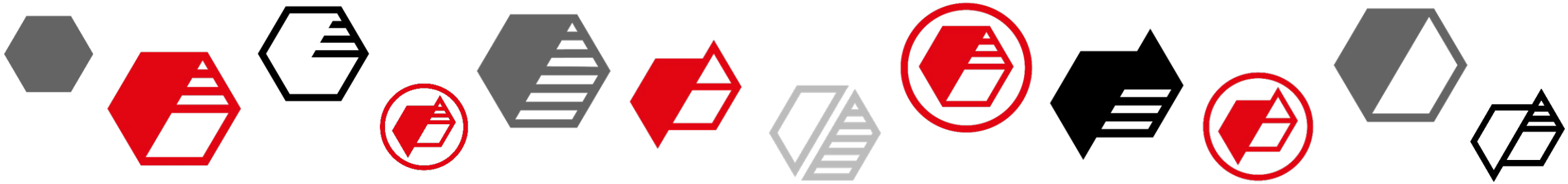
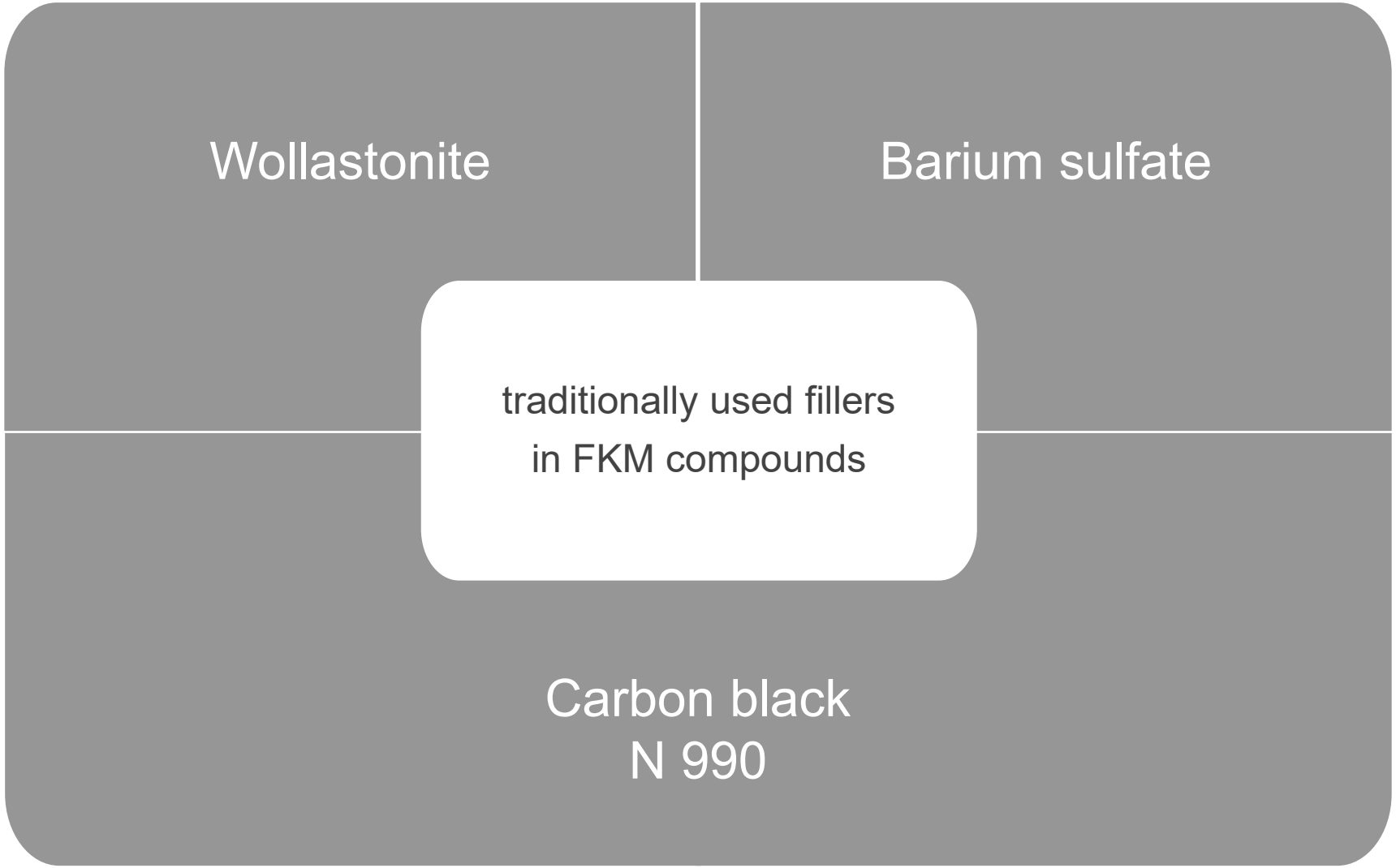


Neuburg Siliceous Earth

as an acid resistant, tintable alternative to carbon black N 990 in peroxide cured FKM

HOFFMANN MINERAL®
We supply materials for good ideas

Status quo


Wollastonite
Barium sulfate
traditionally used fillers
in FKM compounds
Carbon black
N 990

