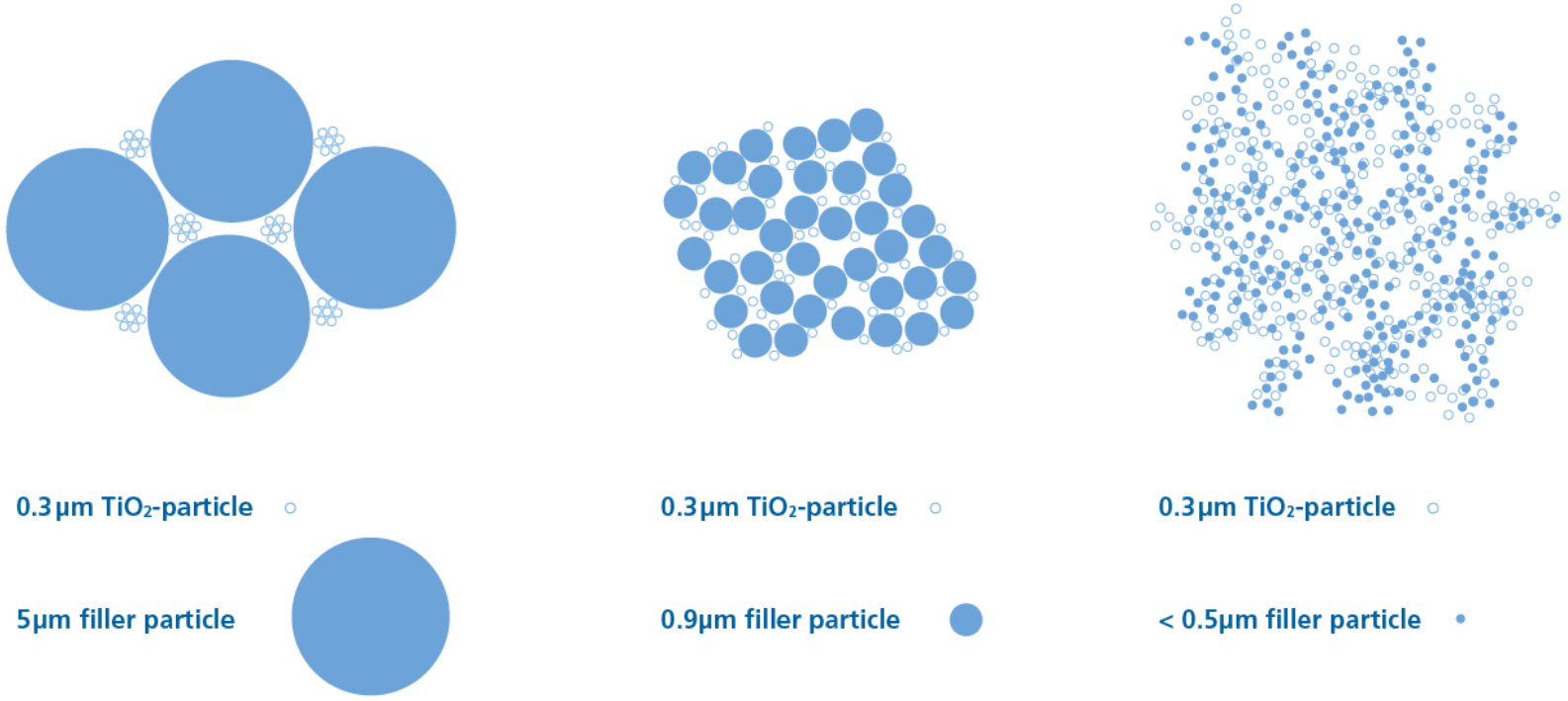
Innovative Calcium Carbonate for TiO2 Extension

TiO2 Market

- Global TiO2 market size valued at USD 18.82 billion
- (CAGR) of 6.3% from 2023 to 2030
- Paints and Coatings Industry – Primary User

