Partial replacement of carbon black with Neuburg Siliceous Earth in cellular, hard EPDM compounds for weight and cost savings

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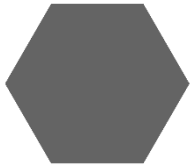
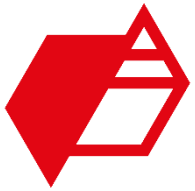
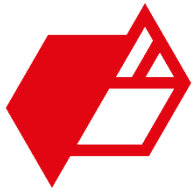
Status quo

cellular compounds	commonly used for automotive applications, for technical and/or economic reasons
	also electrically insulating to prevent electro-chemical corrosion in metal combinations steel/aluminum or steel/magnesium
carbon black	only suitable for conventional, electrically conductive applications
	strong dependency on crude oil prices
Neuburg Siliceous Earth	suitable also for electrically insulating applications
	little dependence on crude oil prices

Formulation variants

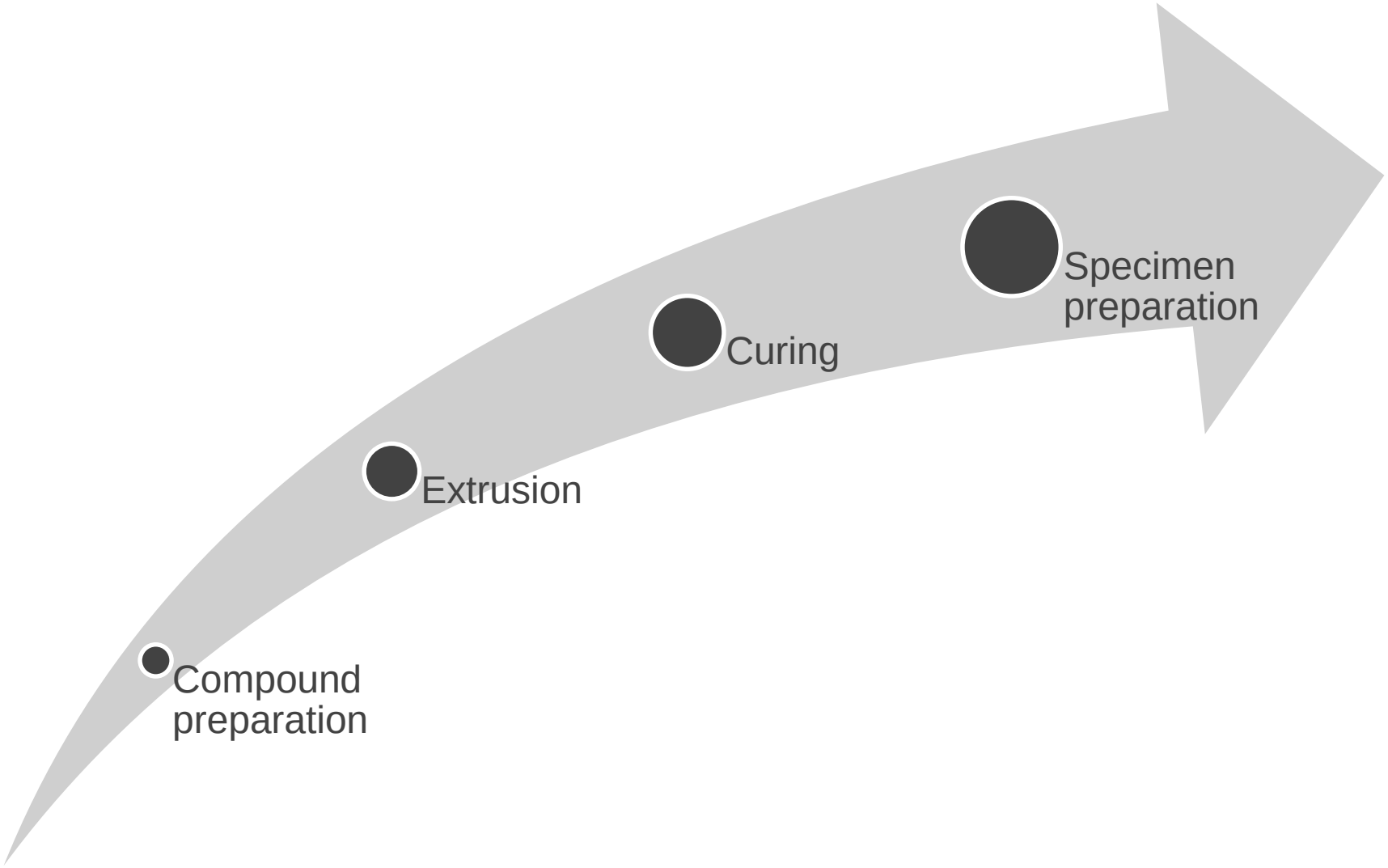
	REFERENCE filled with CB	partial replacement with Neuburg Siliceous Earth (NSE)	
	electrically conductive		**non-conductive**
CB N 550 [vol.%]	28	16	11
Keltan 8550C	100	100	100
CB N 550	**110**	**70**	**50**
Neuburg Siliceous Earth	**-**	**120**	**180**
Process Oil P 460	20	20	20
Zinkoxyd aktiv	5	5	5
Stearic acid	1	1	1
Kezadol GR	2.25	2.25	2.25
PEG 4000	2	2	2
Rhenogran DPG-80	1.1	1.1	1.1
Rhenogran MBT-80	2	2	2
Rhenogran ZBEC-70	2	2	2
Rhenogran TP-50	4	4	4
Rhenogran S-80	1.9	1.9	1.9
Rhenogran CLD-80	1	1	1
Expancel 950 DU 80	5.05	6.65	7.45
Total	*257.3*	*338.9*	*379.7*

