Partial replacement of carbon black with Neuburg Siliceous Earth in cellular EPDM profile compounds

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Status Quo

cellular profiles	frequently used for automotive applications due to weight reduction
	often electrically insulating to avoid electrochemical corrosion
carbon black	pure only usable for conventional, electrically conductive applications
	strong dependence on crude oil prices
Neuburg Siliceous Earth	can also be used for electrically insulating applications
	hardly dependent on crude oil prices

Target Values

- Density
- Mechanical properties
- Electrical properties
- Cell structure
- Water absorption
- Compound costs

Replacement of carbon black with
Neuburg Siliceous Earth

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Base Formulation

Material	phr
Keltan 8550C	100
N 550	as indicated
Neuburg Siliceous Earth (NSE)	as indicated
Process Oil P 460	70
Zinkoxyd aktiv	8
Stearic acid	1
Kezadol GR	2.25
PEG 4000	2
Rhenogran DPG-80	1.1
Rhenogran MBT-80	2
Rhenogran ZBEC-70	2
Rhenogran TP-50	4
Sulfur	1.52
Rhenogran CLD-80	1
TRACEL K 3/95	2.5
TRACEL OBSH 75 EPR-1	1.9

Filler Combinations

in phr	**conventional** filled with CB	**conventional** replacement of CB	**non-conductive**
N 550 [vol.%]	18.8	15.3	11.9
N 550	85	70	55
NSE	-	30	60

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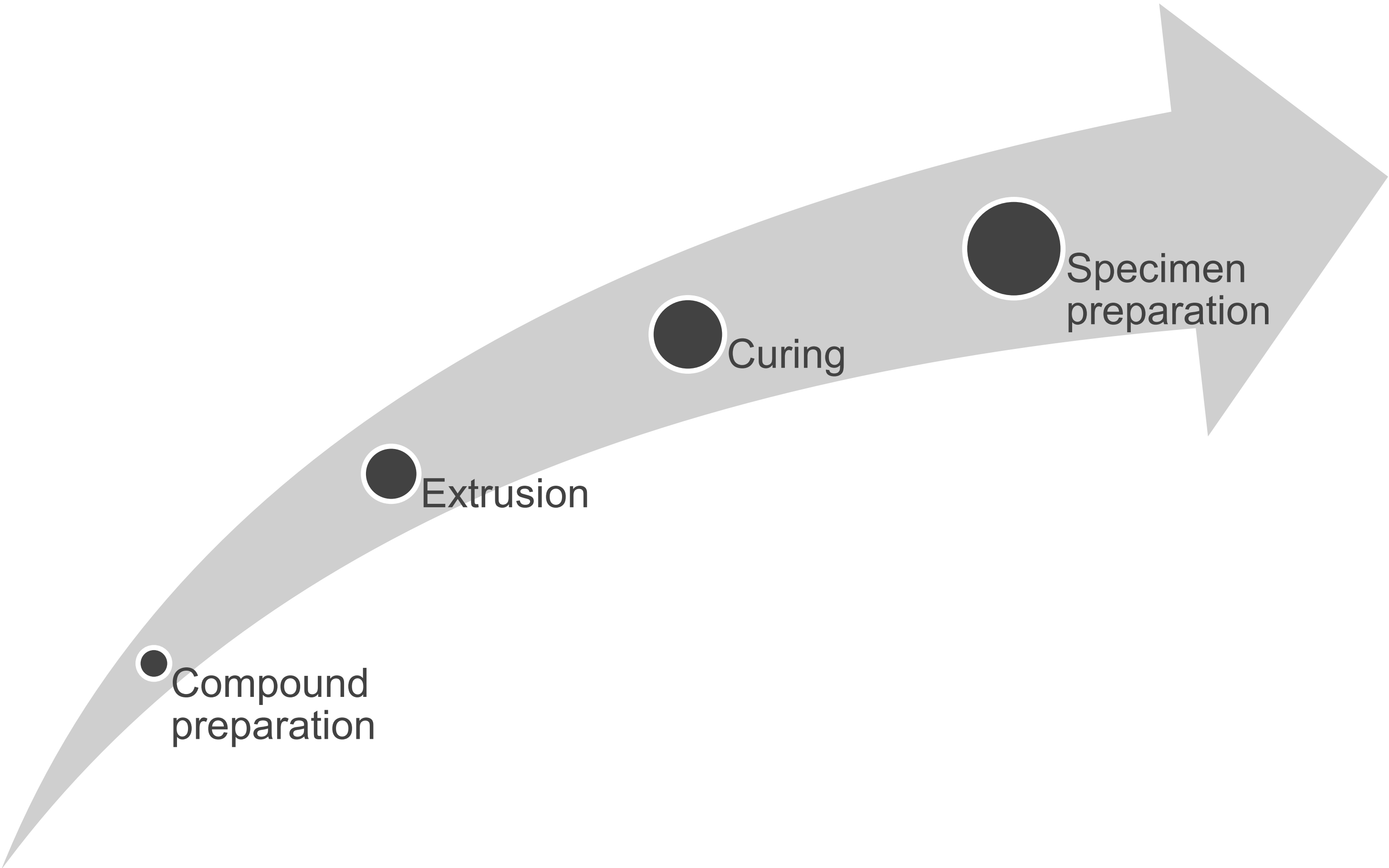
Fillers and Characteristics

Filler	Description	Functionalisation
N 550	carbon black, FEF	-
Sillitin P 87	Neuburg Siliceous Earth, d_{50}: 1.5 µm	-
Sillitin Z 86	Neuburg Siliceous Earth, d_{50}: 1.9 µm	-
Sillitin N 75*	Neuburg Siliceous Earth, d_{50}: 3.0 µm	-
Aktisil PF 216	Neuburg Siliceous Earth, d_{50}: 2.2 µm Basic material: Sillitin Z 86	tetrasulfane, hydrophobic
Aktifit PF 115	Calcined Neuburg Siliceous Earth, d_{50}: 2.0 µm Basic material: Silfit Z 91	amino, hydrophobic