Optimizing Dispersion of TiO2



Smaller particle size

Improved spacing effect

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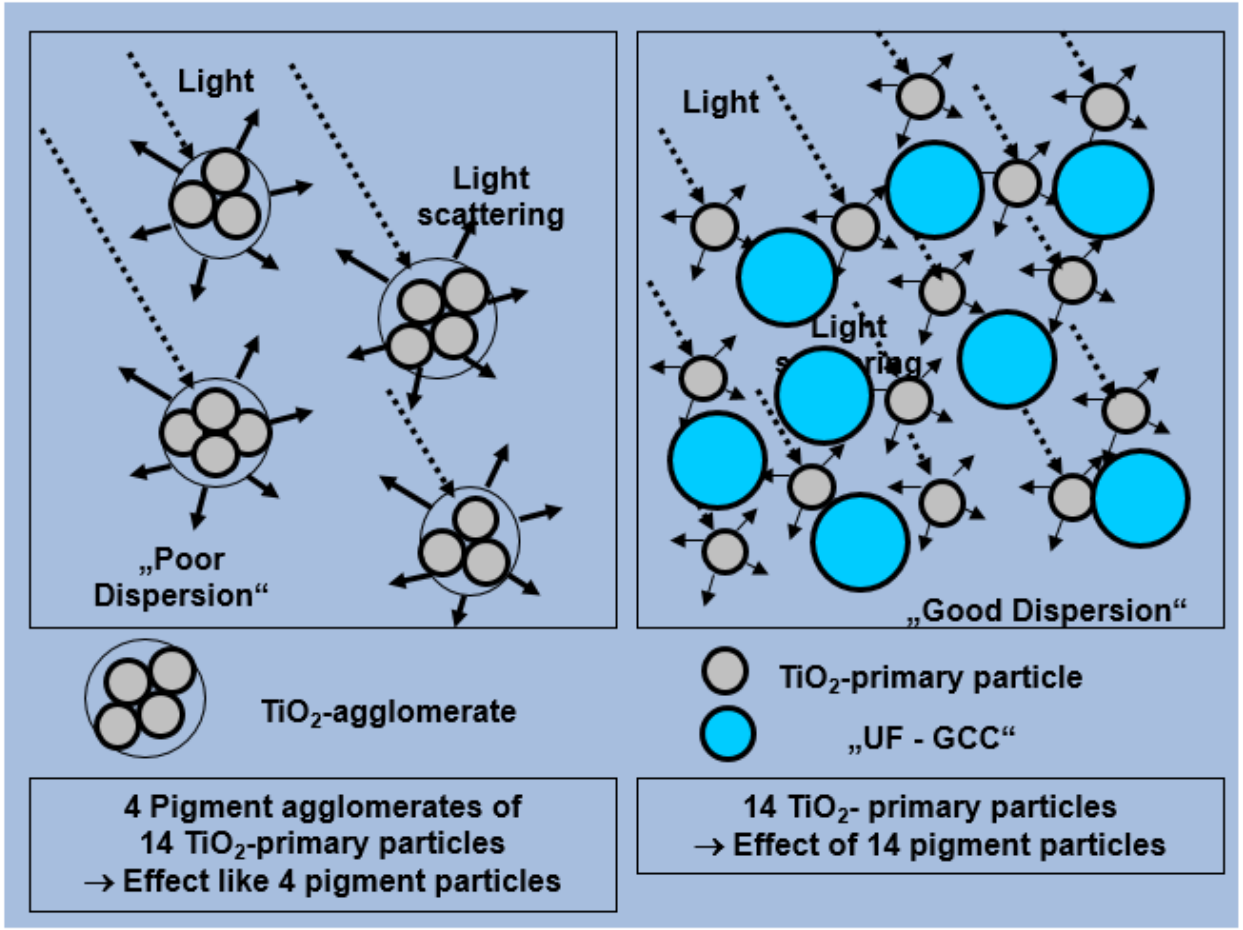
Functional CaCO3 Provide Spacing of TiO2

to prevent re-agglomeration or crowding of TiO_2 particles



Conventional methods of Boosting Opacity

Technology	Pros	Cons
Opaque Polymer	Increase dry hide through air voids	Negative impact to wet hide
Pre-composite polymer	Increases the scattering efficiency	Ease of formulation
Kaolin Clay	Reduction of crowding effect	Negative impact to wet hide
PCC / TiO2 blend	Uniform distribution of TiO2	Cost is indexed to TiO2

Development Challenge

Replace 10-15% TiO_2 by weight with 0.3 µm d50 ground calcium carbonate product while also:

- Having no negative impact to optical properties
  - Gloss, Brightness, Opacity, Color
- CIE ΔE* Avg of 0.3 or less when tinted
- Easily dispersible
- Stable during storage

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Particle Size and Solids of Samples

	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Description	0.3 µm slurry v1	0.7 µm dry	1.4 µm dry	0.3 µm slurry v2	0.3 µm dry	0.3 µm dry humid storage	0.3 µm dry treated v1
% Wt Solids	73.8	100	100	74.3	100	100	100
D50 median micron	0.29	0.7	1.4	0.41	0.28	0.76	0.42
D98 top cut micron	1.3	3.3	6	1.6	1.2	19.5	1.06

	Sample H	Sample I	Sample J	Sample K	Sample L	Sample M	Sample N
Description	0.3 µm dry treated v2	0.9 µm dry	0.3 µm dry treated v3	0.3 µm dry treated v4	0.3 µm dry treated v5	0.3 µm dry treated v6	0.3 µm dry treated v1 humid storage
% Wt Solids	100	100	100	100	100	100	100
D50 median micron	0.4	0.89	0.39	0.39	0.37	0.36	0.4
D98 top cut micron	1.02	3.88	9.81	5.39	2.6	1.84	1.03

Sample Selection

Sample	Description	Surface Treatment
Sample A	0.3 µm slurry v1	No
Sample B	0.7 µm dry	No
Sample C	1.4 µm dry	No
Sample D	0.3 µm slurry v2	No
Sample E	0.3 µm dry	No
Sample F	0.3 µm dry humid storage	No
Sample G	0.3 µm dry treated v1	Yes
Sample H	0.3 µm dry treated v2	Yes
Sample I	0.9 µm dry	No
Sample J	0.3 µm dry treated v3	Yes
Sample L	0.3 µm dry treated v4	Yes
Sample K	0.3 µm dry treated v5	Yes
Sample M	0.3 µm dry treated v6	Yes
Sample N	0.3 µm dry treated v1 humid storage	Yes