Neuburg Siliceous Earth – tested grades

				
	SILLITIN N 75*	SILLITIN Z 86	AKTISIL PF 216	AKTISIL AM
Particle size D_{50}, [µm]	3.0	1.9	2.2	2.2
Particle size D_{97}, [µm]	16	9.0	10	10
Color value L*	88	93.9	94	93.8
Color value b*	20	9.7	9.9	9.9
Functionalization	-	-	tetrasulfane	amino
hydrophobic	no	no	yes	no

* The tests were carried out with Sillitin N 82. This product is no longer available. Recommended: Sillitin N 75.

Course of action



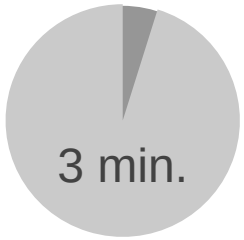
Compound preparation, extrusion and curing

Mixing	
Open mill	Ø 150 x 300 mm
Batch weight	ca. 1200 g
Mill temperature	50 °C
Mixing time	approx. 15 min.

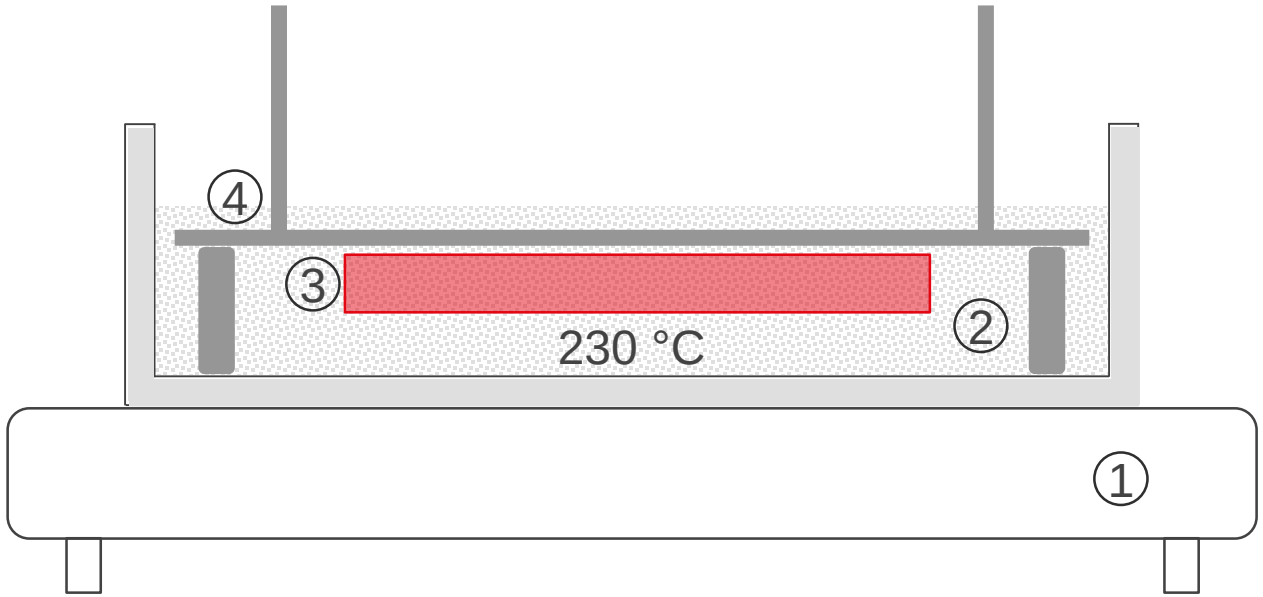
Extrusion, Band 30 x 2 mm	
Speed	3 m/min.
Temperature zone 1+2 / head	70 / 70 / 110 °C