*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

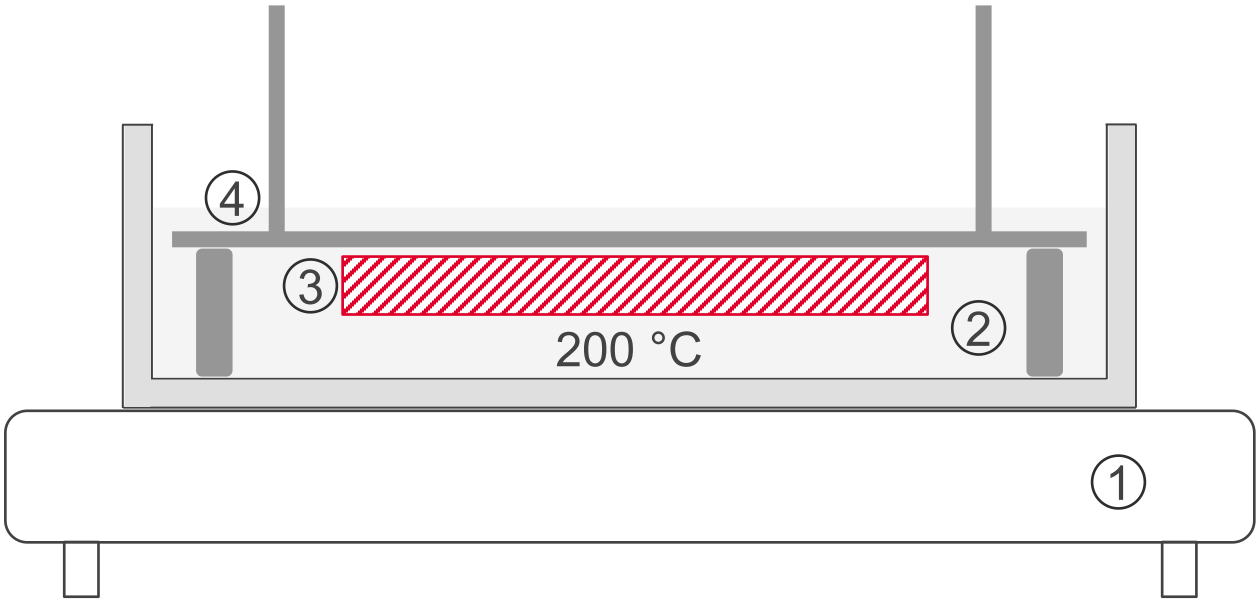
Mixing	
Open mill	Ø 150 x 300 mm
Batch weight	ca. 800 g
Mill Temperature	50 °C
Mixing time	approx. 15 min.

Extrusion, Band 30 x 2 mm	
Speed	3 m/min.
Temp. Zone 1+2 / Head	70 / 70 / 110 °C

Curing	
Salt bath	3 min. / 200 °C

Salt Bath, Schematic

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



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Test Standards

Test	Standard
Hardness	DIN ISO 7619-1
Tensile strength	DIN 53 504, S2
Modulus 100 %	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: 4-5 mm

[1] 2 piled-up specimens used

Density, foamed

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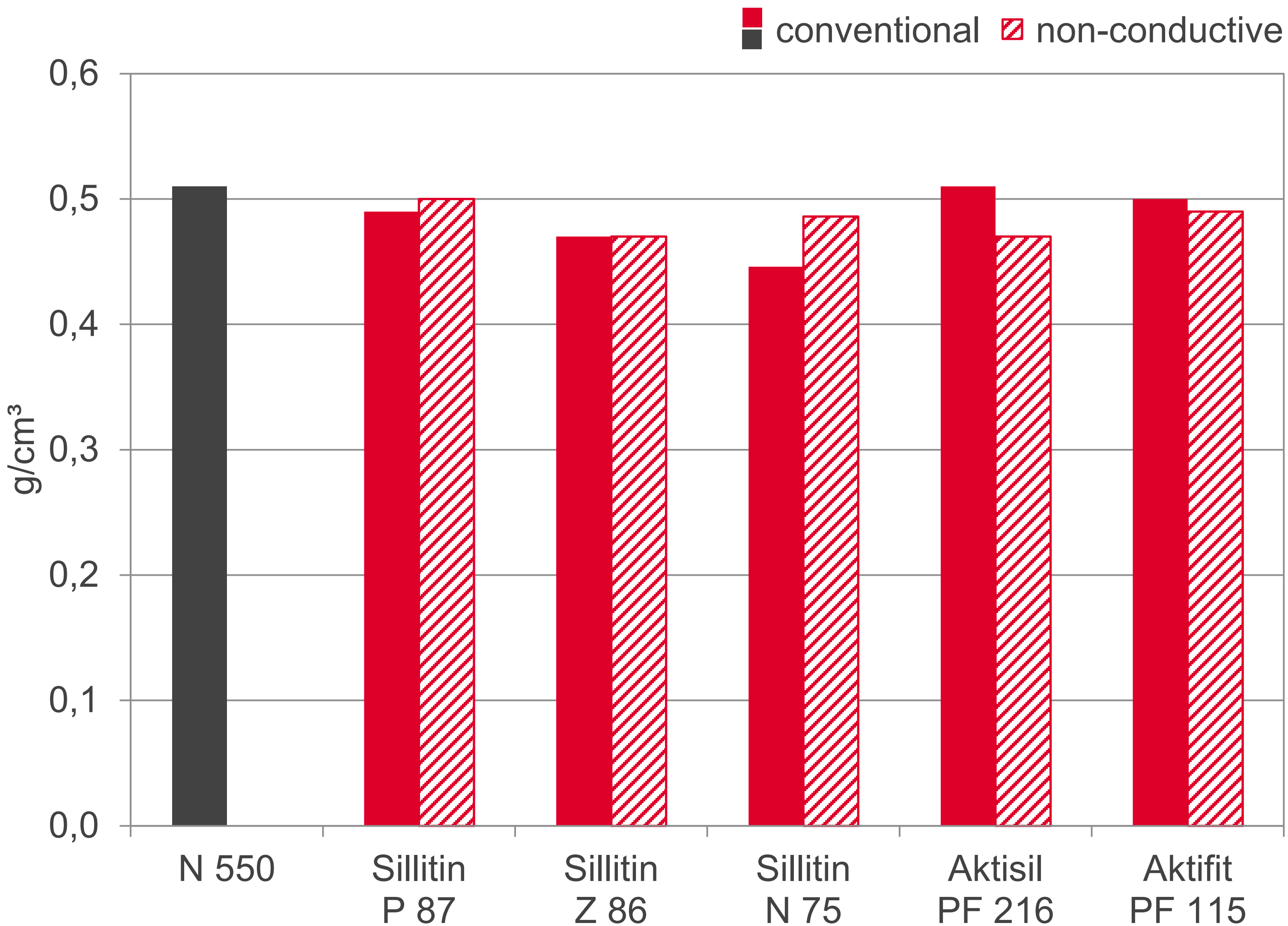