Formulations and Optical Properties – Semi-Gloss Series “A”

SG formulation "A"	Control A1	Paint A2	Paint A3	Paint A4	Paint A5
	Full TiO2 Loading	0.3 µm slurry v1	0.3 µm slurry v2	0.7 µm dry	0.3 µm dry
	Control A1	Sample A	Sample D	Sample B	Sample E
Water	367.56	362.81	362.81	367.58	367.58
TiO2	128.25	115.2	115.2	115.2	115.2
Calcium Carbonate 0.7 µm	25	25	25	25	25
Sample A	-	17.57	-	-	-
Sample D	-	-	17.57	-	-
Sample B	-	-	-	12.8	-
Sample E	-	-	-	-	12.8
Latex 1	224	224	224	224	224
Latex 2	65.5	65.5	65.5	65.5	65.5
Opaque Polymer	79	79	79	79	79
Additives	40.2	40.2	40.2	40.2	40.2
Total	**929.51**	**929.28**	**929.28**	**929.28**	**929.28**
PVC	19.3				
Solids by Weight	40				
Solids by Volume	29.8				

Untinted SG "A" Results		Control A1	Paint A2	Paint A3	Paint A4	Paint A5
		Full TiO2 Loading	0.3 µm slurry v1	0.3 µm slurry v2	0.7 µm dry	0.3 µm dry
		Control A1	Sample A	Sample D	Sample B	Sample E
CIE Lab	L* Avg	95.81	95.6	95.71	95.66	95.63
	a* Avg	-0.62	-0.64	-0.72	-0.61	-0.62
	b* Avg	-0.47	-0.5	-0.61	-0.45	-0.48
Gloss	20° Avg	16	15	14	14	14
	60° Avg	56	56	54	53	54
	85° Avg	87	87	87	85	86
Opacity	Opacity Avg	98.6	98.8	98	98.2	98.6

Tinted SG "A" Results		Control A1	Paint A2	Paint A3	Paint A4	Paint A5
CIE Lab	L* Avg	82.68	82.78	82.75	82.8	82.78
	a* Avg	-15.68	-15.55	-15.52	-15.48	-15.49
	b* Avg	-18.56	-18.4	-18.33	-18.24	-18.24
	ΔE* Avg		0.20	0.28	0.38	0.35
Gloss	20° Avg	5	3	3	5	3
	60° Avg	35	26	26	25	26
	85° Avg	82	78	78	76	76

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Formulations and Optical Properties – Semi-Gloss Series “B”

SG formulation "B"	Control B1	Paint B2	Paint B3	Paint B4
	Full TiO2 Loading	0.3 µm slurry v1	0.7 µm dry	1.4 µm dry
	Control B1	Sample A	Sample B	Sample C
Water	248.9	239.36	248.9	248.9
TiO2	258	232.2	232.2	232.2
Sample A	-	35.34	-	-
Sample B	-	-	25.8	-
Sample C	-	-	-	25.8
Latex	514	514	514	514
Additives	21.5	21.5	21.5	21.5
Total	**1042.4**	**1042.4**	**1042.4**	**1042.4**
PVC	22			
Solids by Weight	50.3			
Solids by Volume	36.6			

Untinted SG "B" Results		Control B1	Paint B2	Paint B3	Paint B4
		Full TiO2 Loading	0.3 µm slurry v1	0.7 µm dry	1.4 µm dry
		Control B1	Sample A	Sample B	Sample C
CIE Lab	L* Avg	96.79	96.47	96.45	96.4
	a* Avg	-0.64	-0.62	-0.64	-0.7
	b* Avg	-0.1	-0.12	-0.12	-0.1
	60° Avg	53	47	43	37
Opacity	Opacity Avg	97.7	97.4	97.2	97.2

Tinted SG "B" Results		Control B1	Paint B2	Paint B3	Paint B4
CIE Lab	L* Avg	82.9	82.5	82.4	82.3
	a* Avg	-15.2	-15.5	-15.5	-15.6
	b* Avg	-18.8	-19	-19.4	-19.3
	ΔE* Avg	-	0.30	0.8	1
	60° Avg	51	48	43	38

Formulations and Optical Properties – Semi-Gloss Series “C”

SG formulation "C"	Control C1	Paint C2	Control C3	Paint C4	Paint C5
	Full TiO2 Loading	0.7 µm dry	0.3 µm slurry v1	0.3 µm dry	0.3 µm dry humid storage
	Control C1	Sample B	Sample A	Sample E	Sample F
Water	367.55	367.55	358.30	367.55	367.55
TiO2	250	225	225	225	225
Sample B	-	25	-	-	-
Sample A	-	-	34.25	-	-
Sample E	-	-	-	25	-
Sample F	-	-	-	-	25
Latex 1	224	224	224	224	224
Latex 2	65.5	65.5	65.5	65.5	65.5
Opaque Polymer	79	79	79	79	79
Additives	29.2	29.2	29.2	29.2	29.2
Total	**1015.25**	**1015.25**	**1015.25**	**1015.25**	**1015.25**
PVC	25.9				
% Wt solids	45.6				
% Vol solids	31.5				