Curing	
Salt bath	3 min. / 230 °C

Salt bath, schematic



1 heating plate
2 salt bath
3 sample
4 weight and spacers



Target values

- Density
- Compound costs
- Extrusion properties
- Electrical properties

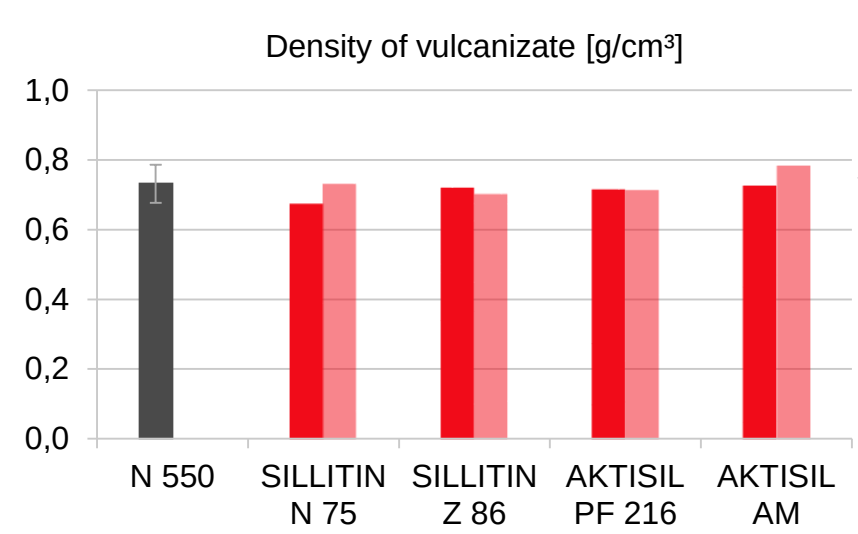
"base setting"

resulting from this

- Physical properties
- Cell structure and surface

Replacement of carbon black with Neuburg Siliceous Earth

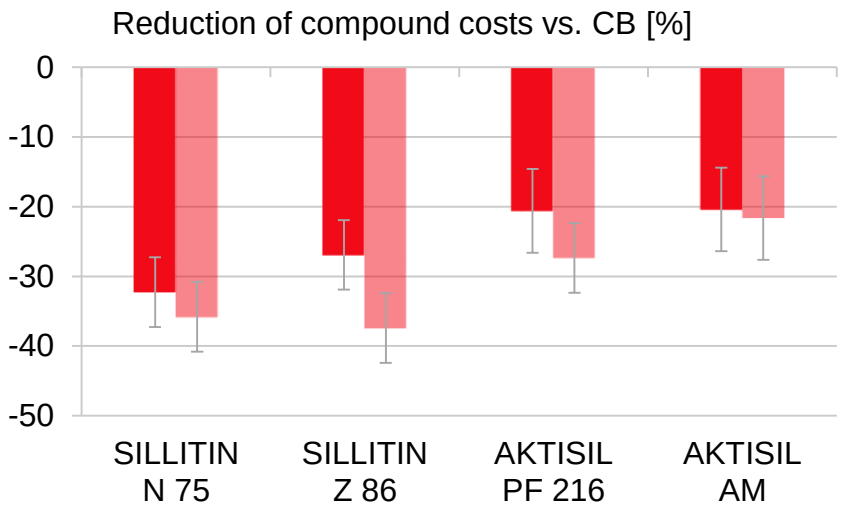
Base setting: consideration of density, costs, extrusion and electrical properties