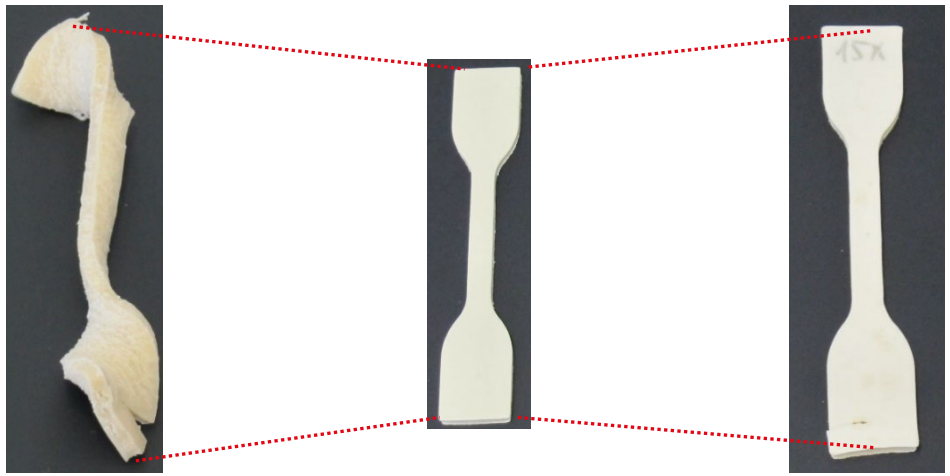
Status quo
Acid resistance

Wollastonite

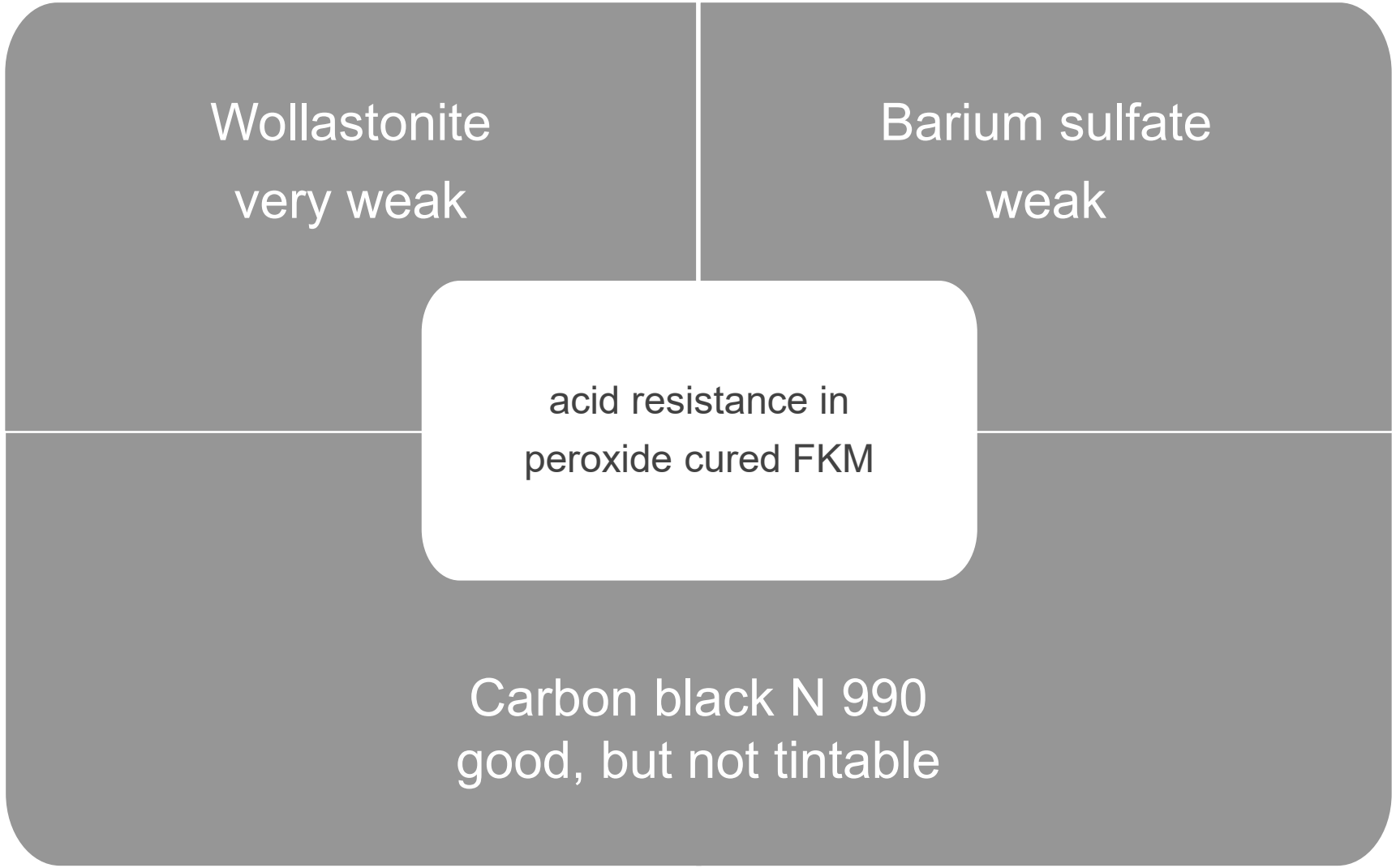
Volume: +500 %
Hardness: -30 Shore A
Tensile strength: -86 %

Barium sulfate

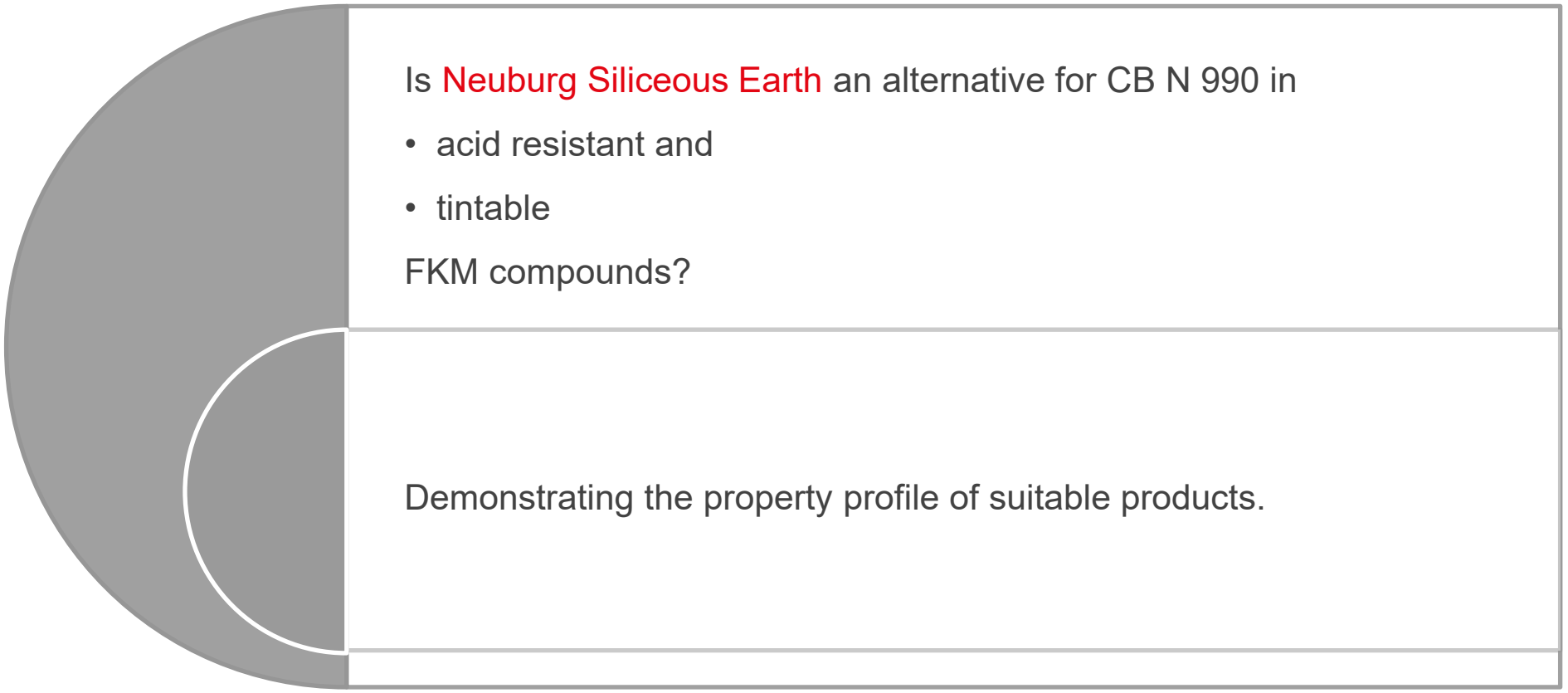
Volume: +120 %
Hardness: -32 Shore A
Tensile strength: -37 %



Status quo
Acid resistance



Objective


Is Neuburg Siliceous Earth an alternative for CB N 990 in
• acid resistant and
• tintable
FKM compounds?
Demonstrating the property profile of suitable products.

