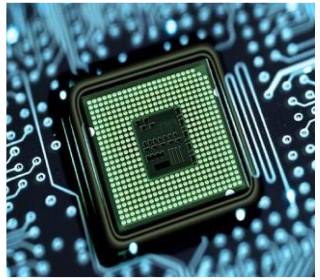
SiLANES #ENABLE






We offer a large variety of products tailored to specific application needs.









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Silanes Connect the Inorganic and Organic World

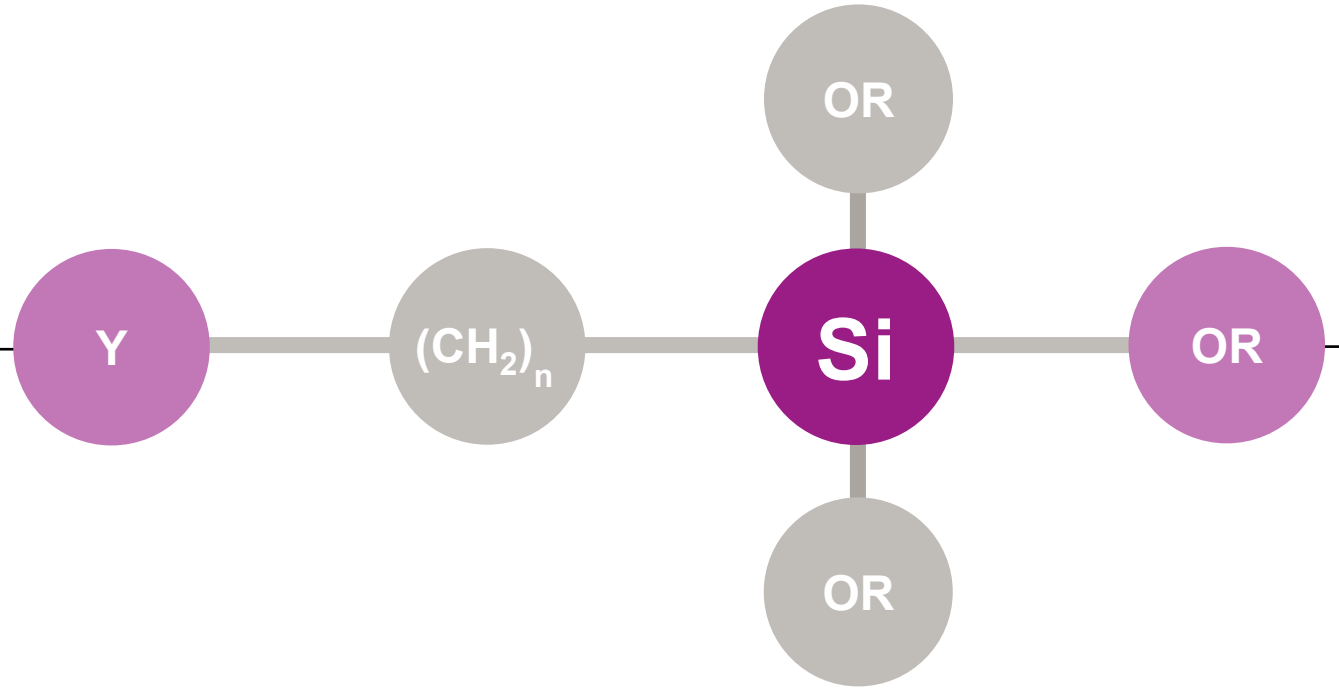
TYPICAL STRUCTURE Most commercial organofunctional silanes feature the same molecular building blocks

Organofunctional group

can react with polymers, resins, rubber…

Organofunctional-Groups
- **Alkyl**
- **Vinyl**
- **Amino**
- **Epoxy**
- **Methacryl**

Etc.



Alkoxy group

can react with fillers, metals, glass, mineral materials…

TYPICAL EFFECT Si | Crosslinking | Adhesion promotion / coupling agent | Surface modification | Precursor / Deposition

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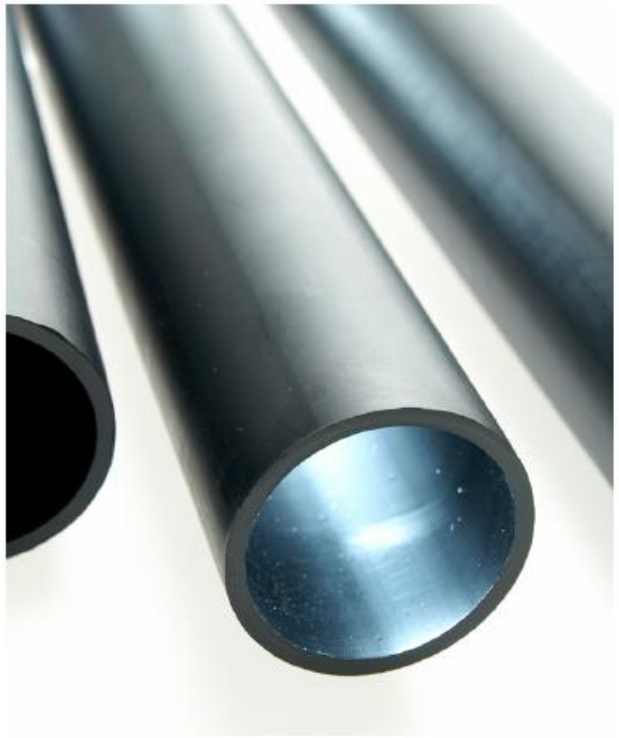
Silfin solutions for silane crosslinking