Hardness

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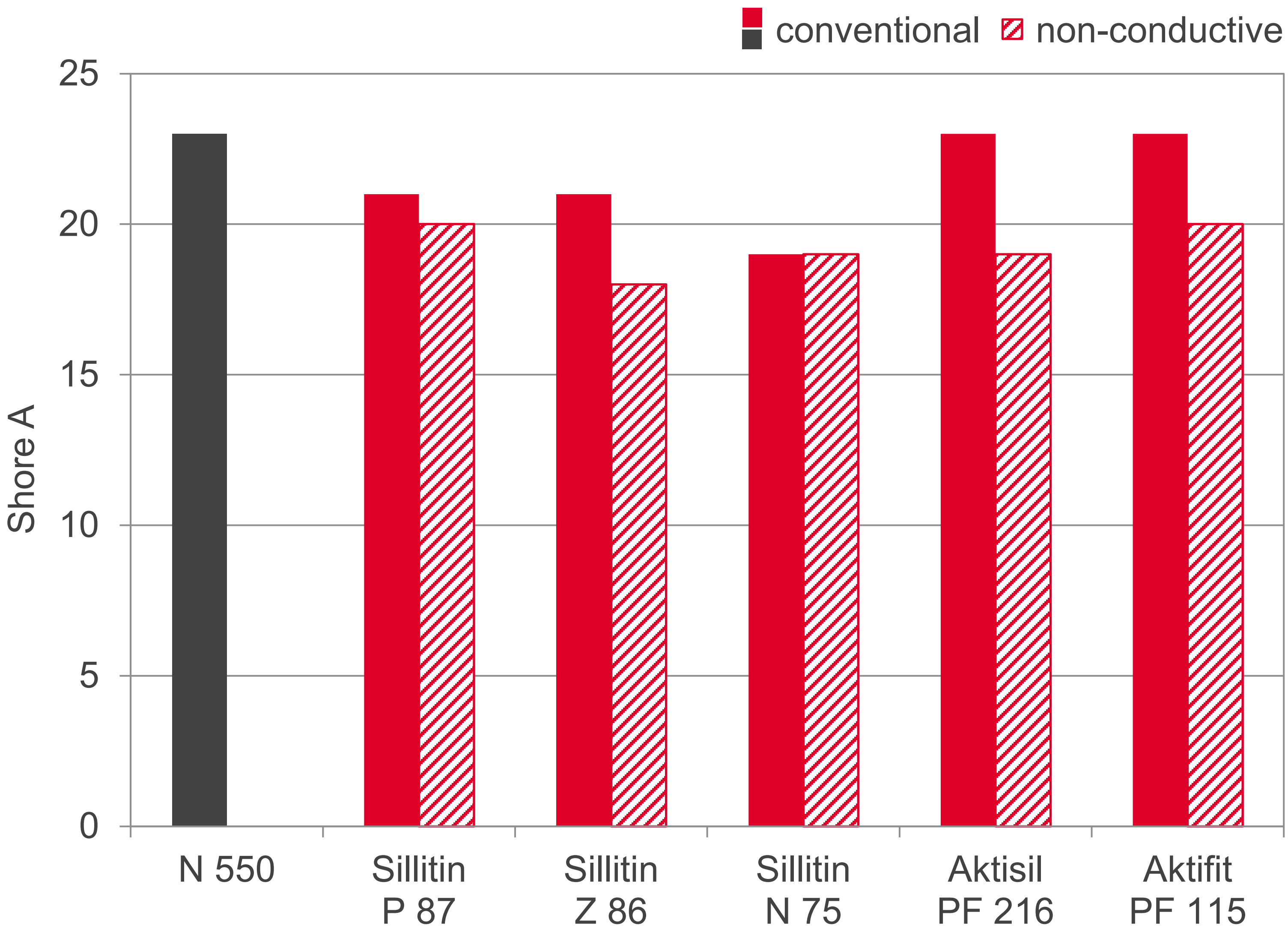
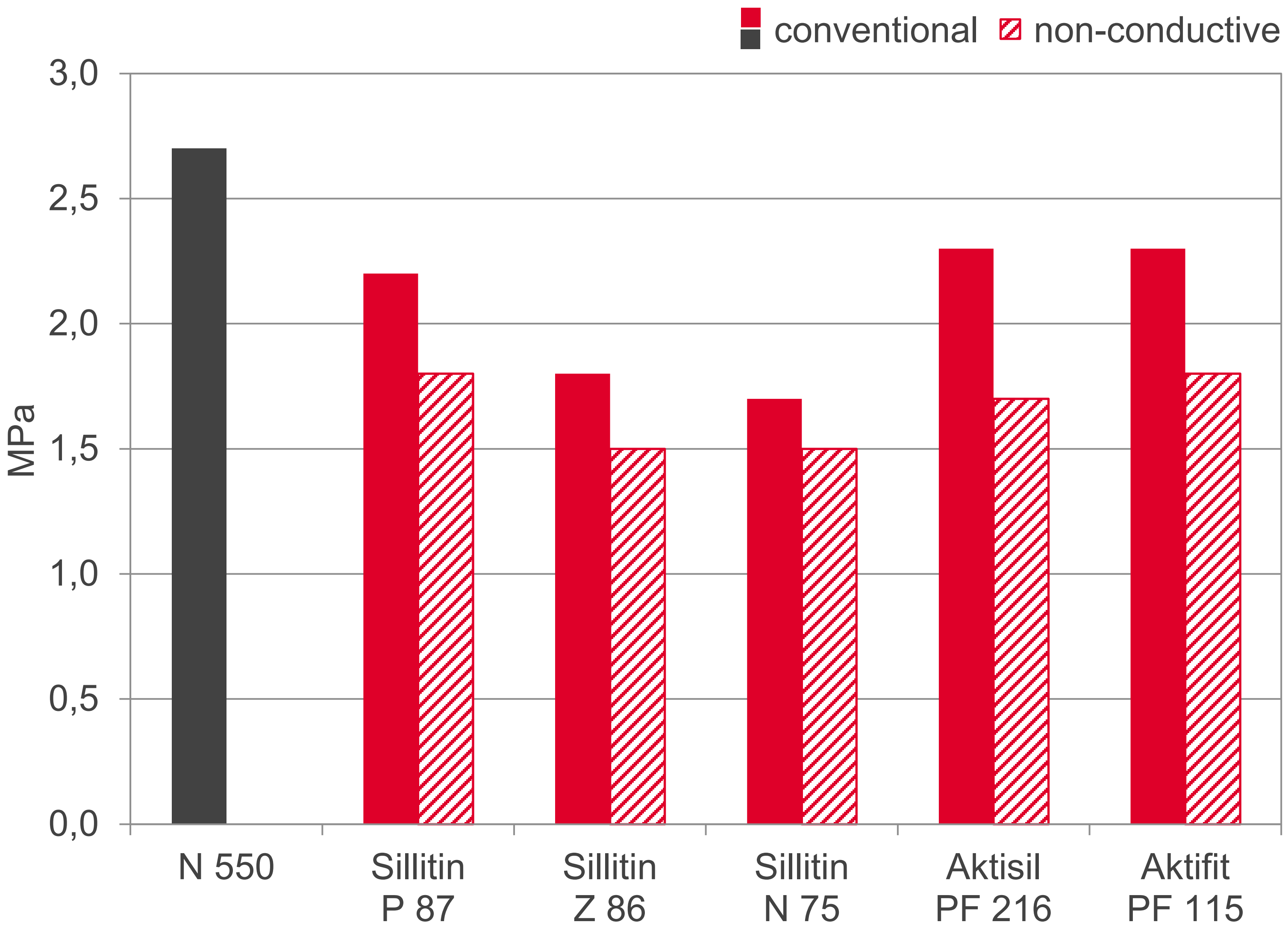
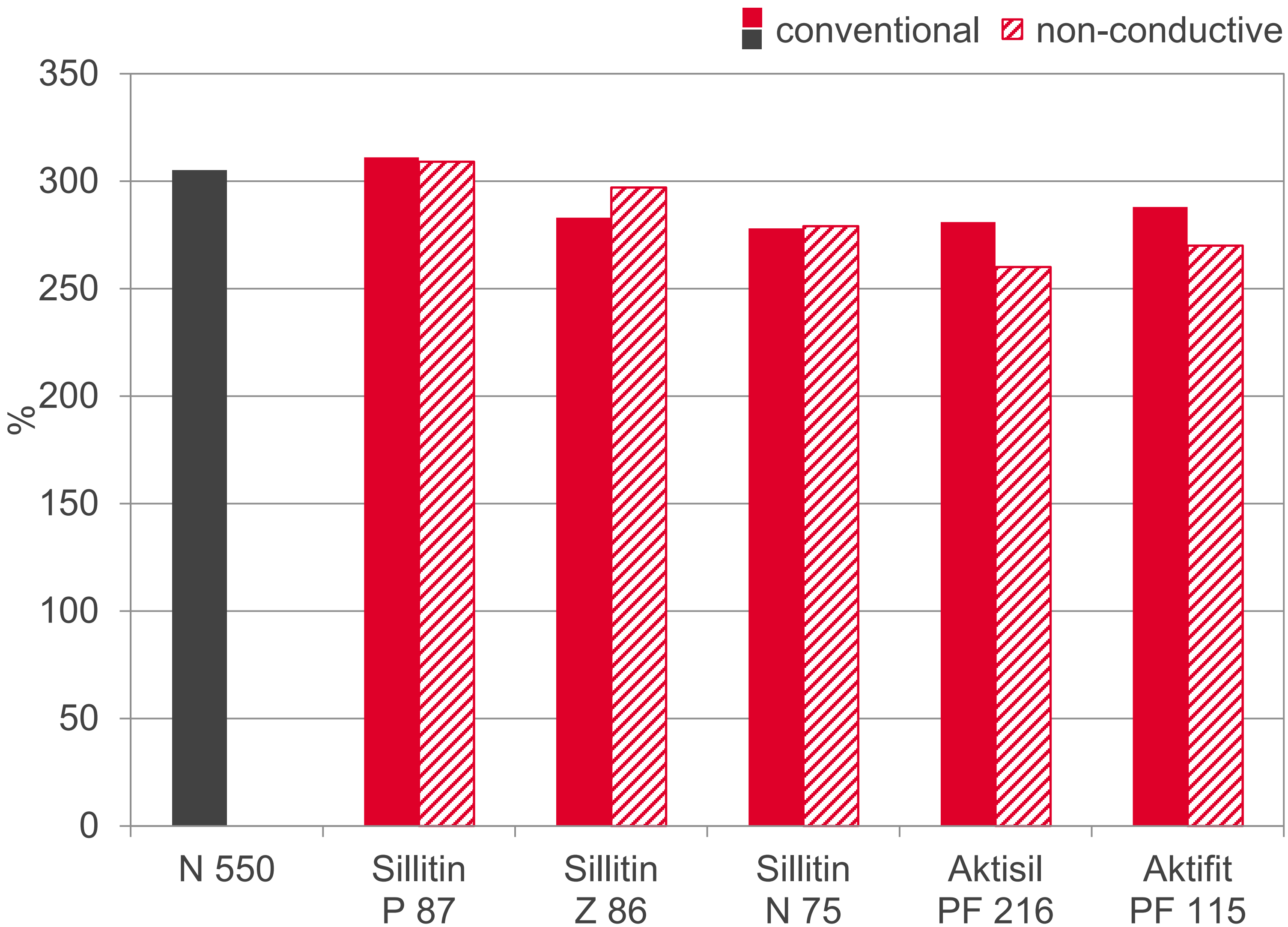