Formulation

in phr		N 990	NSE
Viton GAL-200S	66 % flourine, 25 MU (ML 1+10, 121 °C) terpolymer (HFP+VFD+TFE)	100	100
Zinkoxyd aktiv	ZnO	3	3
Diak No. 7	co-activator TAIC	3	3
Varox DBPH-50	2,5-dimethyl-2,5-di(tertbutylperoxy)-hexane	2	2
N 990	Carbon black	30	-
NSE	Neuburg Siliceous Earth	-	30

Fillers and characteristics

Filler	Description	Functionalization
N 990	Carbon black, MT	-
Sillitin Z 86	Neuburg Siliceous Earth (NSE), d_{50}: 2.4 µm	-
Sillitin V 88	Neuburg Siliceous Earth (NSE), d_{50}: 5.0 µm	-
Aktisil AM	Neuburg Siliceous Earth (NSE), d_{50}: 2.4 µm	Amino
Aktisil VM 56	Neuburg Siliceous Earth (NSE), d_{50}: 2.4 µm	Vinyl
Aktisil Q	Neuburg Siliceous Earth (NSE), d_{50}: 5.0 µm	Methacrylic

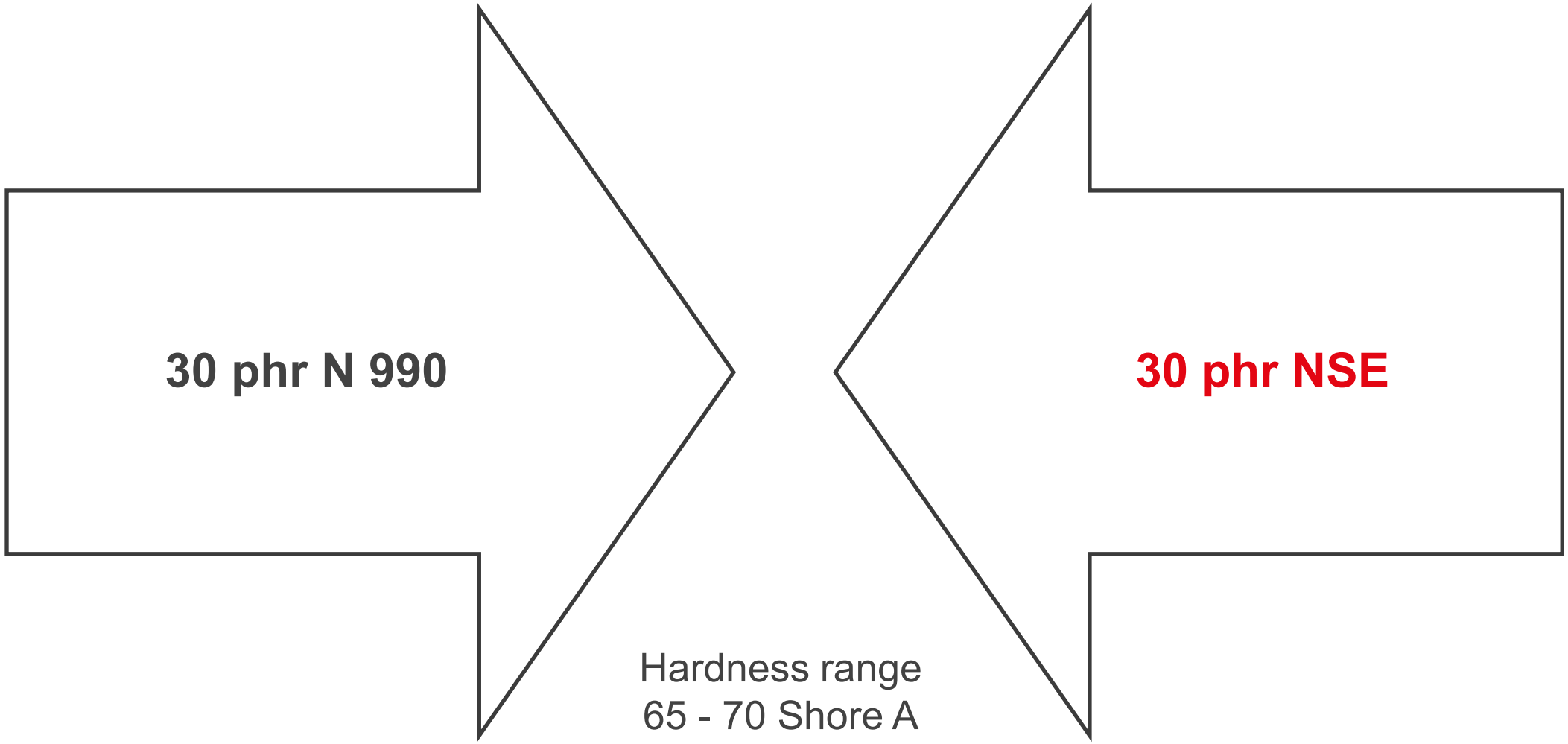
Compound preparation and curing

Mixing	
Open mill	Ø 150 x 300 mm
Batch weight	approx. 1 kg
Temperature	50 °C 30 °C for removing the sheet off the mill
Mixing time	approx. 15 min.
Curing and post-cure	
Cure	7 min. / 177 °C
Post-cure	2 h / 232 °C
All values shown refer to post-cured specimens unless otherwise noted.	

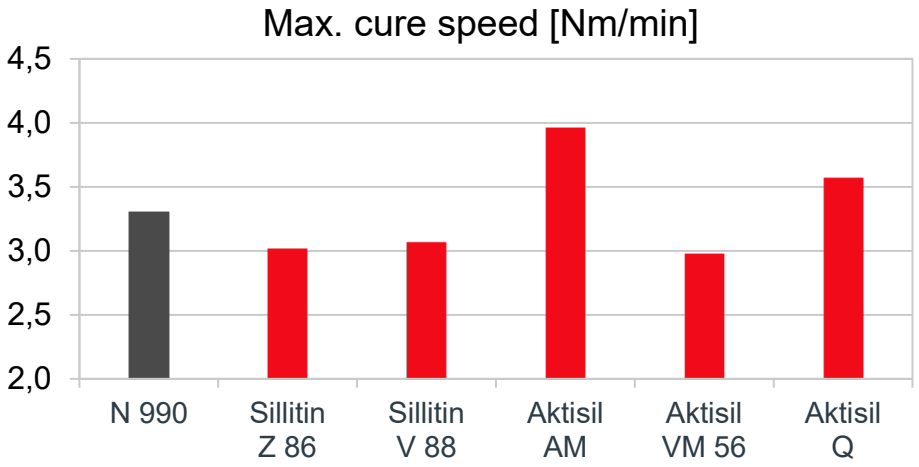
Tests

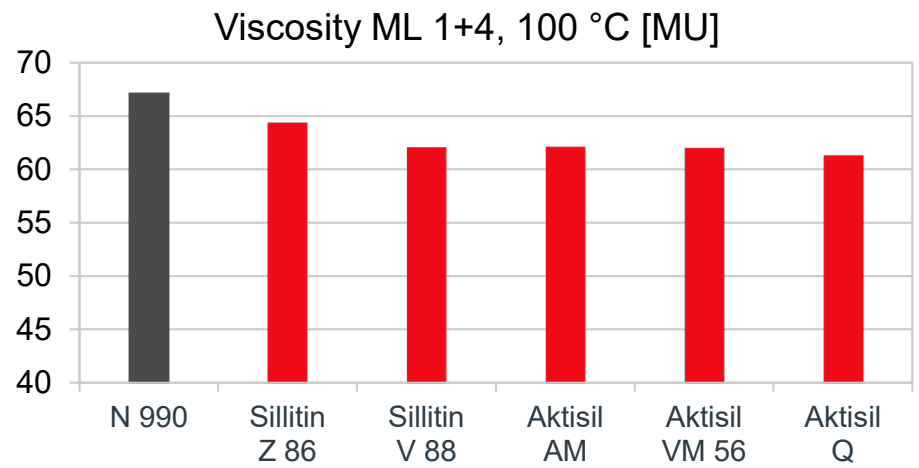
Test	Standard	Conditions
Mooney Viscosity ML 1+4	DIN 53 523, part 3	100 °C
Curemeter testing	DIN 53 529, part 1 – 4	177 °C, 0.2 ° deflection
Tensile test	DIN 53 504, S2	
Compression set	DIN ISO 815-1, type B	70 h / 200 °C / 25 % defl. 70 h / 232 °C / 25 % defl..
Compression set	VW PV 3307	94 h / 23 °C / 50 % defl.. / 5 s 94 h / 150 °C / 50 % defl. / 5 s
Tear resistance	DIN ISO 34-1, A	
Storage in hot air	DIN 53 508	504 h / 210 °C, measured 30‘ after exposure 94 h / 230 °C, measured 30‘ after exposure
Immersion in liquid media	DIN ISO 1817	Fuel FAM B, 70 / 23 °C Oil OS206304, 168 h / 150 °C Acetic acid pH3, 168 h / 100 °C