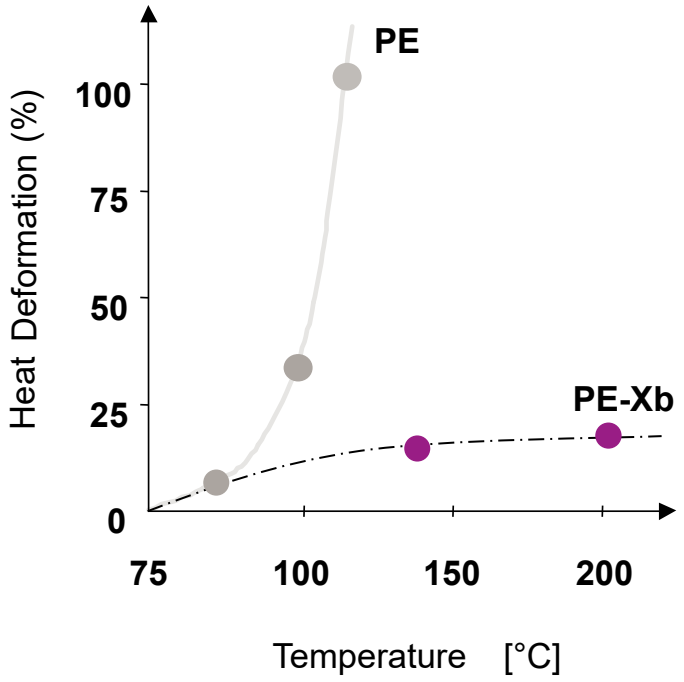


PE crosslinking technologies

- **PE-Xa - crosslinking with peroxide(s)**
- **PE-Xb – crosslinking with silane ("moisture cure" method)**
- **PE-Xc – crosslinking via electron beam process**

Silane-based Crosslinking Enables the Use of PE in Cable Applications

Significantly Increased Heat-Form-Stability



PE (non-crosslinked polyethylene)
PE-Xb (silane crosslinked polyethylene)

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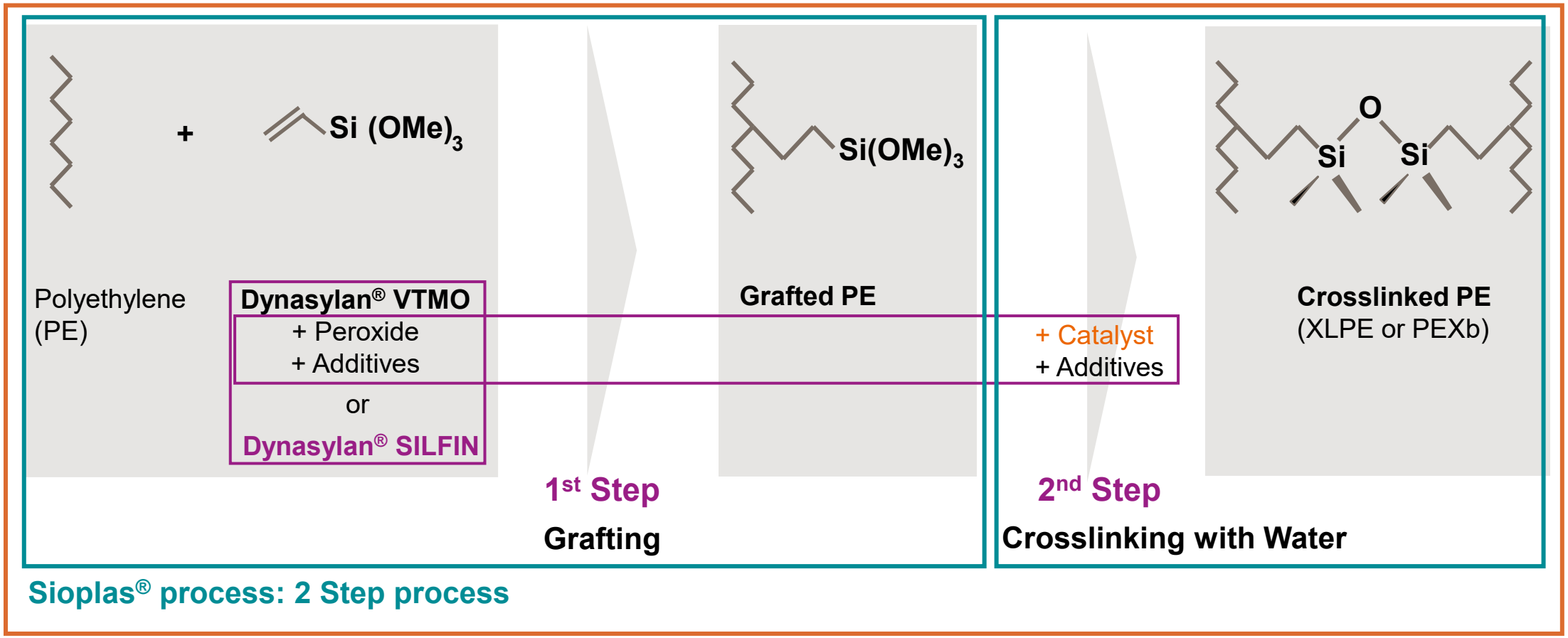
Vinyl-Silanes Act as Crosslinkers for PE



Dynasylan® SILFIN Series to Boost the Performance of your PE-X Cables

Dynasylan® SILFIN series – Product Range

Monosil® process	
SILFIN 06	Excellent x-linking
SILFIN 75	Can be delivered in IBCs
SILFIN 63	High speed x-linking at ambient temperature
SILFIN 50	Suitable for drinking water pipes
Sioplas® process	
SILFIN 13	One product convenience
SILFIN 25	Suitable for drinking water pipes
SILFIN 301	Solution for x-linking HFFR-compounds

Dynasylan® SILFIN series – At a Glance

Attractive product profile

- Multicomponent formulations based on Vinyl-functional Silane.
- Product series with different reactivities.
- Constant & reliable quality of physical blends.