Untinted SG "C" Results		Control C1	Paint C2	Paint C3	Paint C4	Paint C5
		Full TiO2 Loading	0.7 µm dry	0.3 µm slurry v1	0.3 µm dry	0.3 µm dry humid storage
		Control C1	Sample B	Sample A	Sample E	Sample F
CIE Lab	L* Avg	96.62	96.52	96.60	96.37	96.28
	a* Avg	-0.67	-0.65	-0.67	-0.65	-0.65
	b* Avg	-0.31	-0.26	-0.21	-0.28	-0.32
Gloss	20° Avg	1.60	1.40	1.40	1.40	1.40
	60° Avg	14.18	10.63	10.83	7.77	6.87
	85° Avg	78.92	72.57	77.70	65.53	60.07
Y Brightness	Y Brightness Ave	93.91	93.93	93.88	93.46	93.85
Opacity	Opacity Avg	97.40	97.32	97.59	97.38	97.06

Tinted SG "C" Results		Control C1	Paint C2	Paint C3	Paint C4	Paint C5
CIE Lab	L* Avg	84.46	84.25	84.47	84.10	67.06
	a* Avg	-14.57	-14.65	-14.53	-14.79	-14.90
	b* Avg	-17.23	-17.27	-17.12	-17.46	-17.40
	ΔE* Avg		0.23	0.12	0.38	0.48
Gloss	20° Avg	1.07	0.63	0.90	0.90	0.90
	60° Avg	12.08	8.93	9.53	6.83	6.13
	85° Avg	77.84	72.20	76.13	67.87	61.13

Formulations and Optical Properties – Eggshell Series “D”

Eggshell formulation "D"	Control D1	Control D2	Paint D3	Paint D4	Paint D5
	Full TiO2 Loading	0.3 µm slurry v1	0.3 µm slurry v2	0.3 µm dry	0.3 µm dry humid storage
	Control D1	Sample A	Sample D	Sample E	Sample F
Water	233.00	224.49	224.49	233.00	233.00
TiO2	230	207	207	207	207
Sample A	-	31.51	-	-	-
Sample D	-	-	31.51	-	-
Sample E	-	-	-	23	-
Sample F	-	-	-	-	23
Calcined Clay 1.4 µm	55	55	55	55	55
Calcium Carbonate 1.4 µm	55	55	55	55	55
Attapulgite Clay	5	5	5	5	5
Latex	418	418	418	418	418
Additives	43	43	43	43	43
Total	**1039.00**	**1039.00**	**1039.00**	**1039.00**	**1039.00**
PVC	32.5				
% Wt solids	57				
% Vol solids	42				

Untinted Eggshell "D" Results		Control D1	Paint D2	Paint D3	Paint D4	Paint D5
			0.3 µm slurry v1	0.3 µm slurry v2	0.3 µm dry	0.3 µm dry humid storage
		Control D1	Sample A	Sample D	Sample E	Sample F
CIE Lab	L* Avg	95.88	95.78	95.51	95.45	95.48
	a* Avg	-0.71	-0.72	-0.72	-0.74	-0.71
	b* Avg	0.17	0.15	0.10	0.07	0.12
Gloss	20° Avg	1.40	1.40	1.40	1.40	1.40
	60° Avg	4.87	4.97	4.83	4.47	4.33
	85° Avg	33.98	35.03	34.37	28.60	27.93
Y Brightness	Y Brightness Ave	92.17	91.96	91.83	91.61	91.65
Opacity	Opacity Avg	97.01	96.72	96.97	96.80	96.81

Tinted Eggshell "D" Results		Control D1	Paint D2	Paint D3	Paint D4	Paint D5
CIE Lab	L* Avg	84.05	83.57	83.62	83.45	83.38
	a* Avg	-14.61	-14.90	-14.87	-14.96	-14.99
	b* Avg	-16.63	-16.95	-16.88	-17.04	-17.06
	ΔE* Avg		0.65	0.56	0.80	0.88
Gloss	20° Avg	0.92	0.90	0.90	0.90	0.90
	60° Avg	4.22	4.40	4.30	3.83	3.73
	85° Avg	34.00	35.27	35.10	28.80	27.77

Formulations and Optical Properties – Semi-Gloss Series “E”

SG formulation "E"	Control E1	Paint E2	Paint E3	Paint E4	Paint E5
	Full TiO2 Loading	0.3 µm dry treated v1	0.3 µm slurry v2	0.3 µm dry treated v1	0.3 µm slurry v2
	Control E1	Sample G	Sample D	Sample G	Sample D
Water	194	194	187.3	194	189
TiO2	200	180	180	185	185
Calcium Carboante 0.7 µm	25	25	25	25	25
Dolomite	20	20	20	20	20
Sample G	-	20	-	15	-
Sample D	-	-	26.7	-	20
Latex	480	480	480	480	480
Opaque Polymer	40	40	40	40	40
Additives	41	41	41	41	41
Total	**1000**	**1000**	**1000**	**1000**	**1000**
PVC (%)	21.70	22.30	22.30	22.14	22.14
% Wt solids	52.1				
% Vol solids	38.8				