Tensile Strength



Elongation at Break



Modulus 100 %

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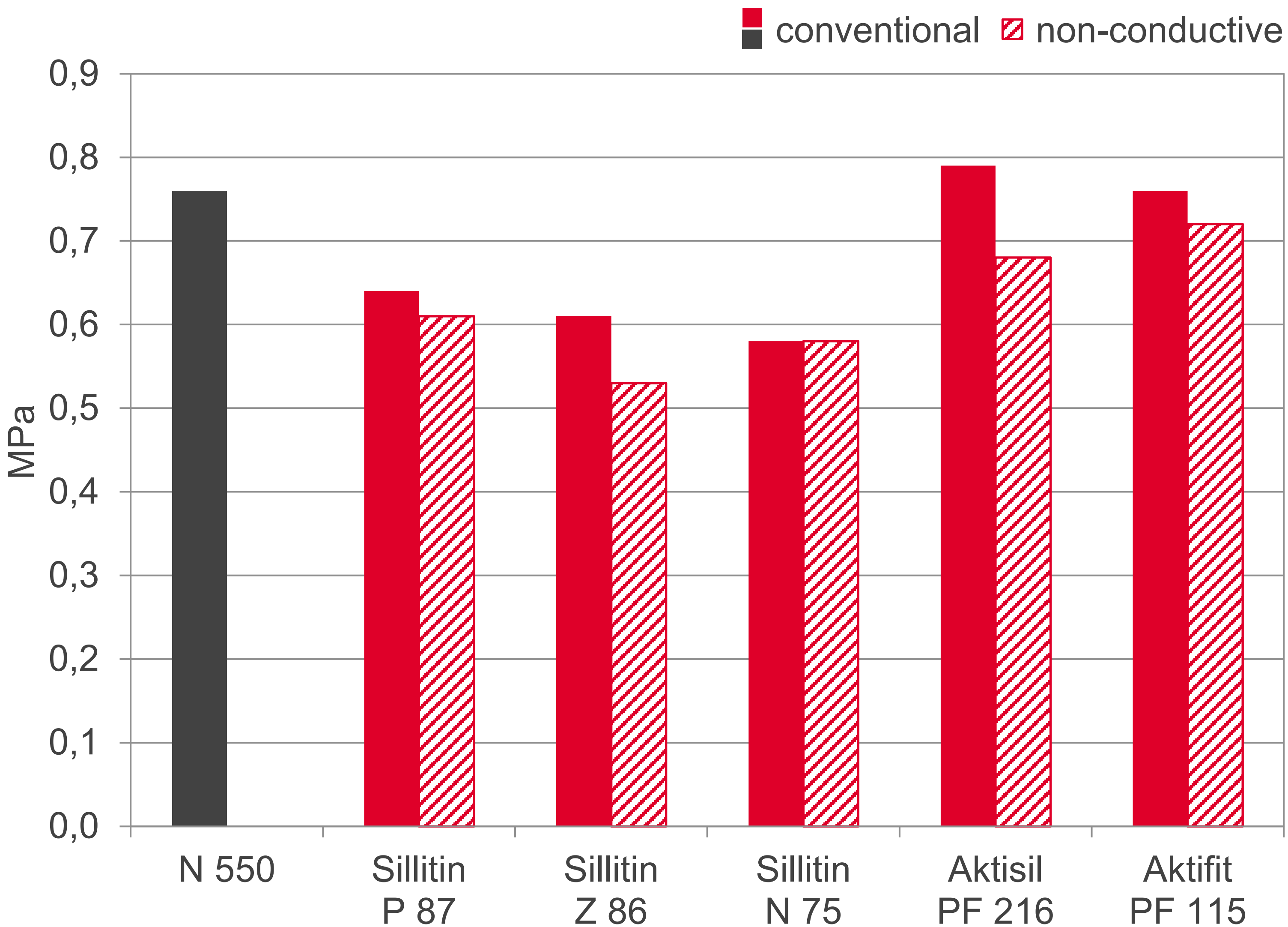

