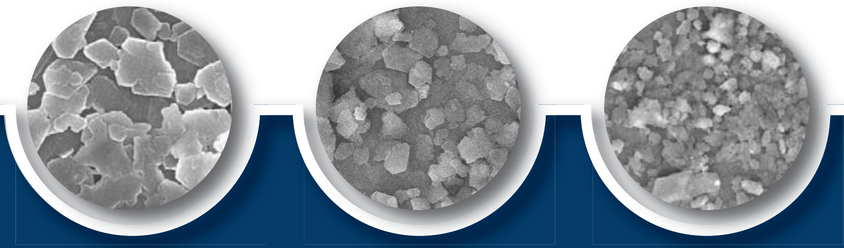


HYDROUS KAOLINS FOR DECORATIVE MATT EMULSION PAINT

Extenders are used to increase volume as a result of their inherently low densities and to improve the technical properties, including the optical properties of paint[1]. A variety of carbonate and silicate type extenders are typically used in decorative emulsion paint to influence these technical properties. Generally the difference in bulk refractive index between any extender and the surrounding medium is insufficient to significantly influence the scattering efficiency of the system. Most extenders can only exert an indirect influence on the optical properties of a pigmented paint by influencing the state of dispersion of a pigment[2].

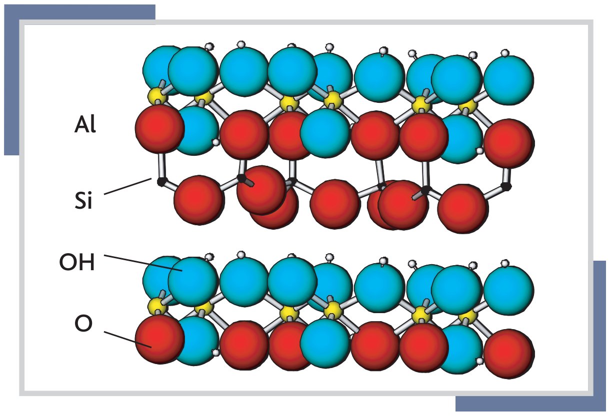
Titanium dioxide (TiO_2) is often poorly dispersed and crowded by the extender particles in decorative emulsion paint[3], particularly the higher the pigment volume concentration (PVC). Subsequently, the main aim of the formulator when selecting an extender or, more typically, a combination of extenders should be to make the most efficient use of the TiO_2 present in the decorative emulsion paint. TiO_2 crowding can be significantly reduced by reducing the particle size of the extender used in high PVC matt emulsions, however, this usually implies that some matting efficiency must be sacrificed. The particle shape of the extender selected should also be taken into consideration since a nodular particle can exert a greater negative influence on TiO_2 crowding than a similar equivalent particle size lamellar particle. Hydrous kaolin is an example of a lamellar extender and is typically used in decorative emulsion paint for its contribution to the paints optical properties. The benefit of using hydrous kaolin in decorative emulsion paint, specifically matt emulsion paint will be discussed.

STRUCTURE AND MINERALOGY

Kaolin is a hydrous aluminium layered silicate with chemical composition $Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O$. Its structure can be depicted as alternate layers of SiO_4 tetrahedrons and $Al(O,OH)_6$ octahedrons that are held together by hydrogen bonds and dipole interactions[1]. This structure is illustrated in Figure 1. The particle shape is typically a hexagonal plate that has an oxygen rich surface on one side and a hydroxyl rich surface on the other. Kaolin is hydrophilic, inert to acid and alkali and is water dispersible[4].

The hydrous kaolin used in decorative emulsion paint is water washed to remove mineral impurities and can be chemically bleached and/or subjected to magnetic separation to improve brightness and colour. Kaolin that is extracted from primary kaolinite deposits and processed in Cornwall, UK was formed by the hydro-thermal degradation of granite and is renowned for its high purity, good colour and influence on low shear rheology.

FIGURE 1: THE STRUCTURE OF HYDROUS KAOLIN



EXPERIMENTAL

The influence that particle size and shape have on the TiO_2 utilisation in a decorative matt emulsion paint can be evaluated by comparing the paint properties of various equivalent spherical particle sizes of $CaCO_3$, talc and hydrous kaolin. The physical properties of the $CaCO_3$, talc and hydrous kaolin extenders evaluated are listed in Table 1, 2 and 3 respectively.

The decorative matt emulsion paint used in this work is a 70% PVC Styrene Acrylic matt emulsion containing 10% TiO_2, 18% 2.5µm $CaCO_3$, 6% 9µm talc and 10% extender under evaluation. This formulation is provided in Figure 2.

The dry film properties of the 70% Styrene Acrylic matt emulsion comparing various equivalent spherical particle sizes of $CaCO_3$, talc and hydrous kaolin are detailed in Table 4-6.