Easy to use

- Ready to use vinyl silane mixtures.
- Products for Sioplas® & Monosil® process.
- Solutions for high throughput rates.

Benefits

- Excellent grafting & crosslinking.
- One product convenience – no mixing by customer needed.
- Unique solutions, e.g. for high-filled HFFR compounds.

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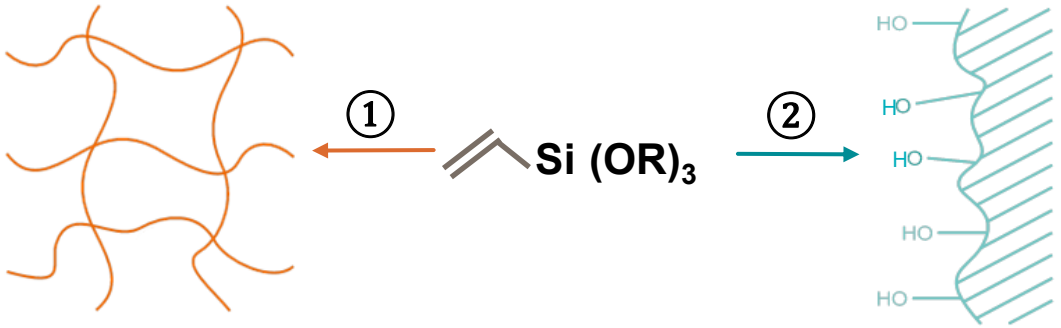
Vinyl- and Alkoxy-Reactivity Need to be Balanced in HFFR Compounds

Challenge of X-linking of Highly Filled HFFR Compounds

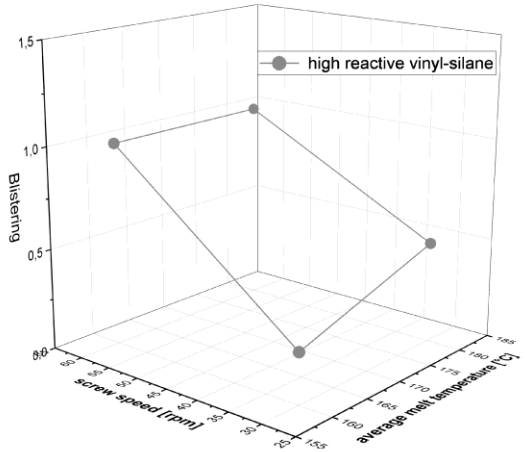


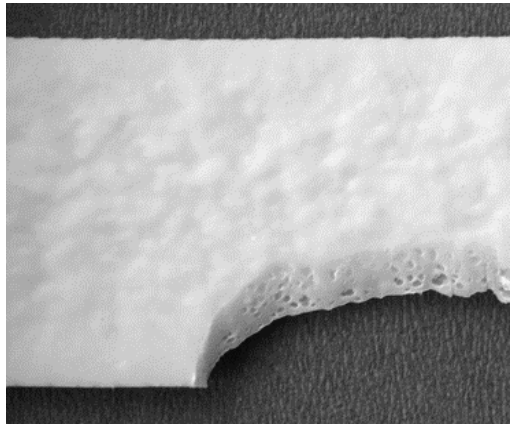
Competitive reactions:

① Vinyl-reactivity via peroxides towards PE chains

② Alkoxy reactivity towards OH-rich HFFR surface

High Alkoxy Reactivity Leads to a Sensitive Process





Study on Crosslinking with high reactive vinyl-silanes

- Melt temperature increased blistering
- Screw speed increases blistering

→ **Small processing window**

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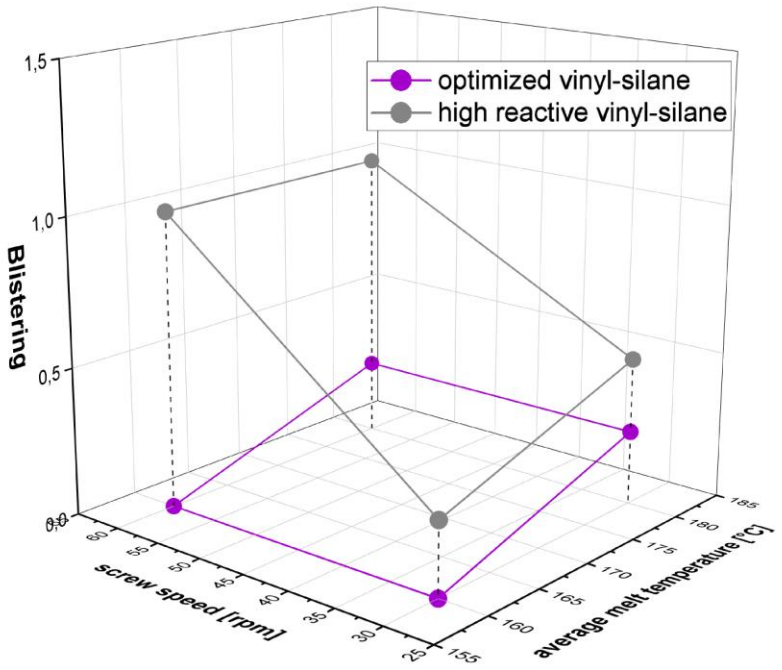
Vinyl-silane with Optimized Selectivity is Preferred for HFFR Compounds

Comparison of Vinyl-silane Selectivity in Crosslinking of Highly Filled HFFR Compounds



Vinylsilane with optimized selectivity shows a smooth surface.

- **Higher screw speed** increased blistering only slightly
- **Higher melt temperature** increased blistering only slightly

Broader processing window is possible

Dynasylan® SILFIN 301 with optimized vinyl-silane selectivity for crosslinking of HFFR compounds.