Neuburg Siliceous Earth vs. N 990

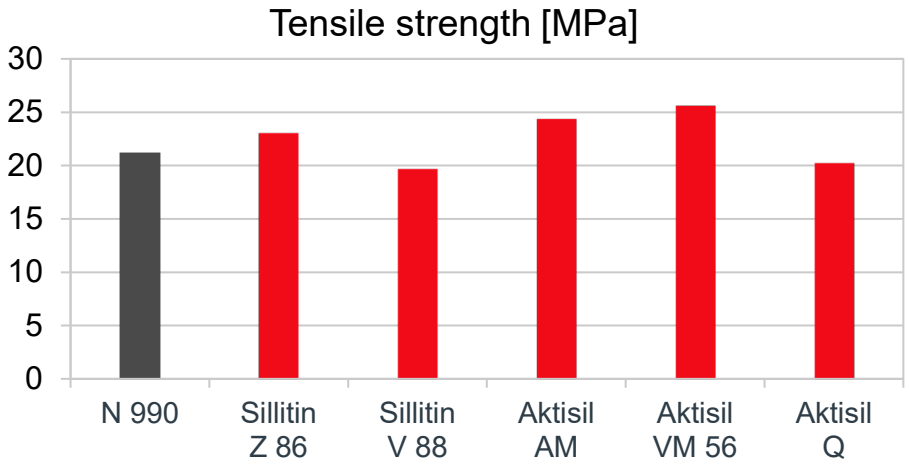


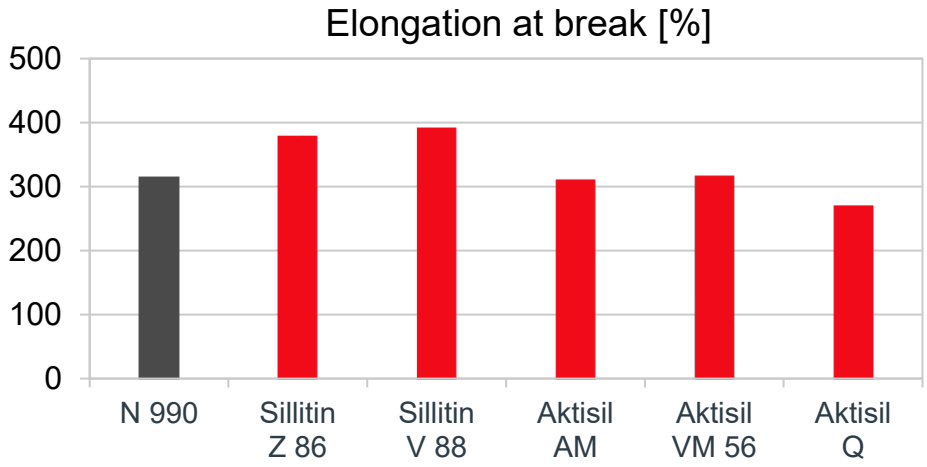
Rheology

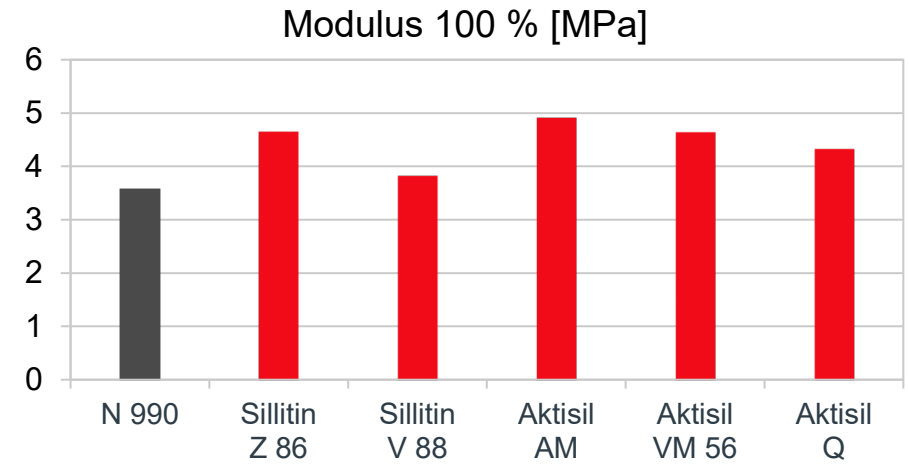

Max. cure speed [Nm/min]
4,5
4,0
3,5
3,0
2,5
2,0
N 990
Sillitin Z 86
Sillitin V 88
Aktisil AM
Aktisil VM 56
Aktisil Q

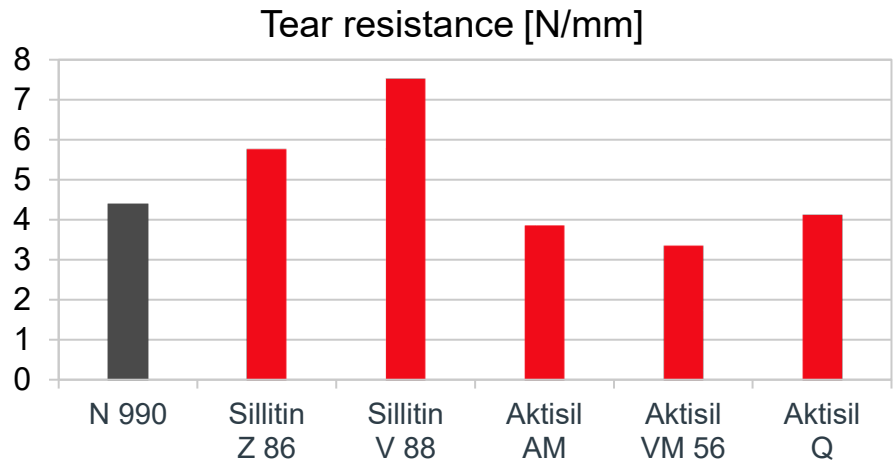

Viscosity ML 1+4, 100 °C [MU]
70
65
60
55
50
45
40
N 990
Sillitin Z 86
Sillitin V 88
Aktisil AM
Aktisil VM 56
Aktisil Q