Untinted SG "E" Results		Control E1	Paint E2	Paint E3	Paint E4	Paint E5
		Full TiO2 Loading	0.3 µm dry treated v1	0.3 µm slurry v2	0.3 µm dry treated v1	0.3 µm slurry v2
		Control E1	Sample G	Sample D	Sample G	Sample D
CIE Lab	L* Avg	96.33	96.25	96.25	96.24	96.30
	a* Avg	-0.73	-0.71	-0.72	-0.72	-0.73
	b* Avg	0.88	0.88	0.88	0.88	0.87
Gloss	20° Avg	10.0	6.2	9.5	7.1	9.1
	60° Avg	45.4	35.1	44.7	38.2	43.8
	85° Avg	74.0	63.0	74.4	66.5	74.2
Y Brightness	Y Brightness Ave	90.80	90.62	90.61	90.59	90.72
Opacity	Opacity Avg	96.77	96.55	96.51	96.74	96.62

Tinted SG "E" Results		Control E1	Paint E2	Paint E3	Paint E4	Paint E5
CIE Lab	L* Avg	63.77	63.26	63.07	63.41	63.28
	a* Avg	-17.89	-17.80	-17.90	-17.80	-17.88
	b* Avg	-36.74	-37.01	-37.23	-36.95	-37.11
	ΔE* Avg	-	0.44	0.60	0.35	0.42
Gloss	20° Avg	10.6	6.2	9.8	7.1	9.8
	60° Avg	46.5	36.1	45.5	38.7	45.2
	85° Avg	76.4	59.4	77.2	69.2	77.0

Results

- Samples left in high temp/humid conditions
  - Pick up moisture
  - Result in low gloss and/or poor CIE ΔE tinted

- Slurry = no gloss reduction, but higher CIE ΔE tinted
  - Particles in slurry do not as easily agglomerate

- Must protect the dry particle with a hydrophobic surface treatment

Formulations – Semi-Gloss Series “F”

SG formulation "F"	Control F1	Paint F2	Paint F3	Paint F4	Paint F5	Paint F6	Paint F7	Paint F8
	Full TiO2 Loading	0.3 µm slurry v2	0.9 µm dry	0.3 µm dry treated v2	0.3 µm dry treated v1	0.3 µm dry treated v3	0.3 µm dry treated v5	0.3 µm dry treated v4
	Control F1	Sample D	Sample I	Sample H	Sample G	Sample J	Sample K	Sample L
Water	214	206	214.0	214	214	214	214	214
TiO2	230	207	207	207	207	207	207	207
Calcium Carbonate 0.7 µm	30	30	30	30	30	30	30	30
Sample D	-	30.7	-	-	-	-	-	-
Sample I	-	-	23	-	-	-	-	-
Sample H	-	-	-	23	-	-	-	-
Sample G	-	-	-	-	23	-	-	-
Sample J	-	-	-	-	-	23	-	-
Sample K	-	-	-	-	-	-	23	-
Sample L	-	-	-	-	-	-	-	23
Attagel 50	1	1	1	1	1	1	1	1
Latex	520	520	520	520	520	520	520	520
Additives	58.5	58.0	58.8	58.5	59.8	60.0	58.8	57.7
Total	**1053.50**	**1053.00**	**1053.80**	**1053.50**	**1054.80**	**1055.00**	**1053.80**	**1052.70**
PVC (%)	25.20							
% Wt solids	50.4							
% Vol solids	37							

Optical Properties – Semi-Gloss Series “F”

Untinted SG "F" Results		Control F1	Paint F2	Paint F3	Paint F4	Paint F5	Paint F6	Paint F7	Paint F8
		Full TiO2 Loading	0.3 µm slurry v2	0.9 µm dry	0.3 µm dry treated v2	0.3 µm dry treated v1	0.3 µm dry treated v3	0.3 µm dry treated v5	0.3 µm dry treated v4
		Control F1	Sample D	Sample I	Sample H	Sample G	Sample J	Sample K	Sample L
CIE Lab	L* Avg	97.87	97.74	97.67	97.71	97.81	97.68	97.53	97.71
	a* Avg	-0.51	-0.51	-0.50	-0.50	-0.50	-0.52	-0.52	-0.52
	b* Avg	1.28	1.23	1.26	1.29	1.35	1.31	1.17	1.26
Gloss	20° Avg	11.2	9.1	8.1	6.8	7.2	6.8	9.2	9.5
	60° Avg	48.4	44.2	41.4	37.0	39.1	37.7	44.9	45.4
	85° Avg	79.3	78.2	77.0	63.6	69.9	64.1	77.9	77.3
Y Brightness	Y Brightness Ave	94.58	94.15	94.03	94.23	94.45	94.07	93.66	94.28
Opacity	Opacity Avg	97.80	97.20	97.60	97.40	97.80	97.70	98.00	97.60