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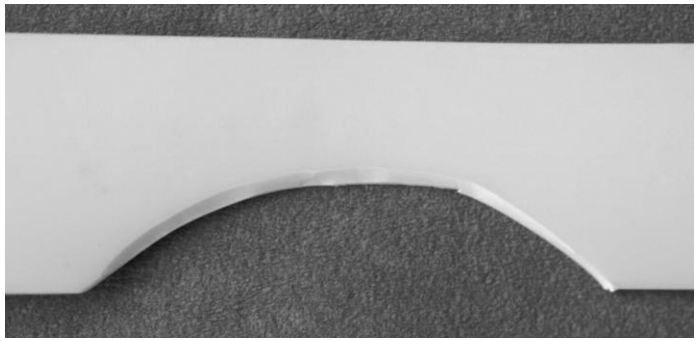
Dynasylan® SILFIN 301 Boosts the Performance of Highly Filled HFFR Compounds

Dynasylan® SILFIN 301 excellent Solution for HFFR Compounds



Typical mechanical properties

Hot-Set [%] (after curing in waterbath @ 80°C for min. 8h)	< 80%
Tensile strength [MPa] (after curing in waterbath @ 80°C for min. 8h)	> 11 MPa
Elongation at break [%]	> 150%

Dynasylan® SILFIN 301 – At a Glance

Attractive product profile

- Multicomponent formulation based on Dynasylan® VTEO.
- Product series with optimized selectivity towards filler surface.
- Constant & reliable quality of physical silane & peroxide blend.

Easy to use

- Ready to use vinyl silane mixtures.
- Product for Sioplas® process.
- Solution for high throughput rates.

Benefits

- Excellent grafting & crosslinking
- Smooth surface of crosslinked HFFR compounds
- No blistering.
- Excellent mechanical properties.

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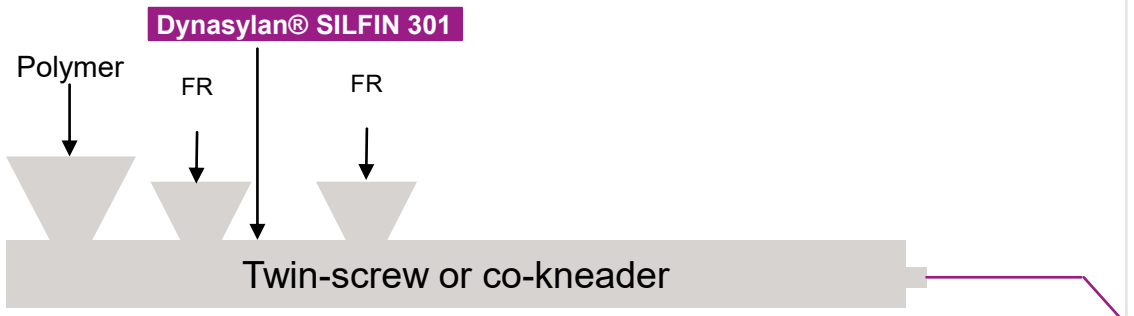
Dynasylan® SILFIN 301 – Formulation examples

	Polar HFFR-compound	Non-Polar HFFR-compound
EVA (28% vinyl acetate) **($MFR_{(190°C, 2.16kg)}$ = 3,0 g/10min)**	75 phr	-
PE-LLD **($MFR_{190°C, 2.16kg)}$ = 1,0 g/10min)**	25 phr	-
PE-M_1 **($MFR_{(190°C, 2.16kg)}$ = 1,0 g/10min)**	-	65 phr
PE-M_2 **($MFR_{(190°C, 2.16kg)}$ = 30 g/10min)**	-	35 phr
Flame retardant **(ATH or MDH)**	160-180 phr	
Dynasylan® SILFIN 301	1.5-2.0 phr	

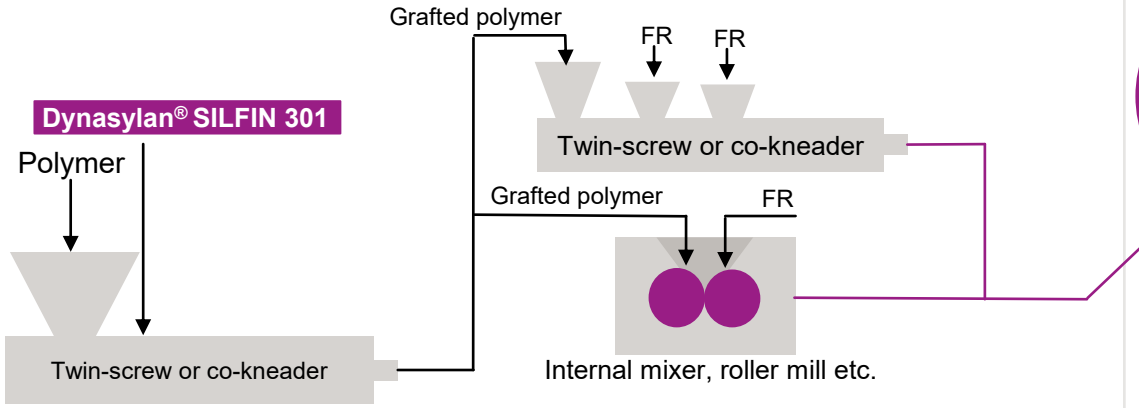
	Polar HFFR-compound	Non-Polar HFFR-compound
Silane grafted polymer (PEg)	97.5%	97.5%
Catalyst-MB (e.g. PE-LD, PE-LLD, EVA containing 0.25% Dibutyl-tin-di-laurate)	2.5%	2.5%
Hot-Set in [%] (tape with 1 mm thickness, after curing in waterbath @80°C for 6-8h)	< 80%	
Tensile strength in [MPa] ((tape with 1 mm thickness, after curing in waterbath @80°C for 6-8h)	> 11 MPa	
Elongation at break in [%]	>150%	