EFFECT ON OPACITY

The results of the analysis show that as the equivalent spherical particle size of the $CaCO_3$, talc and hydrous kaolin decreases, so the opacity of the matt emulsion paint increases as a result of the improved utilisation of the TiO_2. Lamellar particles have a much greater effect on the reduction of the TiO_2 crowding than nodular particles like $CaCO_3$. For example, hydrous kaolin provides a 12% higher spreading rate than talc and a 22% higher spreading rate than $CaCO_3$ when comparing extenders with an equivalent mean spherical particle size of 2.5µm. **Supreme™**, the finest hydrous kaolin tested (d_{50}=0.4µm) provided a 1.6 m²/l spreading rate advantage compared to the finest $CaCO_3$ (d_{50}=0.9µm) tested and a 0.8 m²/l spreading rate advantage compared to the finest talc (d_{50}=1.0µm) tested. A comparison of all these results is illustrated in Figure 2.

FIGURE 2: EFFECT OF EXTENDER PARTICLE SIZE AND SHAPE ON OPACITY

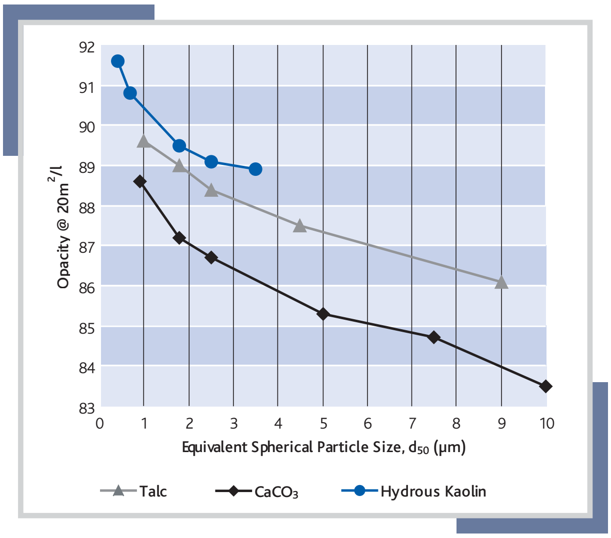
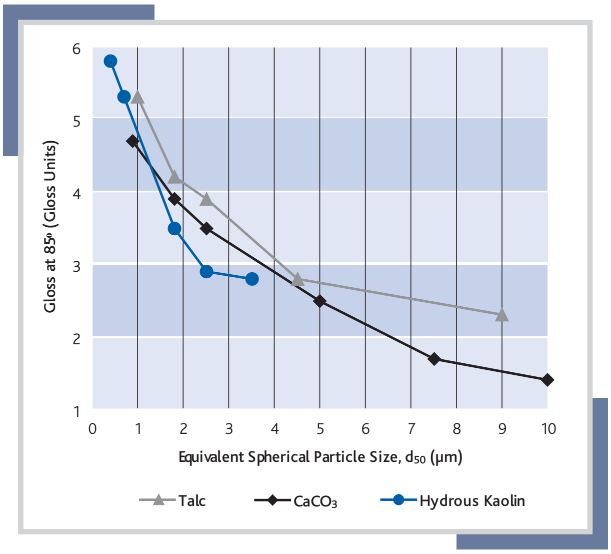


FIGURE 3: EFFECT OF EXTENDER PARTICLE SIZE AND SHAPE ON GLOSS



EFFECT ON GLOSS

Hydrous kaolin provides lower gloss at 85° than $CaCO_3$ and talc when comparing extenders with equivalent spherical particle size. The matting efficiency of coarsest hydrous kaolin tested, **Polwhite E™** (d_{50}=3.5µm), is matched by $CaCO_3$ and talc with an equivalent mean spherical particle size of 5.0µm and 4.5µm respectively. In this series of work, hydrous kaolin provided more

FIGURE 2: 70% PVC STYRENE ACRYLIC MATT EMULSION

Material	%	Description & Supplier
Tioxide TR85	10	Rutile TiO_2, Huntsman Tioxide
Extender Under Test	10	
ImerCarb 2L	18	d_{50}=2.5µm $CaCO_3$, Imerys
Minerals		
Luzenac 0X0	6	d_{50}=9.0µm Talc, Luzenac
Dispex A40	0.4	Dispersing Agent, Ciba Specialty
Chemicals		
10% Calgon S	0.5	Dispersing Agent, Sigma-Aldrich
Dispelair CF246	0.3	Foam Control Agent, Blackburn Chemicals
Rocima V189	0.2	Biocide, Rohm and Haas
Texanol	1	Coalescent Solvent, Eastman
Exxsol D40	1.5	Coalescent Solvent, ExxonMobil Chemical
Natrosol 250MR	0.4	HEC thickener, Aqualon
Acronal 290D	14	Styrene Acrylic Copolymer, BASF
Acrysol TT935	0.8	Associative Thickener, Rohm and Haas
Water	37	
Total	**100.0**	
PVC (%)	70	
Specific Gravity	1.41	
Solid Content (%)	51.7	
Volume Solids (%)	30.2	