Tensile properties

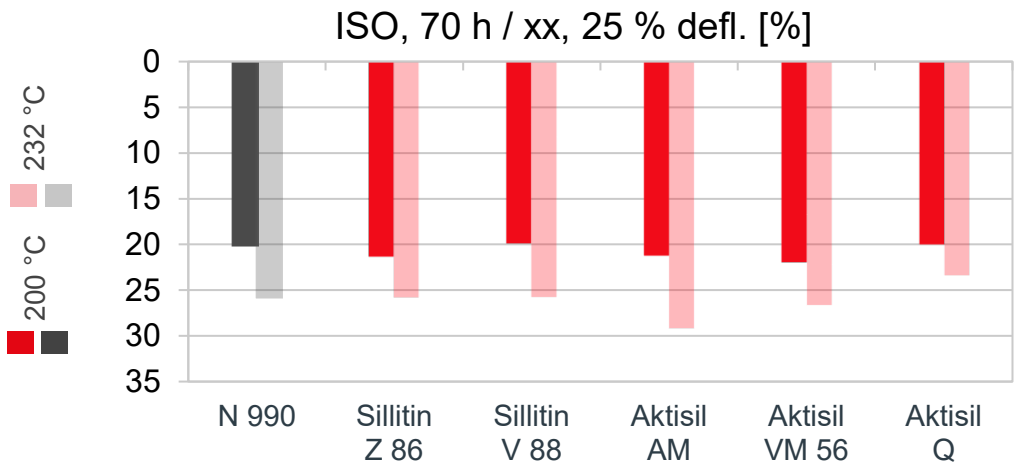


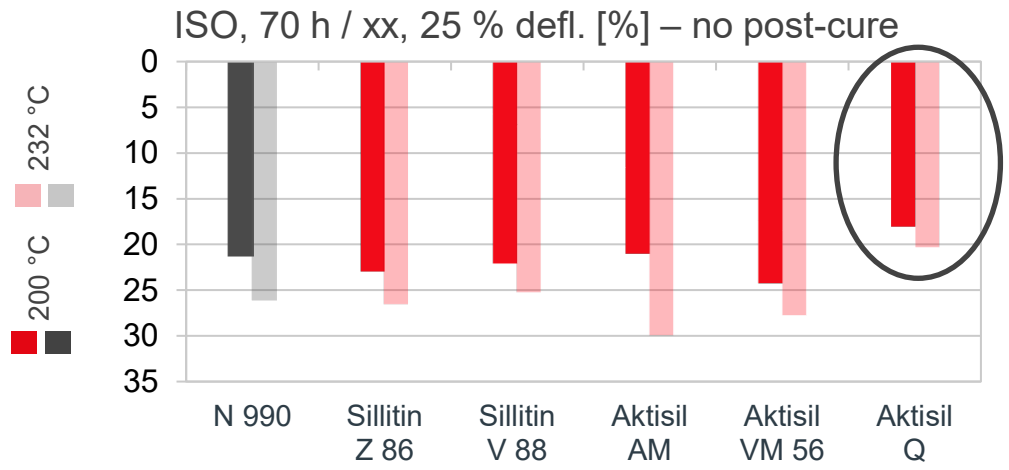


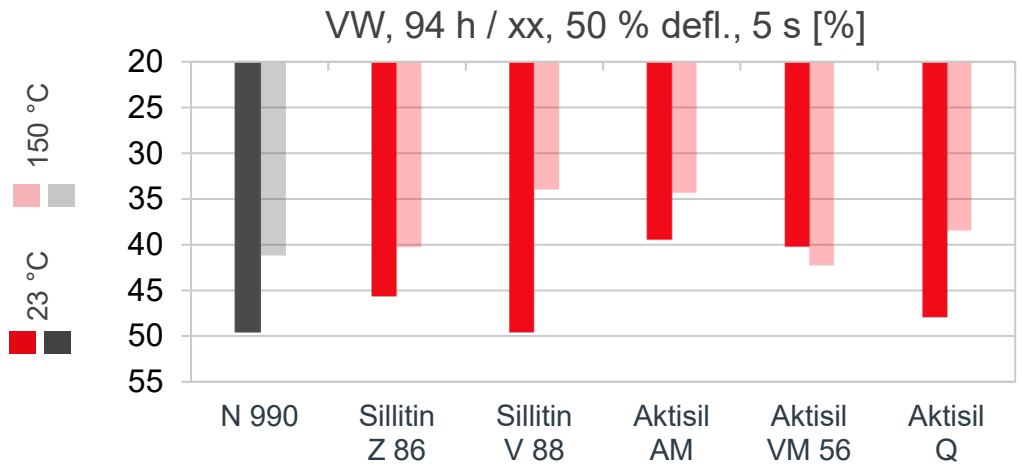




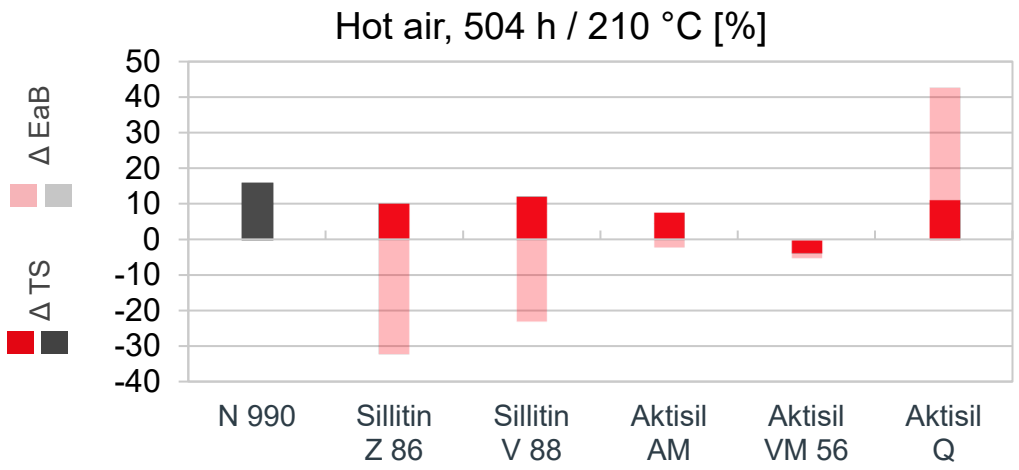
Compression set

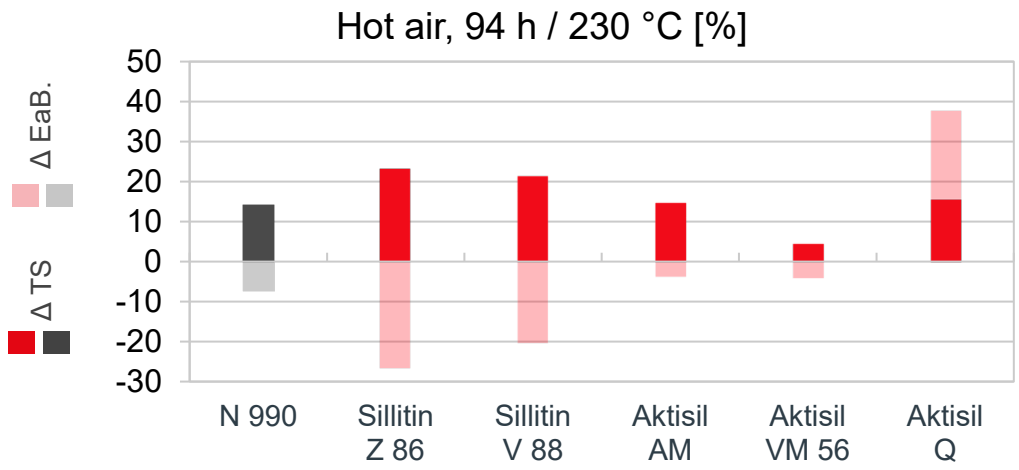


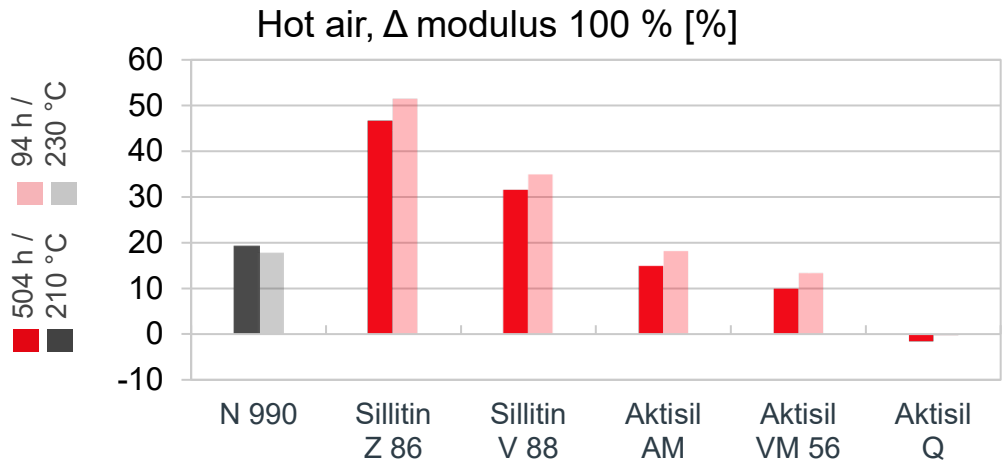




Resistance to hot air and fuel