Dynasylan® SILFIN 301 – Reliable solution for silane x-linking HFFR compounds

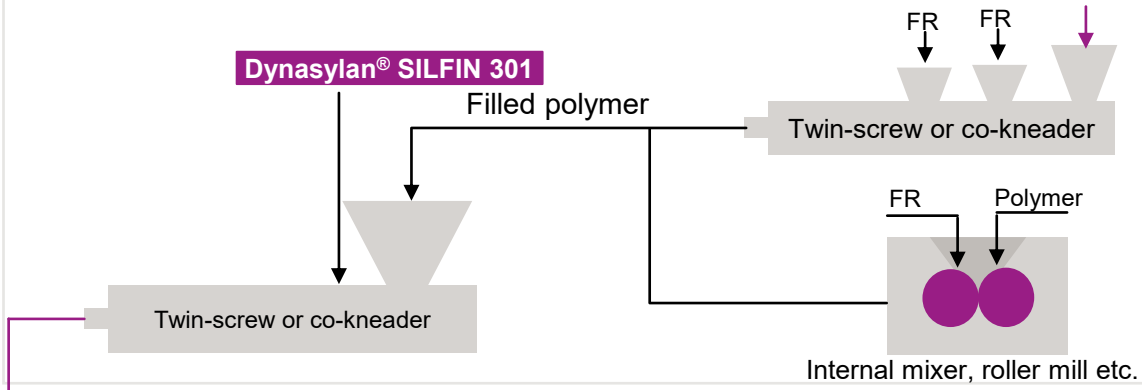
Option 1: Silane grafting and filling in one-step



Option 2: Silane grafting and filling in two-steps

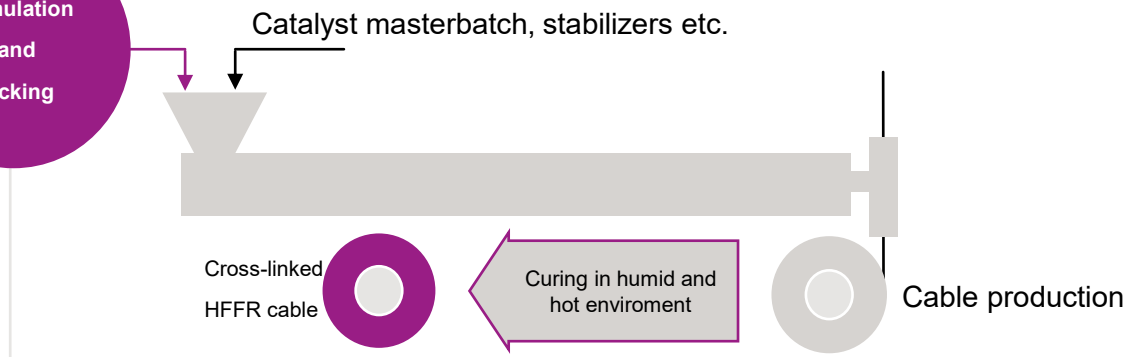


Option 3: Filling and silane grafting in two-steps



Granulation and packing

Finishing step in a single-screw extruder



FR = Flame retardant – e.g. (ATH) Aluminium trihydroxide or (MDH) Magnesium dihydroxide

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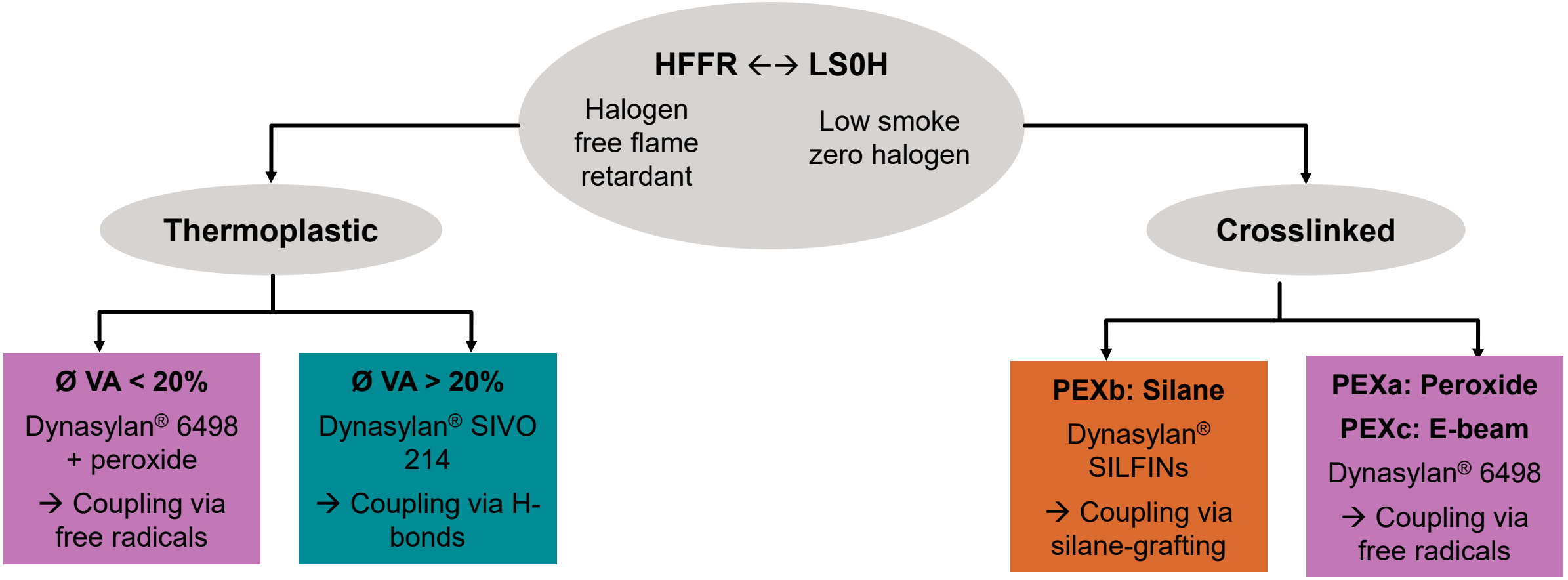
HFFR Compounds for Flameretardant Cable Insulations
Choosing the Suitable Silane Technology