Tear Resistance

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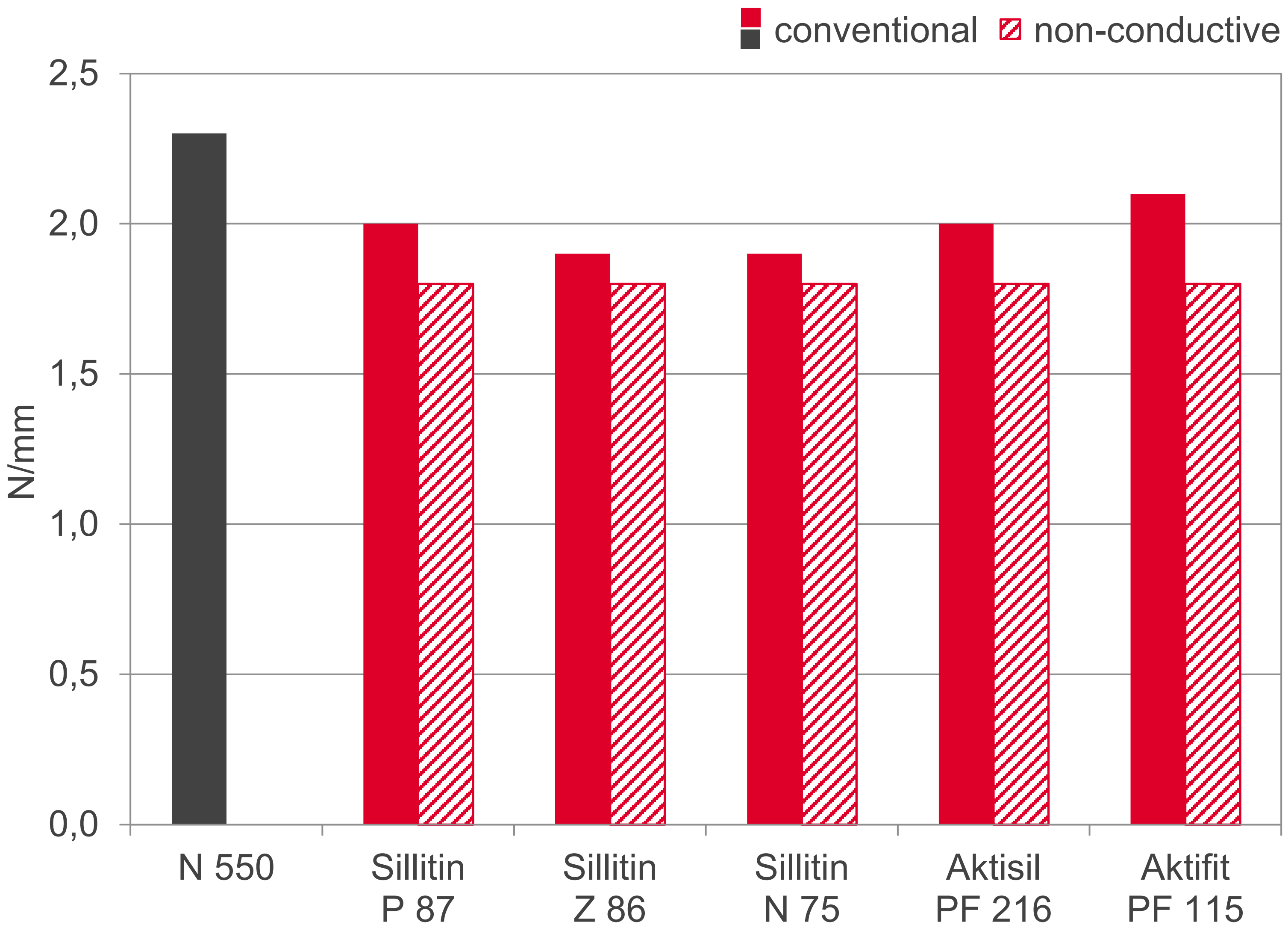

Compression Set
22 h / 70 °C, 50 % Deformation

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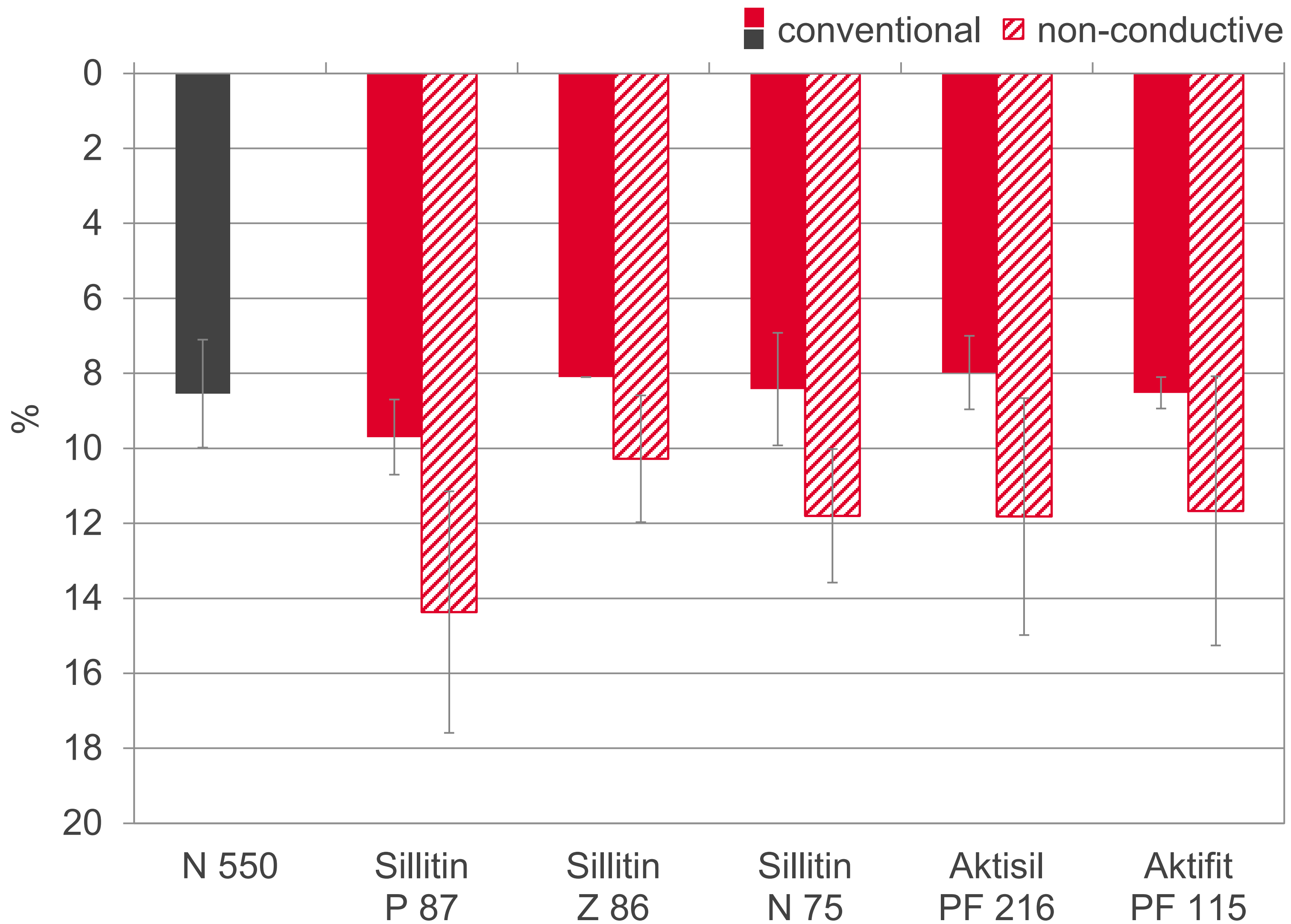