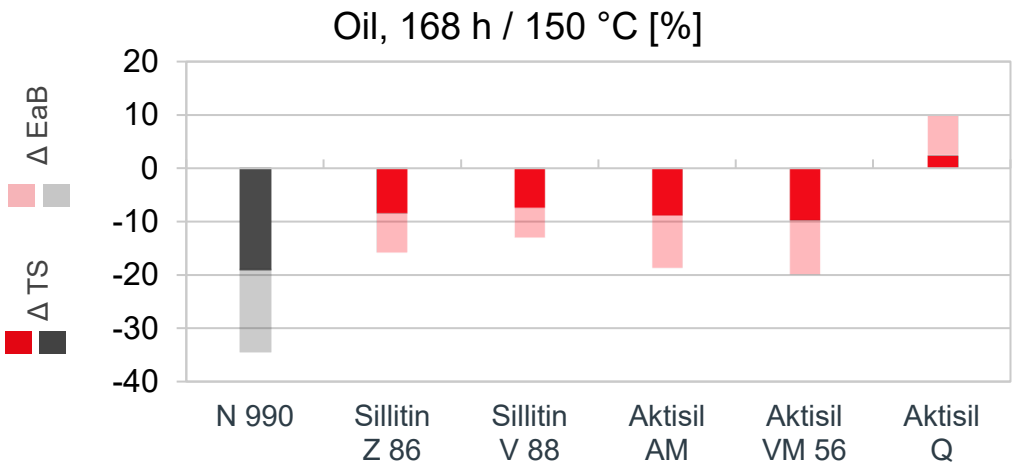


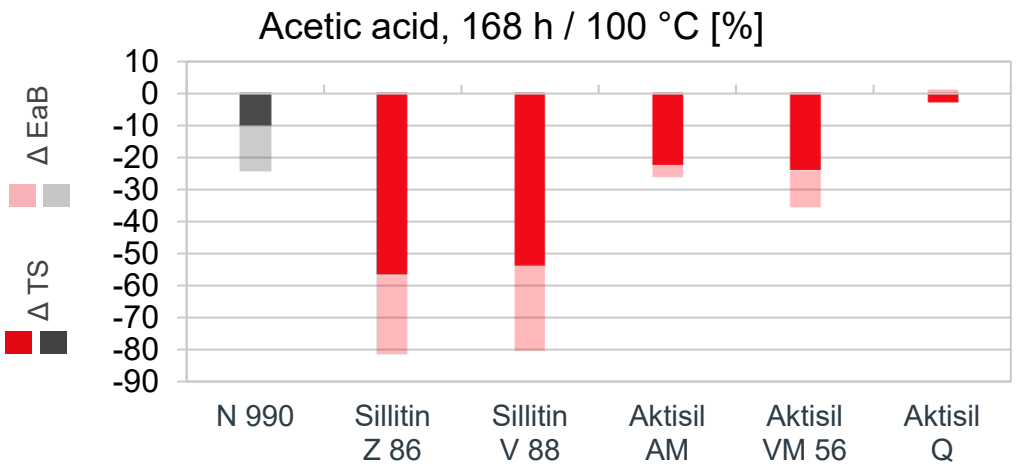


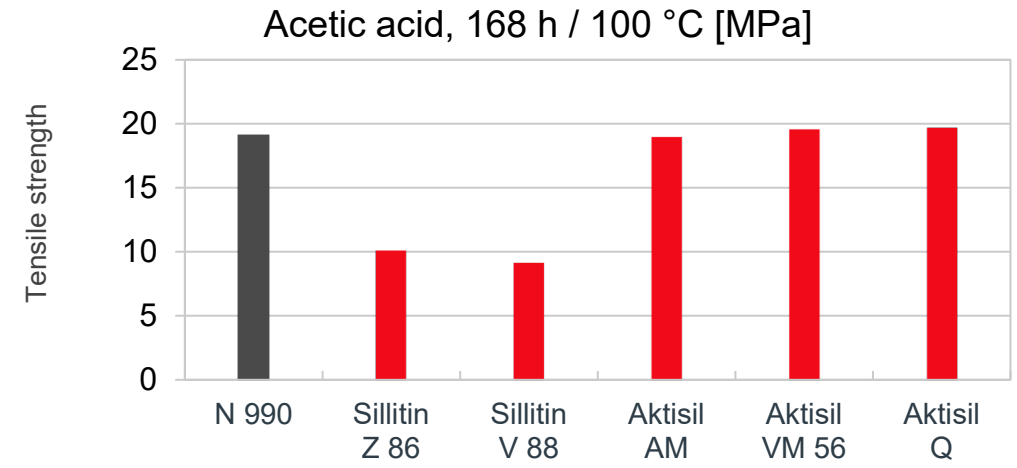


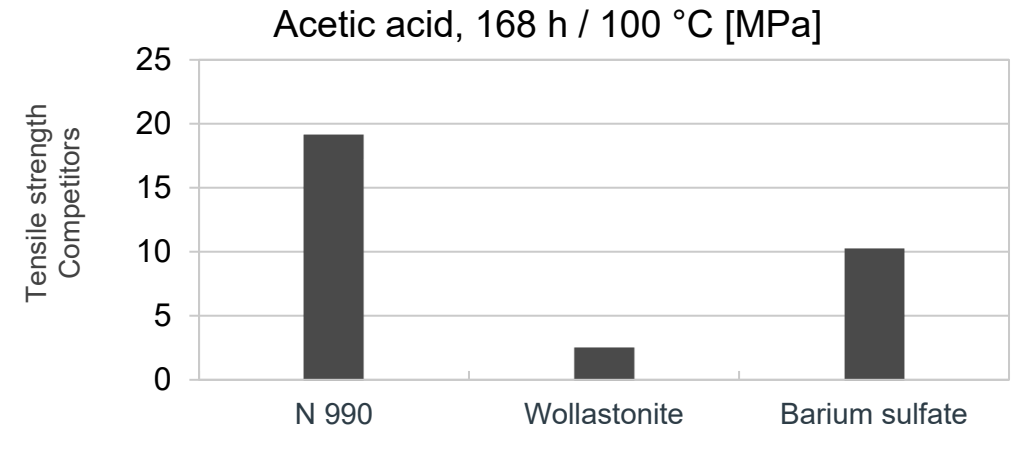
Resistance to fuel with NSE comparable to N 990	
Value ranges:	
Δ Hardness	-8 ± 1 Shore A
Δ Tensile strength	-50 ± 10 %
Δ Elongation at break	-20 ± 10 rel.%
Δ Weight	6.5 – 8.0 %
Δ Volume	15 – 20 %