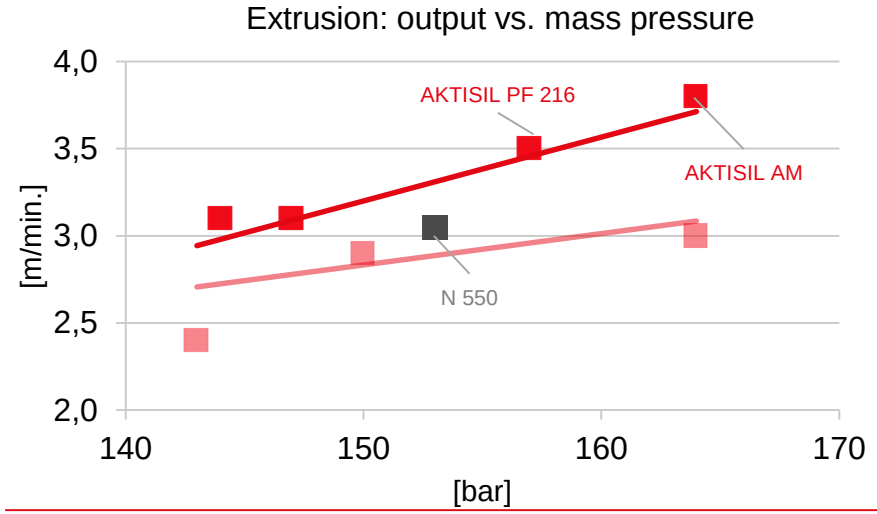


conductive non-conductive

Density comparable despite increased filler content

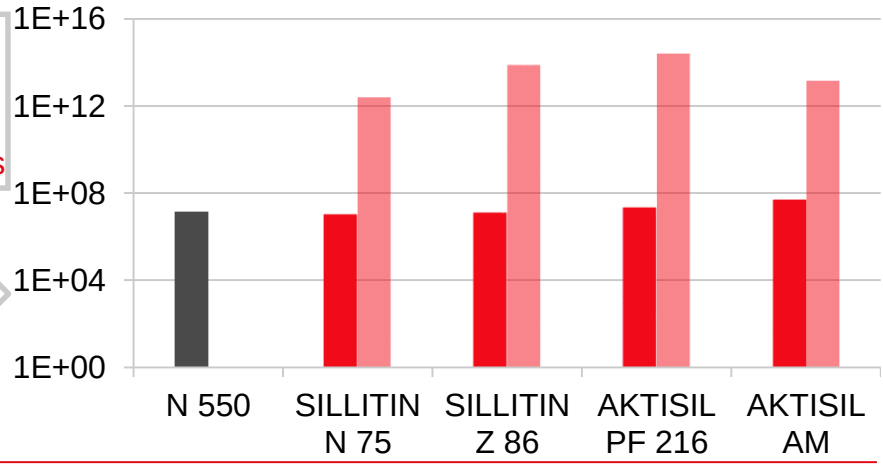
Compound costs significantly reduced
- with all NSE-grades
- esp. in non-cond. variants