Volume Resistivity, 10 V

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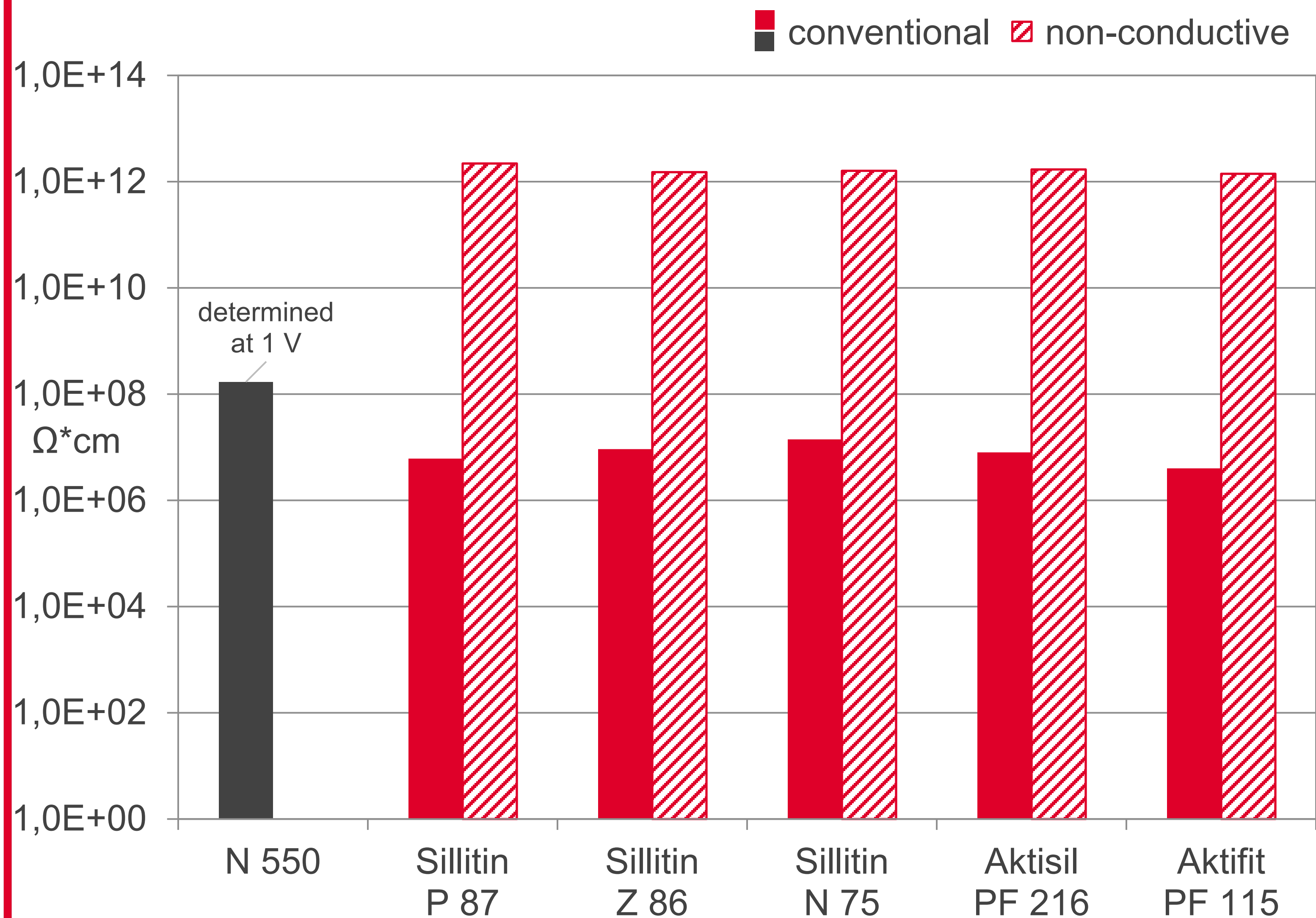
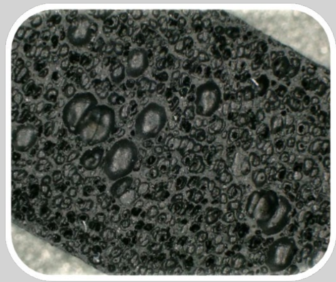
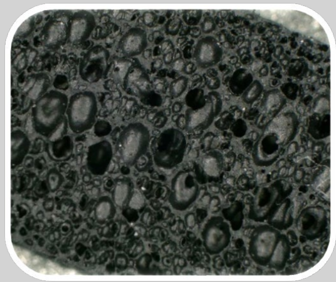
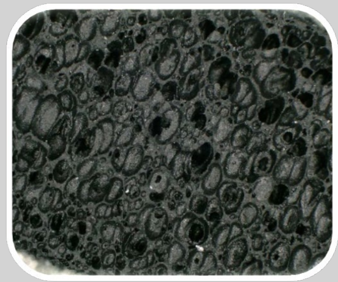


Cell Structure

			
N 550	85	70	55
NSE	-	30	60
	conventional filled with CB	**conventional** replacement of CB	**non-conductive**