than double the matting efficiency of $CaCO_3$ and talc per equivalent mean spherical micron of extender. The lowest gloss at 85°, 1.4 gloss units, was achieved with the coarsest $CaCO_3$ (d_{50}=10µm) tested. The matt emulsion paint containing **Supreme™** had gloss of 5.8 gloss units at 85° and was the highest value recorded. A comparison of all these results is illustrated in Figure 3.

EFFECT ON COLOUR

All particle size $CaCO_3$ tested gave the best overall paint colour in the matt emulsion paint. Only one talc (d_{50}=2.5µm), **Supreme™** (d_{50}=0.4µm) and **Speswhite™** (d_{50}=0.7µm) were able to match the whiteness (L*) of the $CaCO_3$ containing matt emulsion paints. The effect that the choice of extender has on the final paint colour is a function of the extender colour.

EFFECT ON GEL STRENGTH AND LOW SHEAR VISCOSITY

The wet film properties of the 70% Styrene Acrylic matt emulsion comparing various equivalent spherical particle sizes of $CaCO_3$, talc and hydrous kaolin are detailed in Table 7-9.

Gel strength is a measure of the degree of structure and it is related to the paint's in-can appearance. Low shear ($0.3s^{-1}$) viscosity is indicative of the levelling and flow behaviour of the paint and can give an indication of the sag resistance of the paint. The low shear rheology and gel strength of the matt emulsion

FIGURE 4: EFFECT OF EXTENDER PARTICLE SIZE AND SHAPE ON GEL STRENGTH

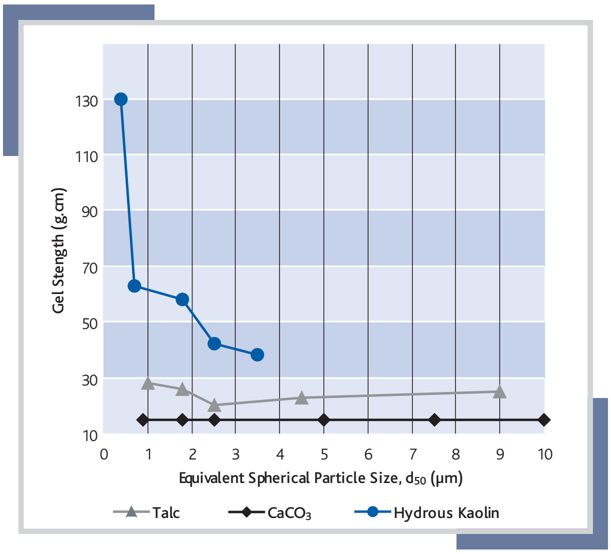
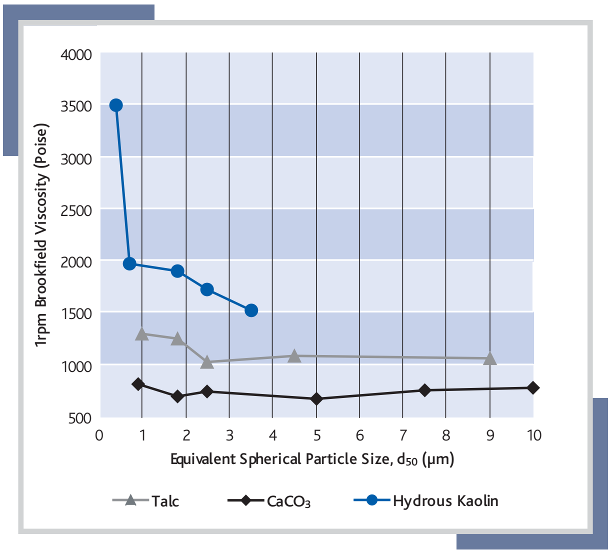


FIGURE 5: EFFECT OF EXTENDER PARTICLE SIZE AND SHAPE ON LOW SHEAR VISCOSITY



paints containing hydrous kaolin is significantly higher than both the $CaCO_3$ and talc containing paints. This is illustrated in Figure 4 and 5 respectively.

SUMMARY

Hydrous kaolin facilitates greater TiO_2 utilisation and is a more effective matting extender than equivalent spherical particle size $CaCO_3$ and talc. The improved low shear rheology provided by hydrous kaolin will improve the storage stability, anti-sag and application properties of matt emulsion compared to paint containing an equivalent quantity of $CaCO_3$ or talc. The matt emulsion paint containing **Supreme**™, fine hydrous kaolin provided the highest opacity and is the most effective extender tested to reduce TiO_2 crowding.