Tinted SG "F" Results		Control F1	Paint F2	Paint F3	Paint F4	Paint F5	Paint F6	Paint F7	Paint F8
CIE Lab	L* Avg	80.93	80.43	80.44	80.42	80.48	80.42	80.39	80.37
	a* Avg	-12.40	-12.61	-12.62	-12.58	-12.56	-12.57	-12.57	-12.58
	b* Avg	-21.02	-21.40	-21.41	-21.36	-21.29	-21.29	-21.37	-21.39
	ΔE* Avg	0.00	0.62	0.65	0.60	0.55	0.59	0.66	0.68
Gloss	20° Avg	10.6	8.5	7.6	6.6	7.1	6.7	9.1	8.9
	60° Avg	46.8	42.6	40.3	36.5	38.6	37.0	43.8	43.5
	85° Avg	77.3	75.7	74.9	62.4	69.0	62.9	75.5	74.8

Formulations – Semi-Gloss Series “G”

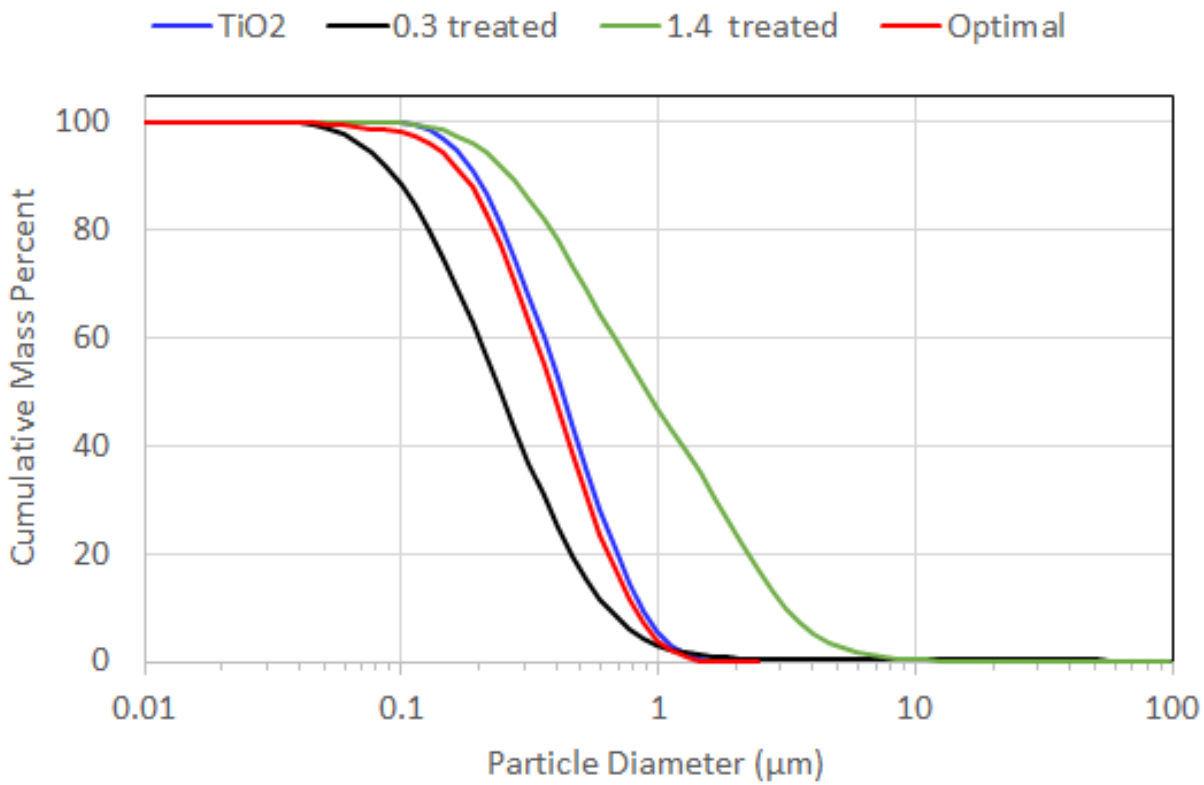
SG formulation "G"	Control G1	Paint G2	Paint G3	Paint G4	Paint G5	Paint G6	Paint G7	Paint G8
	Full TiO2 Loading	0.3 µm dry treated v1	0.3 µm dry treated v1 humid storage	0.3 µm slurry v2	0.3 µm dry treated v1	0.3 µm dry treated v5	0.3 µm dry treated v4	0.3 µm dry treated v6
	Control G1	Sample G	Sample N	Sample D	Sample G	Sample K	Sample L	Sample M
Water	279	279	279.0	274	279	279	279	279
TiO2	150	135	135	135	150	135	135	135
Calcium Carbonate 0.7 µm	25	25	25	25	-	25	25	25
Sample G	-	15	-	-	25	-	-	-
Sample N	-	-	15	-	-	-	-	-
Sample D	-	-	-	19.95	-	-	-	-
Sample K	-	-	-	-	-	15	-	-
Sample L	-	-	-	-	-	-	15	-
Sample M	-	-	-	-	-	-	-	15
Latex	430	430	430	430	430	430	430	430
Opaque Polymer	70	70	70	70	70	70	70	70
Additives	31.77	37.2	38.2	38.7	41	38.4	38.7	38.3
Total	**985.77**	**991.20**	**992.20**	**992.65**	**995.00**	**992.40**	**992.70**	**992.30**
PVC (%)	21.90							
% Wt solids	41.6							
% Vol solids	30.6							