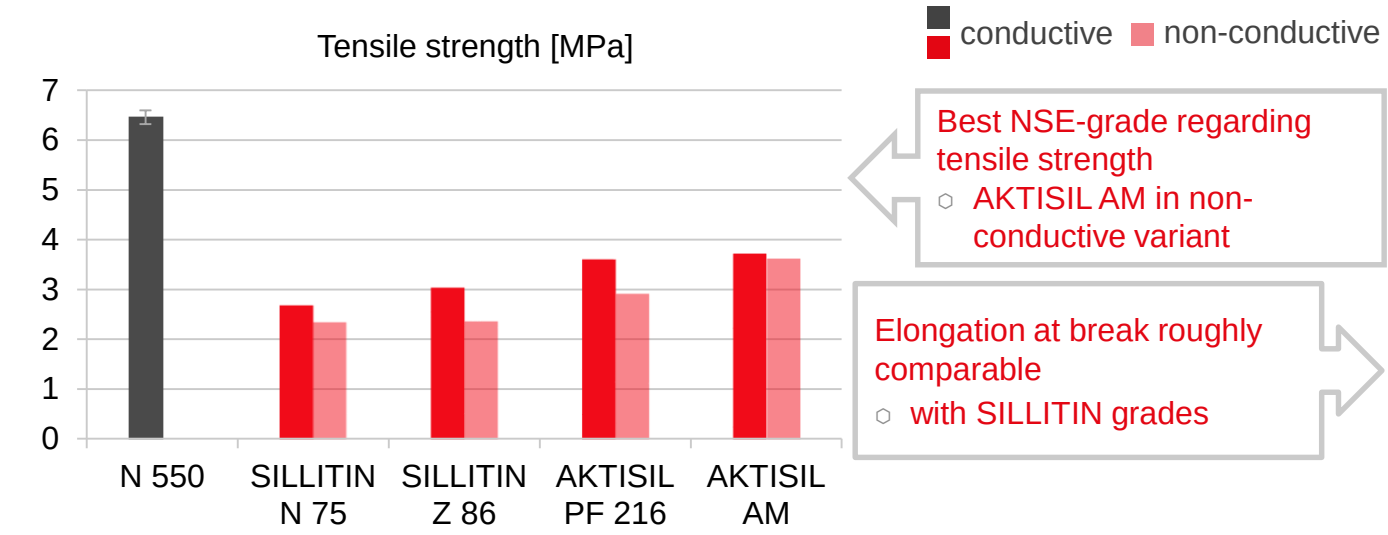


- Output comparable along with reduced pressure
- Output increased with AKTISIL gr. in cond. variants

Electrical resistance significantly increased
- with increased NSE-content

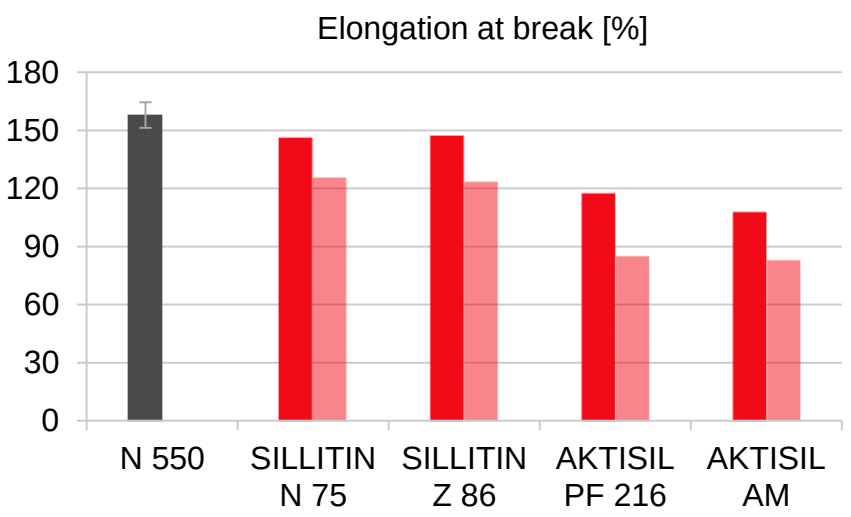


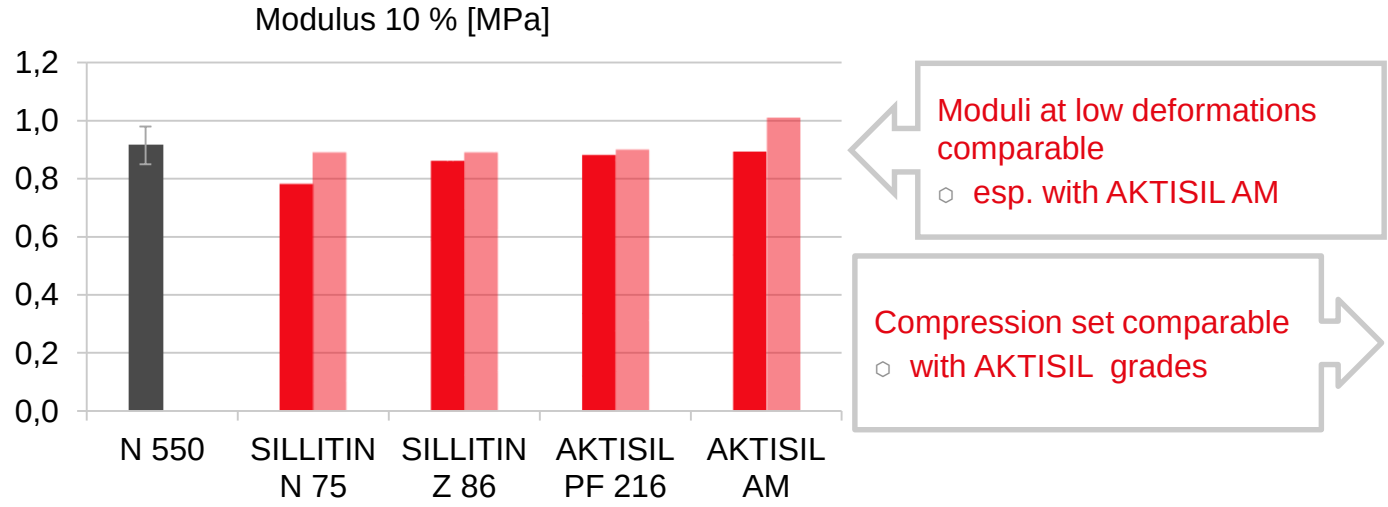
Physical properties resulting from base setting