Resistance to oil and acetic acid



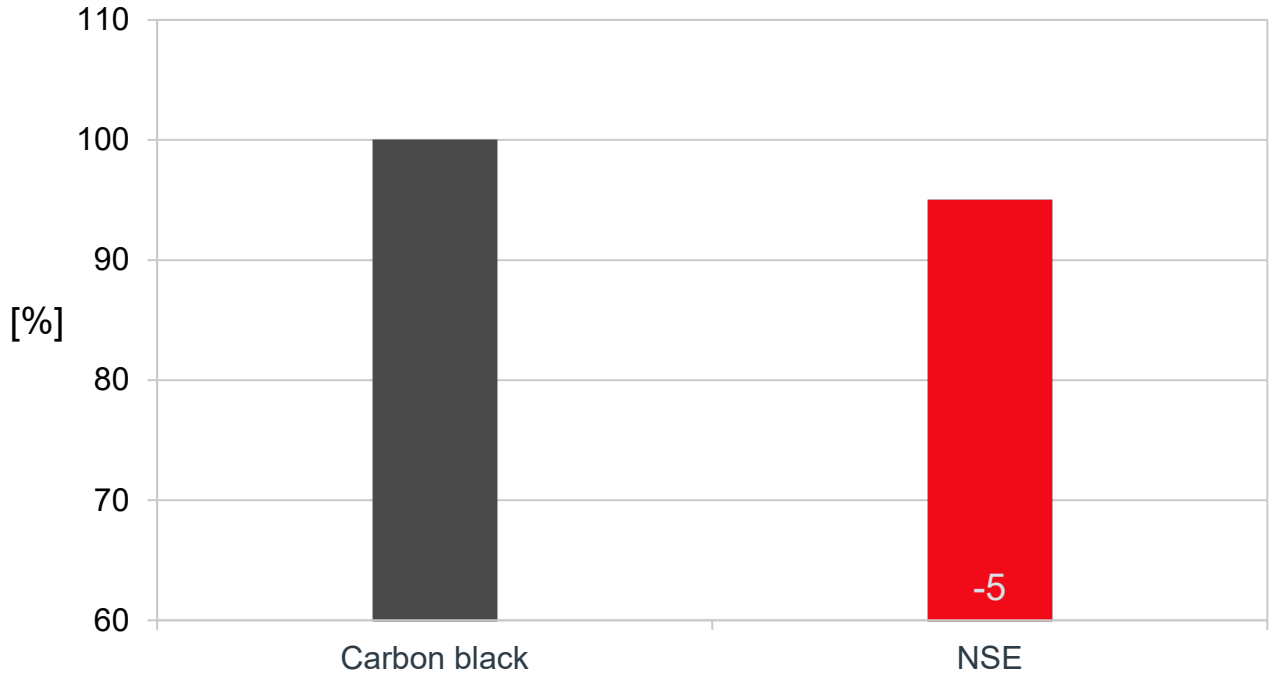






An additional benefit….

Reduction of CO_2 eq. after replacing CB with NSE, volume based



NSE vs. N 990

65 – 70 Shore A	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Cure speed			+		+
Viscosity	+	+	+	+	+
Tensile strength	+	=	+	+	=
Elongation at break	+	+	=	=	
Modulus 100 %	+	=	+	+	+
Tear resistance	+	+	=	=	=
CS ISO 200 °C	=	=	=	=	=
CS ISO 200 °C, no post-cure	=	=	=	=	+
CS ISO 232 °C	=	=	=	=	=
CS ISO 232 °C, no post-cure	=	=	=	=	+
CS VW 23 °C	=	=	+	+	=
CS VW 150 °C	=	+	+	=	=
Resistance to hot air 210 °C			+	+	+
Resistance to hot air 230 °C			=	+	+
Resistance to fuel	=	=	=	=	=
Resistance to oil	+	+	+	+	+
Resistance to acetic acid			=	=	+

✓

Additional benefits:

- colored parts are possible
- reduction of compound carbon footprint

We supply materials for good ideas!

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Results in tabular form

		N 990	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Rheology							
Mooney Viscosity, ML 1+4, 100 °C	MU	67	64	62	62	62	61
Rotorless Curemeter, M_{min}, 177 °C	Nm	0.04	0.04	0.04	0.04	0.04	0.04
Rotorless Curemeter, V_{max}, 177 °C	Nm/min.	3.3	3.0	3.1	4.0	3.0	3.6
Rotorless Curemeter, t_{90}, 177 °C	min.	0.8	0.9	0.9	0.8	0.9	0.8
Mechanical properties (cured 7 min. / 177 °C, no post-cure)							
Hardness	Shore A	65	67	64	64	64	63
Tensile strength	MPa	17	17	14	19	21	16
Elongation at break	%	330	404	390	312	330	257
Modulus 50 %	MPa	1.6	1.9	1.7	1.8	1.7	1.6
Modulus 100 %	MPa	3.2	3.7	3.1	4.2	3.9	3.6
Tear resistance	N/mm	4.6	6.4	6.2	4.5	3.2	4.0
CS ISO 70 h / 200 °C / 25 %	%	21	23	22	21	24	18
CS ISO 70 h / 232 °C / 25 %	%	26	26	25	30	28	20

Results in tabular form

		N 990	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Mechanical properties (cured 7 min. / 177 °C, post-cure 2 h / 232 °C)							
Hardness	Shore A	66	65	65	66	66	65
Tensile strength	MPa	21	23	20	24	26	20
Elongation at break	%	314	379	392	311	318	271
Modulus 50 %	MPa	1.7	2.1	1.8	1.9	1.8	1.7
Modulus 100 %	MPa	3.6	4.6	3.8	4.9	4.6	4.3
Tear resistance	N/mm	4.4	5.8	7.5	3.9	3.4	4.1
CS ISO 70 h / 200 °C / 25 %	%	20	21	20	21	22	20
CS ISO 70 h / 232 °C / 25 %	%	26	26	26	29	27	23
CS VW 94 h / 23 °C / 50 %	%	50	46	50	39	40	48
CS VW 94 h / 150 °C / 50 %	%	41	40	34	34	42	38
Abrasion loss	mm^3	53	80	103	71	64	73

Results in tabular form

		N 990	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Hot air aging, 504 h / 210 °C, measured 30‘ after exposure							
Hardness	Shore A	69	70	68	69	68	67
Tensile strength	MPa	24	25	22	26	25	22
Elongation at break	%	314	257	302	304	312	356
Δ Hardness	Shore A	+3	+5	+3	+3	+2	+2
Δ Tensile strength	%	+16	+10	+12	+7.5	-3,6	+11
Δ Elongation at break	rel.%	0	-32	-23	-2.3	-1,6	+31
Hot air aging, 94 h / 230 °C, measured 30‘ after exposure							
Hardness	Shore A	69	69	67	68	67	65
Tensile strength	MPa	24	28	24	28	27	23
Elongation at break	%	292	278	312	299	304	331
Δ Hardness	Shore A	+3	+4	+2	+2	+1	0
Δ Tensile strength	%	+14	+23	+21	+15	+4,5	+16
Δ Elongation at break	rel.%	-7.2	-27	-20	-3,8	-4.3	+22