Optical Properties – Semi-Gloss Series “G”

Untinted SG "G" Results		Control G1	Paint G2	Paint G3	Paint G4	Paint G5	Paint G6	Paint G7	Paint G8
		Full TiO2 Loading	0.3 µm dry treated v1	0.3 µm dry treated v1 humid storage	0.3 µm slurry v2	0.3 µm dry treated v1	0.3 µm dry treated v5	0.3 µm dry treated v4	0.3 µm dry treated v6
		Control G1	Sample G	Sample N	Sample D	Sample G	Sample K	Sample L	Sample M
CIE Lab	L* Avg	97.31	97.06	97.10	97.13	97.34	96.97	97.05	97.16
	a* Avg	-0.20	-0.19	-0.18	-0.18	-0.45	-0.18	-0.17	-0.15
	b* Avg	0.60	0.66	0.58	0.57	0.99	0.63	0.63	0.47
Gloss	20° Avg	19.0	15.3	17.0	16.1	17.6	15.7	15.0	18.4
	60° Avg	56.2	52.2	54.2	52.8	55.5	52.7	51.6	55.4
	85° Avg	87.1	84.2	86.7	86.0	87.3	84.3	82.8	85.8
Y Brightness	Y Brightness Ave	93.51	93.06	93.23	93.38	93.26	92.31	92.46	93.03
Opacity	Opacity Avg	97.00	96.40	96.50	96.50	97.20	96.70	96.10	96.90

Tinted SG "G" Results		Control G1	Sample G	Sample N	Sample D	Sample G	Sample K	Sample L	Sample M
CIE Lab	L* Avg	79.14	78.48	78.64	78.71	77.24	78.50	78.56	78.63
	a* Avg	-13.12	-13.36	-13.30	-13.26	-18.07	-13.22	-13.25	-13.17
	b* Avg	-22.79	-23.31	-23.20	-23.18	-25.90	-23.08	-23.17	-23.21
	ΔE* Avg	-	0.87	0.68	0.54	0.16	0.52	0.50	0.60

Particle Size Comparison



Burnish & Wet Scrub Resistance – Semi-Gloss Series “G”

Untinted SG "G" Results		Control G1	Paint G2	Paint G3	Paint G4	Paint G5	Paint G6	Paint G7	Paint G8
		Full TiO2 Loading	0.3 µm dry treated v1	0.3 µm dry treated v1 humid storage	0.3 µm slurry v2	0.3 µm dry treated v1	0.3 µm dry treated v5	0.3 µm dry treated v4	0.3 µm dry treated v6
		Control G1	Sample G	Sample N	Sample D	Sample G	Sample K	Sample L	Sample M
Burnish	Gloss 60 - Before	51.6	49.3	50.9	47.8	59.2	47.5	46.0	8.9
	Gloss 60 - After	58.9	55.3	58.1	55.3	67.4	55.1	52.7	104.4
	Gloss 60-% Increase	14.1	12.2	14.1	15.7	13.9	16.0	14.6	1.2
	85° Sheen - Before	82.4	80.8	82.3	81.5	86.9	78.4	78.4	7.0
	85° Sheen - After	85.5	83.4	85.4	83.4	89.6	84.6	81.7	108.8
	85° Sheen-% Increase	3.8	3.2	3.8	2.3	3.1	7.9	4.2	1.0
	Visual Gloss Change	slight	slight	slight	moderate	slight	slight	moderate	Low
Wet Scrub	Wet scrub ASTM	>2500	>2500	>2500	>2500	>2500	>2500	>2500	>2500

Formulations and Optical Properties – Semi-Gloss Series “H”

Flat formulation "H"	Control H1	Paint H2	Paint H3	Paint H4	Paint H5	Paint H6	Paint H7
	Full TiO2 Loading	0.9 µm dry	0.3 µm dry treated v1	0.3 µm slurry v2	0.3 µm dry treated v5	0.3 µm dry treated v4	0.3 µm dry treated v6
	Control H1	Sample I	Sample G	Sample D	Sample K	Sample L	Sample M
Water	272	272	271.6	266	272	272	272
TiO2	175	157.5	157.5	157.5	157.5	157.5	157.5
Nepheline Syenite	50	50	50	50	50	50	50
Calcium Carbonate 12 µm	80	80	80	80	80	80	80
Calcium Carbonate 0.7 µm	25	25	25	25	25	25	25
Diatomaceous Earth	20	20	20	20	20	20	20
Sample I	-	17.5	-	-	-	-	-
Sample G	-	-	17.5	-	-	-	-
Sample D	-	-	-	23.3	-	-	-
Sample K	-	-	-	-	17.5	-	-
Sample L	-	-	-	-	-	17.5	-
Sample M	-	-	-	-	-	-	17.5
Attagel 50	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Latex	425.00	425.00	425.00	425.00	425.00	425.00	425.00
Additives	38.70	38.60	38.60	38.60	38.60	38.60	38.60
Total	**1087.60**	**1087.60**	**1087.60**	**1087.60**	**1087.60**	**1087.60**	**1087.60**
PVC (%)	35.20						
% Wt solids	56.6						
% Vol solids	42						