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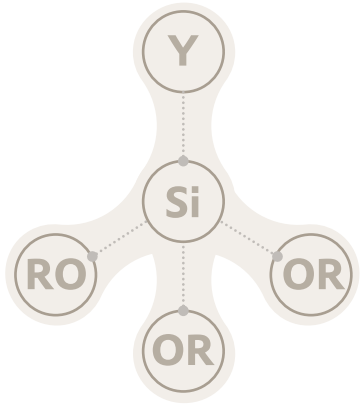
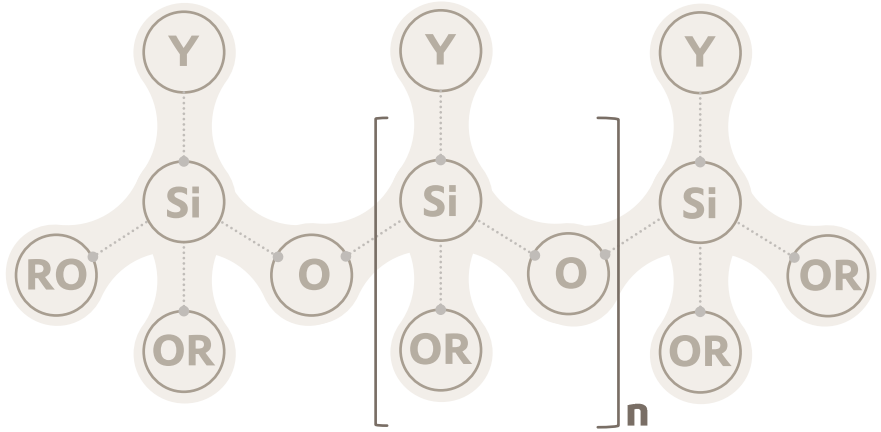
Dynasylan® oligomers outperform monomers

Dynasylan®
Monomer



Dynasylan®
Oligomer



Dynasylan® oligomers outperform monomers

- Higher effectivity and reduced dosage amount
- Reduced volatile by-products
- Enhanced processing
- Safer handling
- Higher boiling and flash point

Dynasylan® oligomers outperform monomers

Dynasylan®	VTMO	VTEO	6490	6498	6598
Viscosity (20°C) [mPas]	0.8	0.7	6.0	3.6	4.6
Flash point [°C]	22	38	> 75	> 87	> 70
Boiling point [°C]	123	158	> 220	240	255
Vinylgroups [%Mass]	18	14	24	21	10
Equimolar exchange factor	0.56	0.71	0.42	0.48	1
Released hydrolysis alcohol [g hydrolysis alcohol/kg Dynasylan®]	650 (Methanol)	730 (Ethanol)	400 (Methanol)	490 (Ethanol)	460 (Ethanol)

Dynasylan® oligomers outperform monomers

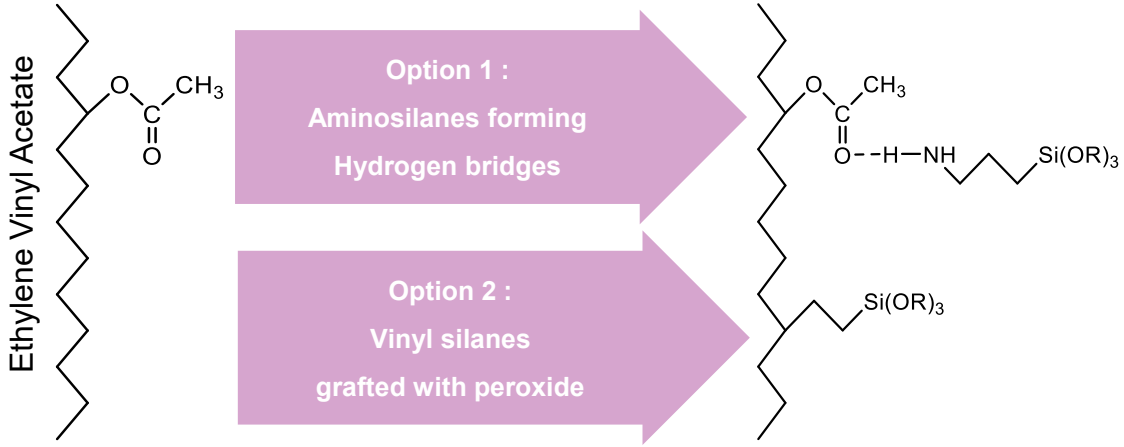
- Higher effectivity and reduced dosage amount
- Reduced volatile by-products
- Higher boiling and flash point
- Safer handling, transport and storage
- Enhanced processing – no product loss at higher processing temperatures

