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Silica Products Technical Service Bulletin
Industrial Rubber
April 20, 2016

PPG AGILON® Performance Silica and Carbon Black Cross Reference for Developing Non-Black Compounds

Choosing a reinforcing filler to replace carbon black for developing new non-black rubber products can be a difficult process. Physical properties for your black compound, like low compression-set and heat build-up, along with good abrasion resistance and tensile strength need to be similar for your new one.

What reinforcing material do you turn to for providing reinforcement? The top choice is PPG's AGILON® performance silica. *Agilon* performance silica is pre-silanized silica. It's pre-treated with mercapto-silane (a sulfur silane) during the precipitation step of silica manufacturing allowing you to achieve the benefits of a silane-coupled silica without the added complexity and time required to incorporate free silane during the rubber mixing process. In addition, since PPG adds the silane, you are left with a more environmentally responsible solution that eliminates more than 99 percent of the alcohol-related VOC emissions compared to traditional silica + silane mixing.

The use of *Agilon* performance silica as a main reinforcing filler in black and non-black compounds has been growing. *Agilon* performance silica can provide additional dynamic property benefits that some non-treated highly reinforcing silica products can't, for example: reduction in heat build-up and lower dynamic-set. *Agilon* performance silica bridges the gap between carbon black and silica regarding abrasion resistance, non-black compounds can now exhibit the same abrasion resistance as black ones.

To show the benefits of *Agilon* performance silica in relation to carbon black, we have evaluated these materials in an EPDM, single pass recipe. The compounds were mixed in a 4-Wing internal mixer using good laboratory practices and ASTM D3182 as our guide.

	<i>Agilon 400G-D</i>	<i>Agilon 454G-D</i>	<i>Agilon 458G-D</i>
N₂ (BET-5) Surface Area, m²/g	75	140	115
Effective surface area, m²/g	140	200	200
SH, Wt. %	0.5	0.5	0.5
Carbon, Wt. %	4.0	4.0	6.0
pH	6.5	6.5	6.5

Formula (Density: Carbon Black = 1.080, Agilon 1.090)

Keltan 5469Q - 100, Keltan 4450S DE - 50, Struktol WB-212 - 2, AC-6 PE - 3, UM Blue - 3, Carbon Black & Agilon - 60, Natka 1200 Clay - 15, Naphthenic Oil - 8, Stearic Acid - 2, Mastermix 5594 ZnO (80) - 10, Mastermix Sulfur 4194 (80) - 1.3, Mastermix TBBS 4184 (75) - 2.7 ZDBC Polybound 393 (75) - 2, Mastermix MBS 5567 (50) - 4

Processing and Cure - Process viscosity at operating temperatures are typically lower for carbon black when compared to non-treated silica but *Agilon* 400G-D silica matches processing ease. *Agilon* performance silica provides excellent scorch safety at processing and curing temperatures while maintaining similar cross-link density.

Processing	N110	N220	N330	N339	N550	N650	N774	N990	Agilon 454G	Agilon 400G	Agilon 458G
Mooney Plasticity											
ML 1+4, 100°C, MU	61.6	60.8	56.3	60.9	59.1	59.6	52.8	45.0	71.1	60.2	64.6
Mooney Scorch											
MS @ 135°C, T5 rise, minutes	15.8	13.7	15.3	14.4	16.6	16.8	19.5	23.0	24.1	14.9	20.2
MDR 2000 @ 170°C, 1° arc											
MV, dNm	2.8	2.7	2.5	2.6	2.2	2.3	2.0	1.7	3.7	2.6	2.9
MH, dNm	19.0	18.4	17.7	17.3	17.1	17.2	15.9	15.1	19.0	18.0	19.4
MH-ML, crosslinking, dNm	16.1	15.7	15.2	14.7	14.8	14.9	14.0	13.3	15.3	15.4	16.5
Ts2, minutes	2.3	2.2	2.4	2.2	2.8	2.8	3.1	3.8	3.2	3.0	3.1
TC90, minutes	5.6	5.1	5.3	4.9	5.5	5.5	6.0	6.7	6.7	6.0	6.1

Durometer - *Agilon* 454G and *Agilon* 458G silicas are similar in hardness to the higher structure blacks like N110, N220, N330, and N339 whereas *Agilon* 400G-D silica is similar to N550 up to 774. In most cases, *Agilon* performance silica has less hardness change under heated conditions.

	N110	N220	N330	N339	N550	N650	N774	N990	Agilon 454G	Agilon 400G	Agilon 458G
Shore A Durometer											
23°C	60	60	59	61	56	56	57	51	60	56	58
100°C	53	54	53	52	51	52	52	47	56	52	54

Tensile Strength and Tear Resistance - *Agilon* performance silica provides equal or better tear resistance as measured by Die C. Tensile properties such as breaking strength and modulus are equal or better than the carbon blacks used in this study.

	N110	N220	N330	N339	N550	N650	N774	N990	Agilon 454G	Agilon 400G	Agilon 458G
Die C Tear Resistance, N/mm	30.3	29.8	29.9	30.9	27.7	27.5	22.9	14.5	35.9	28.4	29.0
Tensile Properties - Original											
Tensile Strength, MPa	16.5	16.8	17.8	17.0	12.8	11.4	9.7	3.3	19.1	15.0	13.2
Elongation, %	615	609	621	587	552	552	597	430	731	611	620
300% Modulus, MPa	4.5	5.2	5.0	5.6	5.9	5.9	4.1	2.8	4.0	5.3	4.9

Compression-Set – *Agilon* 400G silica provides similar set resistance as the carbon blacks evaluated in this study.

	N110	N220	N330	N339	N550	N650	N774	N990	Agilon 454G	Agilon 400G	Agilon 458G
Compression Set, %	52.7	53.4	54.3	49.3	56.3	50.9	52.2	57.0	62.6	53.9	55.3

Dynamic Properties – *Agilon* 400G and *Agilon* 458G silicas provide similar permanent set, HBU, and dynamic compression as the higher structure carbon blacks used in this study. All of the *Agilon* performance silica products provide better static compression resistance than the blacks.

	N110	N220	N330	N339	N550	N650	N774	N990	Agilon 454G	Agilon 400G	Agilon 458G
Goodrich Flexometer: Stroke - 22.5%, Load - 1 MPa, Temp. - 100°C											
Static Compression, %	26.7	24.2	26.5	25.1	25.7	25.7	28.7	30.3	23.2	24.5	23.0
Dynamic Compression, %	15.0	14.0	16.2	15.4	12.8	13.0	16.2	18.2	18.8	14.1	13.4
Permanent Set, %	5.2	4.1	4.4	7.5	4.2	4.2	4.3	5.0	10.3	5.0	5.8
HBU, °C	24	23	21	22	18	19	16	13	23	16	18

As seen from the above data, *Agilon* performance silica is the clear choice for compounders seeking a reinforcing filler for developing new neutral and colored rubber compounds used in both static and dynamic applications. Additional benefits of using *Agilon* performance silica are obtained in relation to improved tensile strength, abrasion and tear resistance.

Agilon performance silica is available in both granule and powder form. Furthermore, *Agilon* performance silica products may be used as intended in the manufacture of repeated-use rubber food-contact articles, and that such use complies fully with the Federal Food, Drug, and Cosmetic Act and all applicable food additive regulations, including the applications described under Section 177.2600.

For additional information, please visit: <http://www.ppgsilica.com/Applications/Rubber/Industrial-Rubber.aspx>