Formulations and Optical Properties – Semi-Gloss Series “H”

Untinted Flat "H" Results		Control H1	Paint H2	Paint H3	Paint H4	Paint H5	Paint H6	Paint H7
		Full TiO2 Loading	0.9 µm dry	0.3 µm dry treated v1	0.3 µm slurry v2	0.3 µm dry treated v5	0.3 µm dry treated v4	0.3 µm dry treated v6
		Control H1	Sample I	Sample G	Sample D	Sample K	Sample L	Sample M
CIE Lab	L* Avg	96.50	96.36	96.31	96.38	96.37	96.26	96.35
	a* Avg	-0.28	-0.26	-0.27	-0.27	-0.26	-0.27	-0.49
	b* Avg	0.92	0.97	0.85	0.84	0.74	0.76	1.18
Gloss	20° Avg	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	60° Avg	4.3	4.3	4.4	4.4	4.4	4.4	4.3
	85° Avg	2.7	2.9	2.8	2.9	2.8	2.7	2.6
Y Brightness	Y Brightness Ave	91.56	91.24	91.09	91.41	91.01	90.91	90.82
Opacity	Opacity Avg	95.60	95.10	95.60	95.90	95.40	95.60	96.00

Tinted Flat "H" Results		Control H1	Sample I	Sample G	Sample D	Sample K	Sample L	Sample M
CIE Lab	L* Avg	78.76	78.02	78.15	78.00	78.35	78.28	78.30
	a* Avg	-12.95	-13.24	-13.19	-13.27	-13.14	-13.15	-13.10
	b* Avg	-22.32	-23.01	-22.89	-23.03	-22.79	-22.82	-22.79
	ΔE* Avg	0.00	1.07	0.88	1.16	0.68	0.71	0.50

Best Performers – Samples A, B, & G

Paint		Paint B2	Paint C2	Paint C3	Paint E4	Paint G5
Sample Description		0.3 µm slurry v1	0.7 µm dry	0.3 µm slurry v1	0.3 µm dry treated v1	0.3 µm dry treated v1
Untinted Results		Sample A	Sample B	Sample A	Sample G	Sample G
PVC		21.99	25.92	25.92	21.70	21.85
% Wt Solids		50.33	45.64	45.64	52.10	41.57
% Vol Solids		36.63	31.46	31.46	38.76	30.63
CIE Lab	L* Avg	0.32	0.10	0.02	0.09	0.34
	a* Avg	-0.02	-0.03	0.00	-0.01	-0.02
	b* Avg	0.02	-0.04	-0.09	0.00	-0.03
Gloss	20° Avg	-	0.2	0.2	2.9	3.3
	60° Avg	6.0	3.6	3.4	7.2	3.5
	85° Avg	-	6.4	1.2	7.5	2.8
Y Brightness	Y Brightness Ave	0.30	-0.02	-0.19	0.21	0.25
Opacity	Opacity Avg	0.30	0.08	-0.19	0.03	0.30

Tinted Results		Paint B2 Sample A	Paint C2 Sample B	Paint C3 Sample A	Paint E4 Sample G	Paint G5 Sample G
CIE Lab	L* Avg	0.40	0.00	-0.01	0.36	0.64
	a* Avg	0.30	0.21	-0.04	-0.09	0.10
	b* Avg	0.20	0.08	-0.12	0.21	0.29
	ΔE* Avg	0.30	0.23	0.12	0.35	0.16
Gloss	20° Avg	-	0.4	0.2	3.5	-
	60° Avg	3.0	3.1	2.5	7.8	-
	85° Avg	-	5.6	1.7	7.2	-

These are Δ values and are relative to the control

Δ = Control - Sample

Carbon Footprint Reduction

UFGCC – 0.214 tCO2e/tCaCO3

TiO2 - 5.3 tCO2e/tTiO2

UFGCC is 25x LESS!

CO_2 Reduction

UFGCC

1

Reduce formulation cost and carbon footprint while maintaining key paint properties

2

Improve paint performance at equal formulation cost

3

Conclusions

- Can displace 10% TiO2 by weight with 0.3µm dry treated
- Can be done with minimal impact to optical properties
- UFGCC slurry w/ d50 of 0.3µm is the best performer
- PSD of the material is critical
- Surface treatments are needed
- Moisture pickup results in agglomeration
- Treated UFGCC results in good dispersion in water-based
- Overextension of TiO2 is possible

Future Work

- Develop a drop in solution across full PVC range
- Check against higher TiO2 levels
- Check against slurry grade TiO2
- Deeper review on dispersant selection

9/10/2024

MINERAL
COMPETENCE
SINCE 1884

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