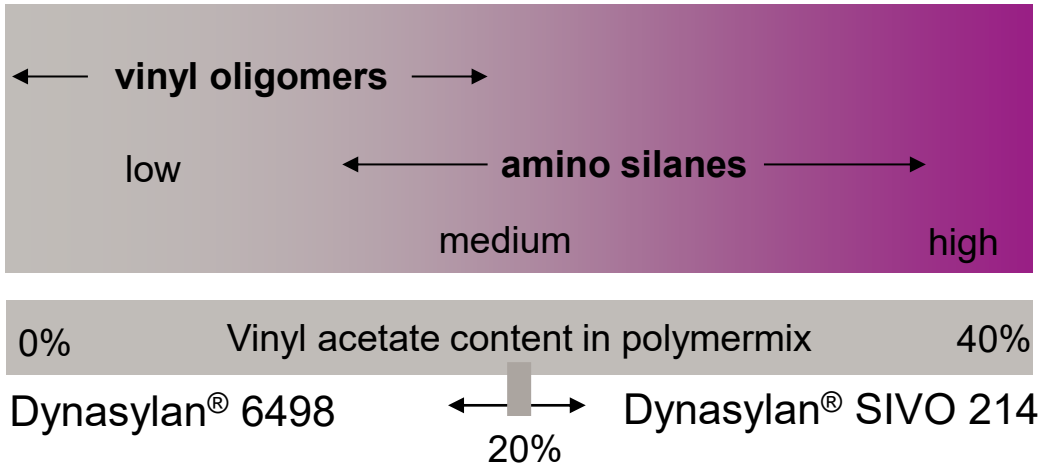
HFFR compounds for flameretardant cable insulations – choosing the suitable functionality!

Halogen-Free Flame Retardants compound formulation	
100 phr	Polymer (PE, PE/EVA, PP)
150 -200 phr	Filler (ATH, MDH)
1,5 phr	Silane (vinyl-/ amino-)
0,01 – 0,03 phr	DCUP (in the case of vinyl oligomers)

No silane – leads to poor surfaces, low flexibility and bad mechanical properties

Compatibilized with suitable silane – smooth surface, high flexibility, excellent mechanical properties





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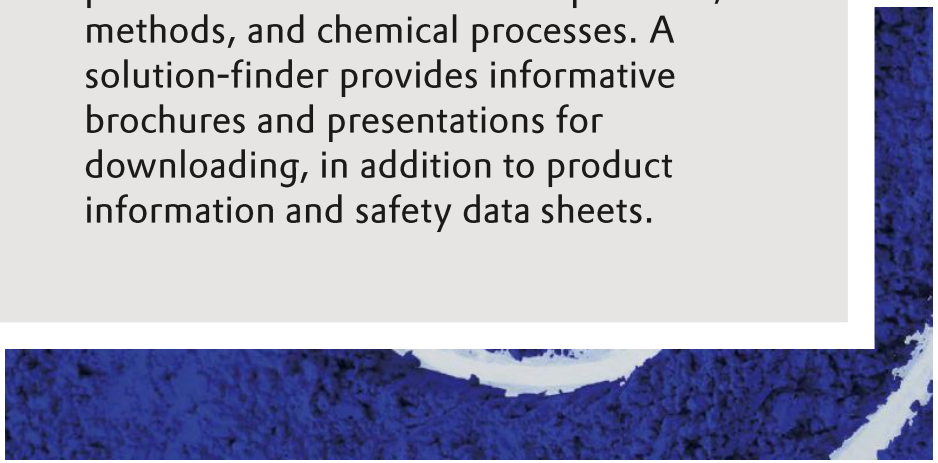
Dynasylan® on the Internet

Information, addresses, and contacts

Our website offers a well-structured platform with information on products, methods, and chemical processes. A solution-finder provides informative brochures and presentations for downloading, in addition to product information and safety data sheets.



The database containing details of Evonik contacts and dealers worldwide gives convenient access to important contact data at any time.