Best NSE-grade regarding tensile strength
- AKTISIL AM in non-conductive variant

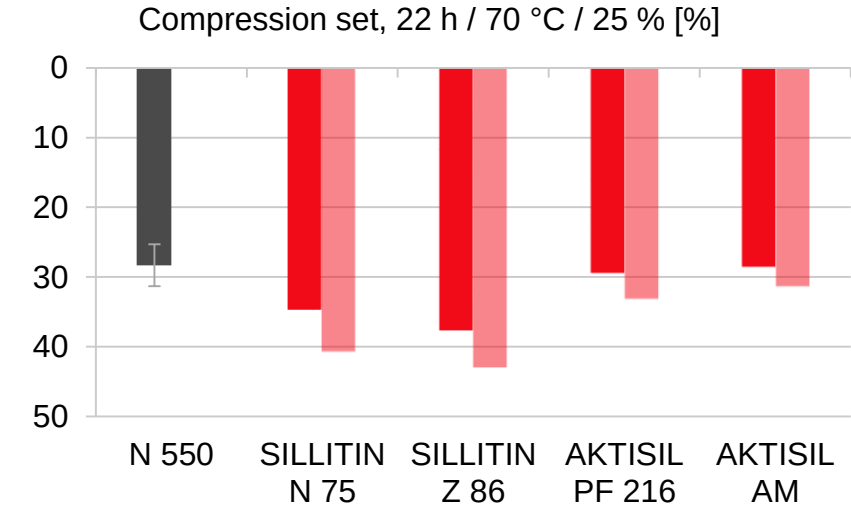
Elongation at break roughly comparable
- with SILLITIN grades



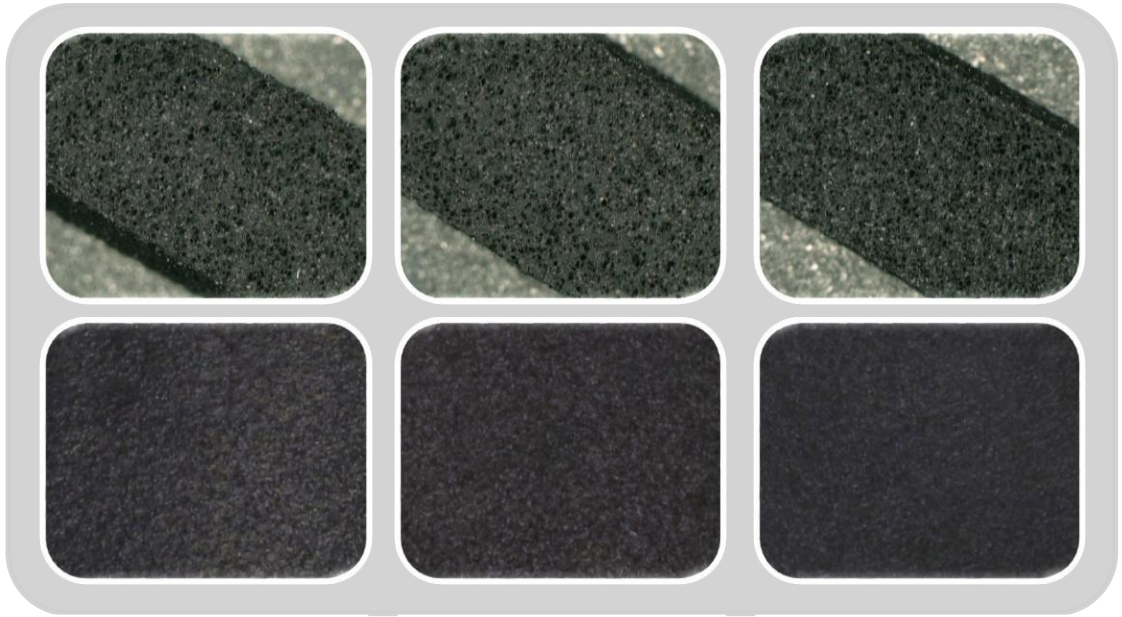


Moduli at low deformations comparable
- esp. with AKTISIL AM

Compression set comparable
- with AKTISIL grades



Cell structure and surface



	el. conductive filled with CB	**el. conductive** CB replacement	**non-conductive**
N 550	110	70	50
NSE	-	120	180