comparable cell structures

Water Absorption, in a Vacuum

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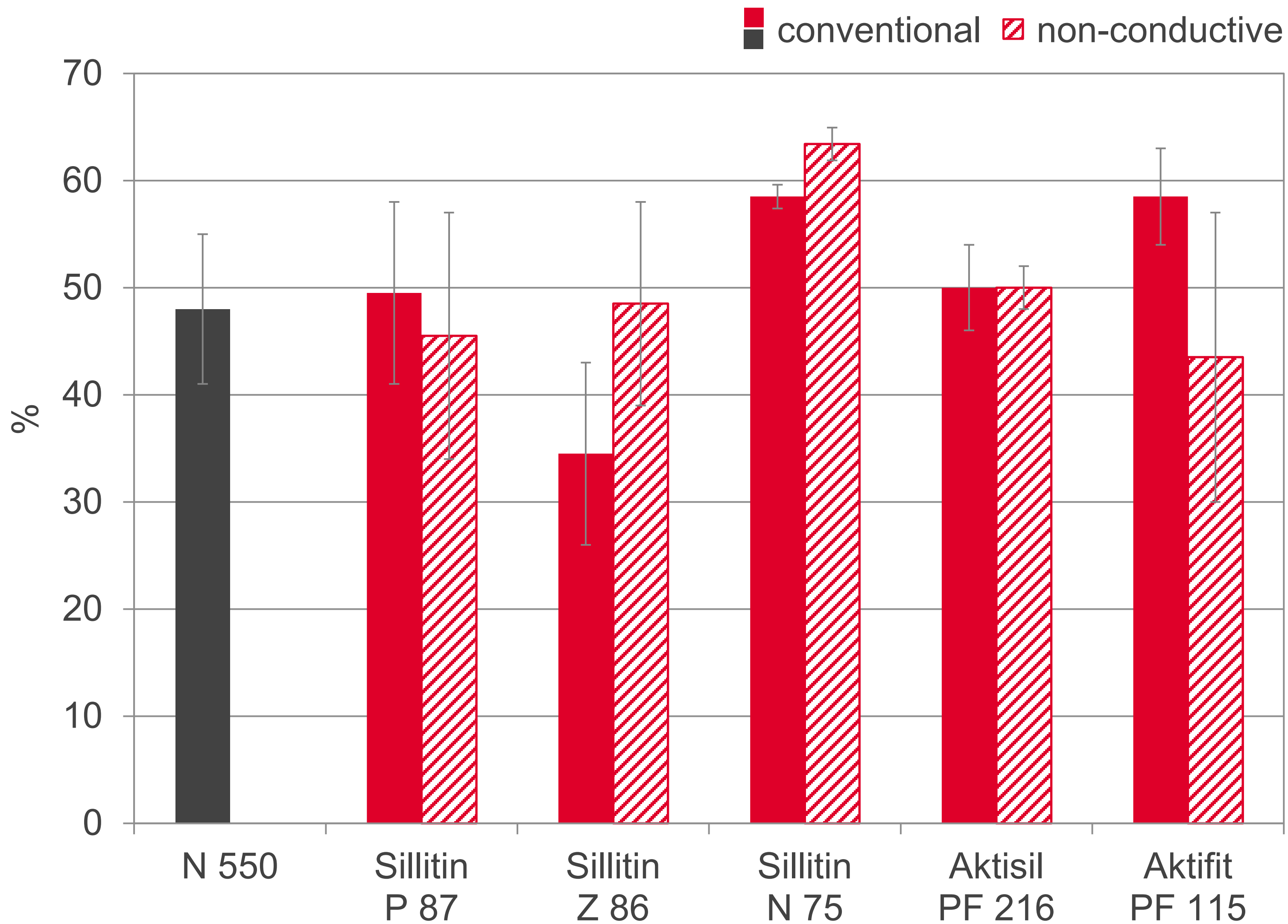
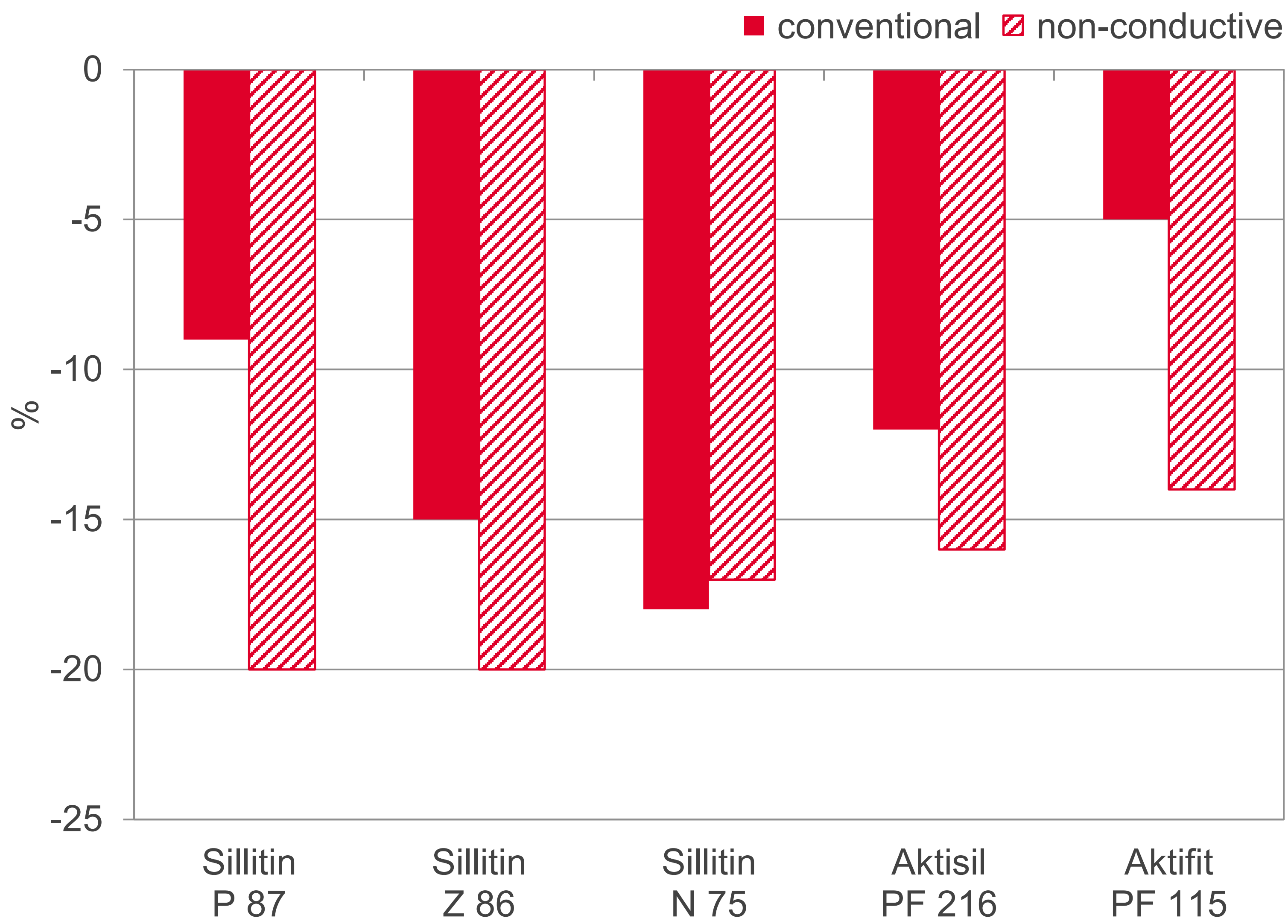
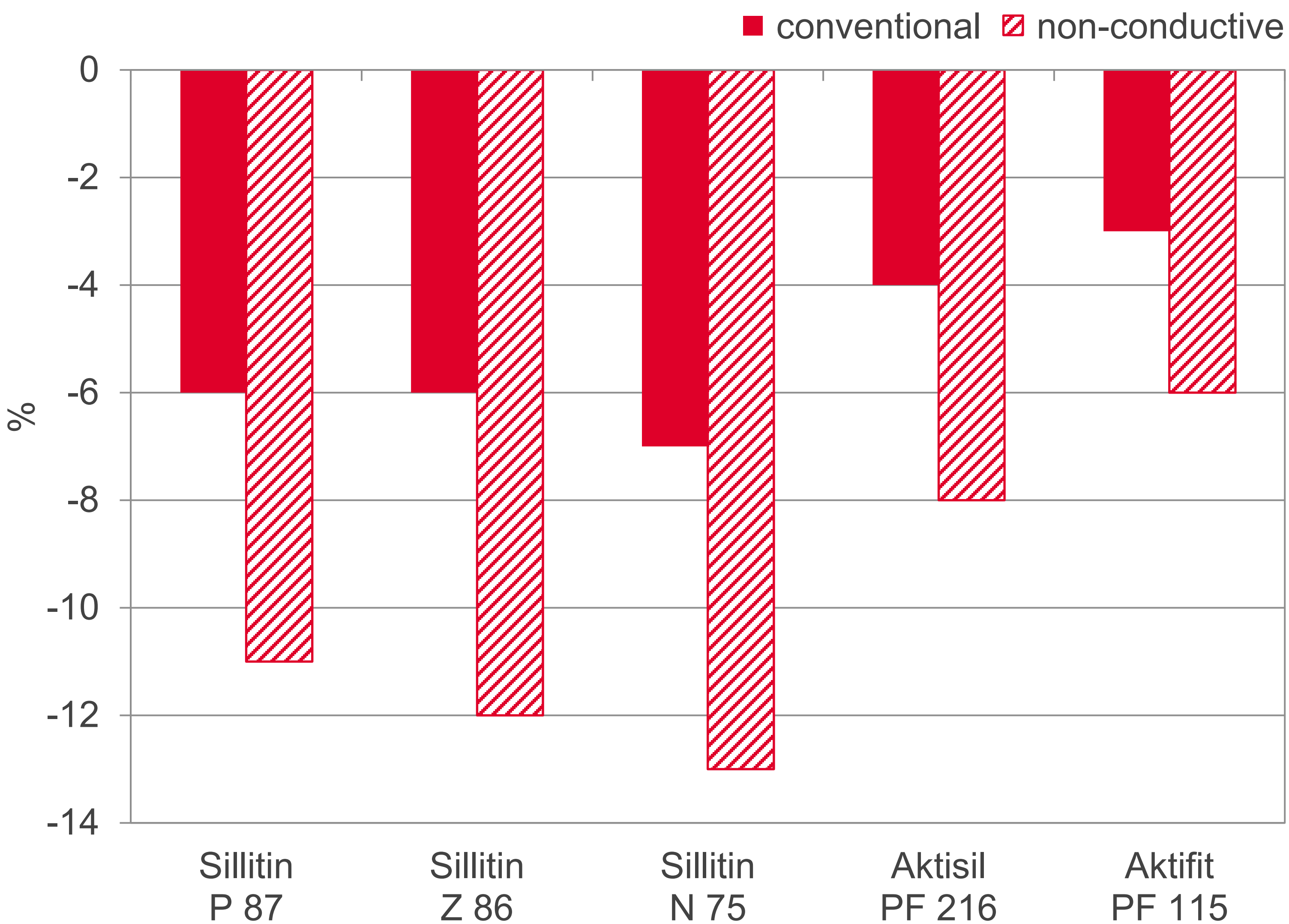