www.evonik.com

ask-se@evonik.com

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Dynasylan® Disclaimer

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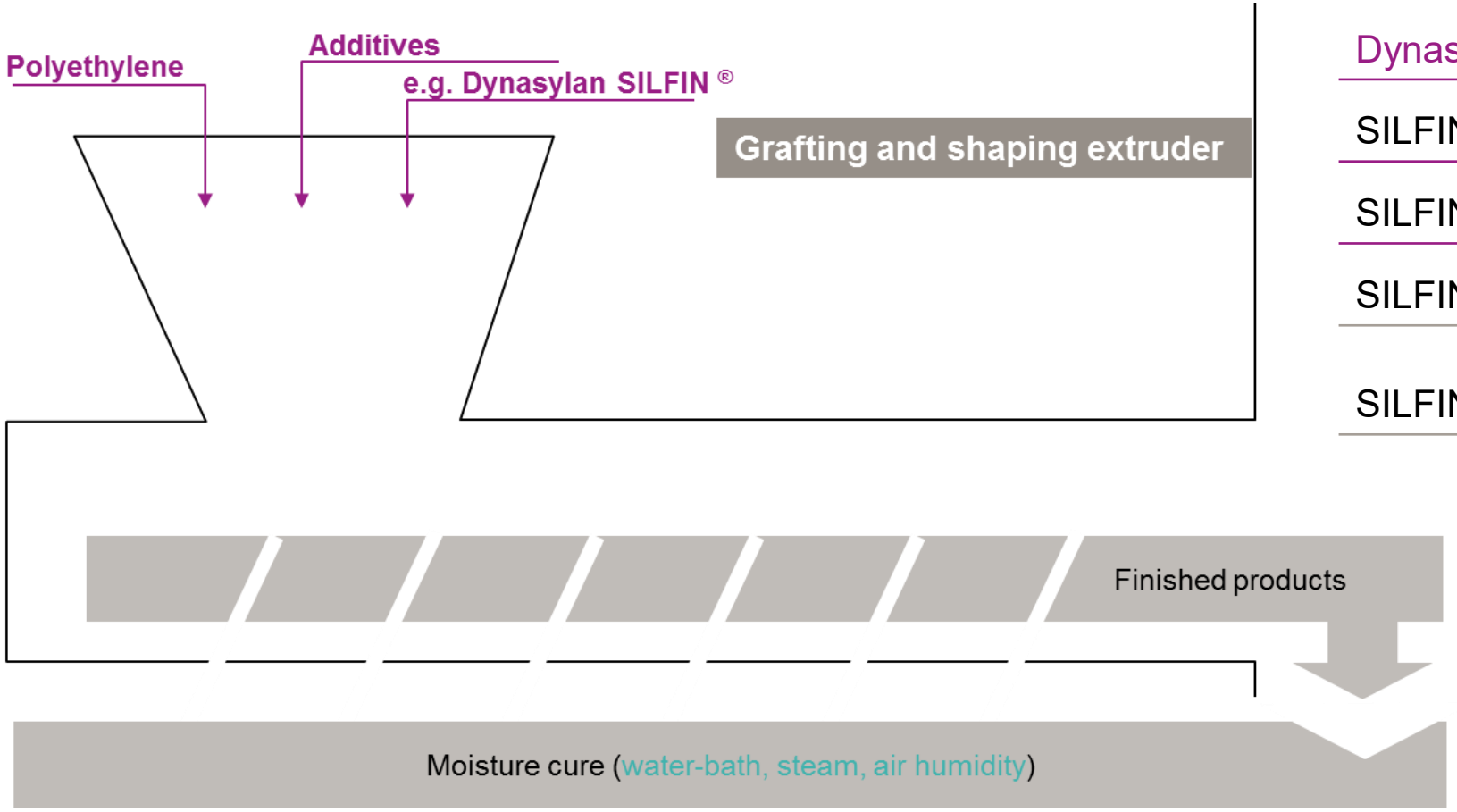
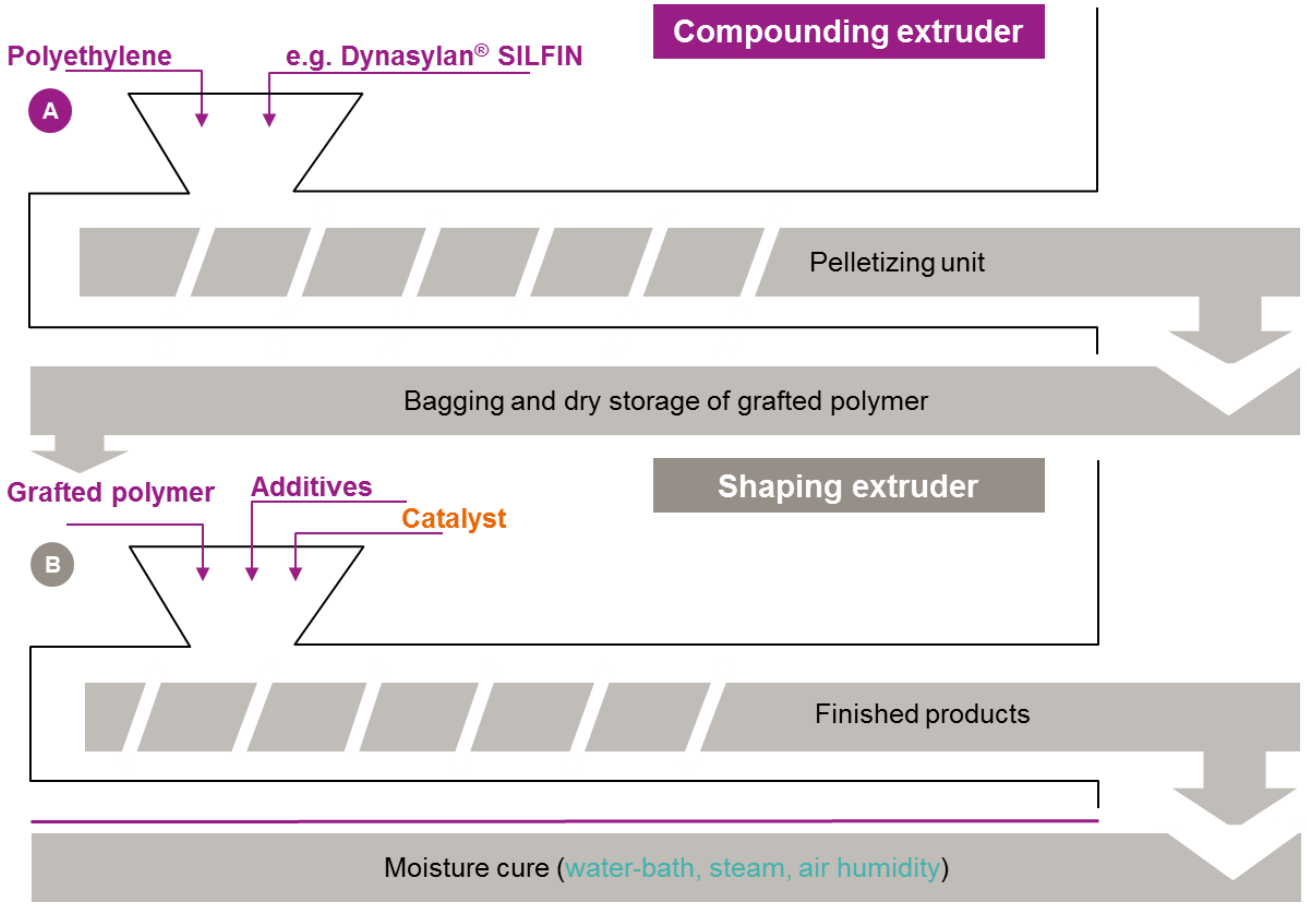
Silane crosslinking technology – the Monosil® process



Dynasylan®	Characteristics
SILFIN 06	Excellent x-linking
SILFIN 50	Drinking-water-pipes
SILFIN 75	Can be delivered in IBC
SILFIN 63	High speed X-linking (ambient curing)

Silane crosslinking technology – two-step process (Sioplas®)



Dynasylan®	Characteristics
SILFIN 13	One product convenience
	Higher throughput rates
SILFIN 25	Drinking-water-pipes
SILFIN 301	Effective for HFFR compounds