Cell structure

comparable

Surface

matting increased with increased NSE-content

larger images of the surfaces

Replacing carbon black with Neuburg Siliceous Earth

unchanged properties

- Cell structures comparable
- Density comparable despite increased filler content
- Output comparable along with reduced mass pressure
- Elongation at break roughly comparable with SILLITIN grades
- Moduli at low deformations comparable, esp. with AKTISIL AM
- Compression set comparable with AKTISIL grades

+ additional benefits

conductive

- Surfaces more matte
- Output increased with AKTISIL grades
- Significant reduction of compound costs, even with AKTISIL grades

non-conductive

- Surfaces even more matte
- AKTISIL AM for highest tensile strength among NSE-grades
- Significant increase in electrical resistance
- Significant reduction of compound costs, esp. with SILLITIN grades

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Results in tabular form

		conductive					non-conductive			
		N 550	SILLITIN Z 86	SILLITIN N 75	AKTISIL PF 216	AKTISIL AM	SILLITIN Z 86	SILLITIN N 75	AKTISIL PF 216	AKTISIL AM
Rheology, rotorless curemeter, 230 °C, 0.2° defl.										
M_{min}, 177 °C	min.	0.33	0.28	0.32	0.30	0.36	0.30	0.35	0.31	0.40
$M_{max-min}$, 177 °C	Nm	1.16	1.30	1.35	1.41	1.22	1.45	1.46	1.47	1.41
V_{max}, 177 °C	Nm/min.	3.6	4.1	4.0	4.1	4.0	4.5	4.5	4.4	4.5
t_{90}, 177 °C	min.	3.0	2.1	3.1	3.4	1.9	2.6	2.7	2.7	2.8
Extrusion, band (30 x 2 mm), 50 rpm, 70 / 70 / 110 °C (zone 1 / zone 2 / head)										
Output	m/min.	3.1	3.1	3.1	3.5	3.8	2.9	3.1	2.4	3.0
Mass pressure	bar	153	147	144	157	164	150	147	143	164
Mechanical properties, curing in salt bath 3 min. / 230 °C										
Density	g/cm³	0.73	0.67	0.72	0.72	0.73	0.73	0.70	0.71	0.78
Hardness	Shore A	63	57	61	60	62	60	59	63	66
Tensile strength	MPa	6.3	2.7	3.0	3.6	3.7	2.3	2.4	2.9	3.6
Modulus 10 %	MPa	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0
Elongation at break	%	158	146	147	117	108	125	123	85	83
Tear resistance	N/mm	4.6	3.1	3.3	3.1	2.8	2.8	2.8	2.4	2.6
Compression set 22 h / 70 °C / 25 %	%	28	35	38	29	29	41	43	33	31
Water absorption	%	0.2	0.7	0.9	0.5	0.4	0.4	0.4	0.4	0.3
Volume resistivity	Ω*cm	1.3×10^{7}	1.0×10^{7}	1.2×10^{7}	2.1×10^{7}	4.7×10^{7}	2.3×10^{12}	7.1×10^{13}	2.3×10^{14}	1.3×10^{13}

Detailed pictures of the surfaces

el. conductive
filled with CB

el. conductive
CB replacement

el. conductive
filled with CB

non-conductive

Test standards

Test	Standard
Hardness	DIN ISO 7619-1
Tensile strength	DIN 53 504, S2
Modulus 10 %	DIN 53 504, S2
Elongation at break	DIN 53 504, S2
Tear resistance	DIN ISO 34-1, A
Compression set [1]	DIN ISO 815-1, B
Volume resistivity	DIN IEC 93
Water absorption	ASTM D 1056

Thickness of the sheet from which specimens have been cut out:
approx. 3.5 - 4.5 mm

[1] 2 piled-up specimens used