Results in tabular form

		N 990	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Exposure to fuel FAM B, 70 h / 23 °C							
Hardness	Shore A	59	60	57	58	57	58
Tensile strength	MPa	12	9.3	7.8	11	13	10
Elongation at break	%	231	340	331	238	251	206
Δ Hardness	Shore A	-7	-5	-8	-8	-9	-7
Δ Tensile strength	%	-44	-60	-60	-53	-51	-49
Δ Elongation at break	rel.%	-26	-10	-16	-24	-21	-24
Δ Weight	%	+6.7	+7.9	+7.7	+6.8	+7.8	+8.0
Δ Volume	%	+15	+19	+18	+17	+19	+19

Results in tabular form

		N 990	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Exposure to engine oil OS206304, 168 h / 150 °C							
Hardness	Shore A	65	66	64	65	64	64
Tensile strength	MPa	17	21	18	22	23	21
Elongation at break	%	266	351	370	281	286	291
Δ Hardness	Shore A	-1	+1	-1	-1	-2	-1
Δ Tensile strength	%	-19	-8.4	-7.4	-8.8	-9.7	+2.3
Δ Elongation at break	rel.%	-15	-7.4	-5.6	-9.8	-10	+7.3
Δ Weight	%	+0.8	+0.6	+0.6	+0.7	+0.8	+0.6
Δ Volume	%	+1.4	+1.1	+0.7	+1.2	+1.4	+0.7

Results in tabular form

		N 990	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Exposure to acetic acid pH3, 168 h / 100 °C							
Hardness	Shore A	54	40	38	47	48	51
Tensile strength	MPa	19	10	9,1	19	19	20
Elongation at break	%	268	285	288	300	281	274
Δ Hardness	Shore A	-12	-25	-27	-19	-18	-14
Δ Tensile strength	%	-9.7	-56	-54	-22	-24	-3,0
Δ Elongation at break	rel.%	-15	-25	-27	-3.7	-12	+1.2
Δ Weight	%	+17	+49	+36	+24	+25	+23
Δ Volume	%	+30	+94	+68	+47	+47	+43

Results in tabular form – only competitors

		N 990	Wollastonite AST	Wollastonite EST	Barium sulfate
Rheology					
Mooney Viscosity, ML 1+4, 100 °C	MU	67	63	59	66
Rotorless Curemeter, M_{min}, 177 °C	Nm	0.04	0.03	0.03	0.04
Rotorless Curemeter, V_{max}, 177 °C	Nm/min.	3.3	3.4	3.1	3.4
Rotorless Curemeter, t_{90}, 177 °C	min.	0.8	0.9	0.9	0.9
Mechanical properties (cured 7 min. / 177 °C, no post-cure)					
Hardness	Shore A	65	61	63	61
Tensile strength	MPa	17	18	16	15
Elongation at break	%	330	397	393	421
Modulus 50 %	MPa	1.6	1.9	1.6	1.4
Modulus 100 %	MPa	3.2	4.2	3.2	2.1
Tear resistance	N/mm	4.6	6.0	5.9	4.7
Compression set ISO 70 h / 200 °C / 25 %	%	21	24	21	22
Compression set ISO 70 h / 232 °C / 25 %	%	26	35	28	31

Results in tabular form – only competitors

		N 990	Wollastonite AST	Wollastonite EST	Barium sulfate
Mechanical properties (cured 7 min. / 177 °C, post-cure 2 h / 232 °C)					
Hardness	Shore A	66	64	64	64
Tensile strength	MPa	21	19	20	16
Elongation at break	%	314	337	399	407
Modulus 50 %	MPa	1.7	1.7	1.7	1.4
Modulus 100 %	MPa	3.6	3.9	3.5	2.4
Tear resistance	N/mm	4.4	6.2	6.9	6.1
Compression set ISO 70 h / 200 °C / 25 %	%	20	22	18	22
Compression set ISO 70 h / 232 °C / 25 %	%	26	29	24	28
Compression set VW 94 h / 23 °C / 50 %	%	50	51	51	49
Compression set VW 94 h / 150 °C / 50 %	%	41	35	36	36
Abrasion loss	mm^3	53	104	114	124

Results in tabular form – only competitors

		N 990	Wollastonite AST	Wollastonite EST	Barium sulfate
Hot air aging, 504 h / 210 °C, measured 30‘ after exposure					
Hardness	Shore A	69	64	64	65
Tensile strength	MPa	24	20	21	24
Elongation at break	%	314	331	390	372
Δ Hardness	Shore A	+3	-3	0	-2
Δ Tensile strength	%	+16	+6.1	+3.1	+43
Δ Elongation at break	rel.%	0	-1.7	-2.3	-8.6
Hot air aging, 94 h / 230 °C, measured 30‘ after exposure					
Hardness	Shore A	69	65	65	65
Tensile strength	MPa	24	22	22	25
Elongation at break	%	292	325	335	353
Δ Hardness	Shore A	+3	-2	+1	-2
Δ Tensile strength	%	+14	+18	+7.9	+51
Δ Elongation at break	rel.%	-7.2	-3.6	-16	-13

Results in tabular form – only competitors

		N 990	Wollastonite AST	Wollastonite EST	Barium sulfate
Exposure to fuel FAM B, 70 h / 23 °C					
Hardness	Shore A	59	56	55	52
Tensile strength	MPa	12	8.6	7.0	7.7
Elongation at break	%	231	241	261	329
Δ Hardness	Shore A	-7	-11	-9	-15
Δ Tensile strength	%	-44	-53	-66	-53
Δ Elongation at break	rel.%	-26	-28	-35	-19
Δ Weight	%	+6.7	+7.6	+7.2	+7.4
Δ Volume	%	+15	+19	+18	+20

Results in tabular form – only competitors

		N 990	Wollastonite AST	Wollastonite EST	Barium sulfate
Exposure to engine oil OS206304, 168 h / 150 °C					
Hardness	Shore A	65	62	62	62
Tensile strength	MPa	17	17	13	11
Elongation at break	%	266	286	297	340
Δ Hardness	Shore A	-1	-5	-2	-5
Δ Tensile strength	%	-19	-7.1	-35	-34
Δ Elongation at break	rel.%	-15	-15	-26	-17
Δ Weight	%	+0.8	+0.6	+0.6	+0.5
Δ Volume	%	+1.4	+1.2	+1.1	+1.3

Results in tabular form – only competitors

		N 990	Wollastonite AST	Wollastonite EST	Barium sulfate
Exposure to acetic acid pH3, 168 h / 100 °C					
Hardness	Shore A	54	37	non determinable	35
Tensile strength	MPa	19	2,6	2,8	10
Elongation at break	%	268	54	84	252
Δ Hardness	Shore A	-12	-30	non determinable	-32
Δ Tensile strength	%	-9.7	-86	-86	-37
Δ Elongation at break	rel.%	-15	-84	-79	-38
Δ Weight	%	+17	+288	+227	+55
Δ Volume	%	+30	+593	+499	+121