Compound Costs, Volume-related
NSE vs. N 550



Compound Costs, Weight-related
NSE vs. N 550



Conclusion
Replacement of CB N 550 with NSE

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conventional

- comparable cell structures
- comparable modulus level with Aktisil PF 216 and Aktifit PF 115 in the tensile test
- comparable compression set
- reduced water absorption with Sillitin Z 86
- partly significant reduction of costs

non-conductive

- comparable cell structures
- distinct increase of volume resistivity
- nearly comparable modulus level with Aktisil PF 216 and Aktifit PF 115 in the tensile test
- markedly reduced compound costs, even with functionalized NSEs

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APPENDIX

		conventional					
		N 550	Sillitin P 87	Sillitin Z 86	Sillitin N 75	Aktisil PF 216	Aktifit PF 115
Rheology							
Mooney viscosity, ML 1+2, 120 °C	MU	40	41	43	43	45	43
Mooney scorch ML +5, 120 °C	min.	5.0	4.6	4.5	4.5	4.4	4.6
Rotorless curemeter M_{max}-M_{min} 200°C	Nm	0.60	0.63	0.64	0.59	0.67	0.65
Rotorless curemeter V_{max} 200 °C	Nm/min.	1.27	1.25	1.33	1.32	1.31	1.31
Rotorless curemeter t_{90} 200 °C	min.	1.1	1.1	1.1	1.1	1.2	1.1
Curing in salt bath, 3 min. / 200 °C							
Density	g/cm³	0.51	0.49	0.47	0.45	0.51	0.50
Hardness	Sh. A	23	21	21	19	23	23
Tensile strength	MPa	2.7	2.2	1.8	1.7	2.3	2.3
Modulus 10 %	MPa	0.12	0.11	0.10	0.09	0.12	0.11
Modulus 100 %	MPa	0.8	0.6	0.6	0.6	0.8	0.8
Elongation at break	%	305	311	283	278	281	288
Tear resistance	N/mm	2.3	2.0	1.9	1.9	2.0	2.1
CS, 22 h / 70 °C, 50 % def.	%	8,6	9.7	8.1	8.4	8.0	8.5
Water absorption	%	48	50	35	59	50	59
Volume resistivity 10 V (N 550 at 1 V)	Ω*cm	1.7×10^8	6.1×10^6	9.2×10^6	1.4×10^7	8.0×10^6	4.0×10^6

Table of Results

		non-conductive				
		Sillitin P 87	Sillitin Z 86	Sillitin N 75	Aktisil PF 216	Aktifit PF 115
Rheology						
Mooney viscosity, ML 1+2, 120 °C	MU	39	42	43	42	41
Mooney scorch ML +5, 120 °C	min.	4.9	4.5	4.5	4.5	4.7
Rotorless curemeter M_{max}-M_{min} 200°C	Nm	0.57	0.60	0.61	0.59	0.58
Rotorless curemeter V_{max} 200 °C	Nm/min.	1.29	1.28	1.28	1.25	1.28
Rotorless curemeter t_{90} 200 °C	min.	1.3	1.2	1.1	1.2	1.1
Curing in salt bath, 3 min. / 200 °C						
Density	g/cm³	0.50	0.47	0.49	0.47	0.49
Hardness	Sh. A	20	18	19	19	20
Tensile strength	MPa	1.8	1.5	1.5	1.7	1.8
Modulus 10 %	MPa	0.11	0.09	0.10	0.10	0.10
Modulus 100 %	MPa	0.6	0.5	0.6	07	0.7
Elongation at break	%	309	297	279	260	270
Tear resistance	N/mm	1.8	1.8	1.8	1.8	1.8
CS, 22 h / 70 °C, 50 % def.	%	14	10	12	12	12
Water absorption	%	46	49	63	50	44
Volume resistivity 10 V	Ω*cm	2.2×10^{12}	1.5×10^{12}	1.6×10^{12}	1.7×10^{12}	1.4×10^{12}