TABLE 1: PHYSICAL PROPERTIES OF $CaCO_3$ EVALUATED

	$CaCO_3$ (d_{50}=10µm)	$CaCO_3$ (d_{50}=7.5µm)	$CaCO_3$ (d_{50}=5µm)	$CaCO_3$ (d_{50}=2.5µm)	$CaCO_3$ (d_{50}=1.8µm)	$CaCO_3$ (d_{50}=0.9µm)
ISO Brightness R457 (ISO 2469)	93.3	91.7	92.7	94.5	93.1	93.0
Yellowness	1.6	2.1	1.8	1.5	1.6	1.2
Oil Absorption, g oil/100g (ISO 787/5)	17	15	16	19	21	24
Particle Size (Sedigraph 5100)						
+10µm, %	51.0	38.8	13.6	2.1	0.1	0.1
-2µm, %	16	13	18	42	54	88
d_{50} (µm)	9.9	7.4	5.1	2.5	1.8	0.9

TABLE 2: PHYSICAL PROPERTIES OF TALC EVALUATED

	Talc (d_{50}=9µm)	Talc (d_{50}=4.5µm)	Talc (d_{50}=2.5µm)	Talc (d_{50}=1.8µm)	Talc (d_{50}=1.0µm)
ISO Brightness R457 (ISO 2469)	84.6	83.3	89.8	85.5	87.0
Yellowness	0.4	1.1	2.7	1.3	1.4
Oil Absorption, g oil/100g (ISO 787/5)	35	44	46	60	69
Particle Size (Sedigraph 5100)					
+10µm, %	44.1	8.9	3.2	4.3	0.1
-2µm, %	15	17	37	52	82
d_{50} (µm)	8.8	4.2	2.6	1.9	1.1

TABLE 3: PHYSICAL PROPERTIES OF HYDROUS KAOLIN EVALUATED

	Polwhite E™ (d_{50}=3.5µm)	Kaolin (d_{50}=2.6µm)	Polwhite B™ (d_{50}=1.8µm)	Speswhite™ (d_{50}=0.7µm)	Supreme™ (d_{50}=0.4µm)
ISO Brightness R457 (ISO 2469)	78.7	79.3	82.2	85.6	87.7
Yellowness	6.2	6.0	5.1	4.3	3.8
Oil Absorption, g oil/100g (ISO 787/5)	33	35	38	42	46
Particle Size (Sedigraph 5100)					
+10µm, %	8.2	6.8	3.8	0.3	0.1
-2µm, %	32	44	54	78	94
d_{50} (µm)	3.4	2.6	1.7	0.7	0.4

TABLE 4: DRY FILM PROPERTIES OF THE MATT EMULSION PAINTS CONTAINING THE EVALUATED $CaCO_3$ GRADES

	$CaCO_3$ (d_{50}=10µm)	$CaCO_3$ (d_{50}=7.5µm)	$CaCO_3$ (d_{50}=5µm)	$CaCO_3$ (d_{50}=2.5µm)	$CaCO_3$ (d_{50}=1.8µm)	$CaCO_3$ (d_{50}=0.9µm)
Opacity @ 20m^2/l (ISO6504/2): %	83.5	84.7	85.3	86.7	87.2	88.6
Dry Contrast Ratio at 100µm (ISO 2814), %	87.1	89.0	89.5	90.2	90.7	92.0
Spreading Rate @ 98% CR: m^2/l	5.6	5.9	6.1	6.6	6.8	7.4
Colour (ISO 7724/2), L*	95.9	96.0	96.0	96.2	96.2	96.3
a*	-0.65	-0.63	-0.61	-0.59	-0.56	-0.54
b*	1.37	1.40	1.37	1.30	1.35	1.32
Gloss at 85° (ISO 2813): Gloss Units	1.41.7	2.8	3.5	3.9	4.7	
Stain Resistance (Gilsonite) : %	95	93	91	92	91	92
Mud Crack Resistance (Plasterboard): µm	>2500	>2500	>2500	>2500	>2500	>2500
Wet Scrub Resistance (ISO 11998): µm	10	12	15	16	17	17

TABLE 5: DRY FILM PROPERTIES OF THE MATT EMULSION PAINTS CONTAINING THE EVALUATED TALC GRADES

	Talc (d_{50}=9µm)	Talc (d_{50}=4.5µm)	Talc (d_{50}=2.5µm)	Talc (d_{50}=1.8µm)	Talc (d_{50}=1.0µm)
Opacity @ 20m^2/l (ISO6504/2): %	86.1	87.5	88.4	89.0	89.6
Dry Contrast Ratio at 100µm (ISO 2814), %	91.3	92.3	93.5	94.2	94.8
Spreading Rate @ 98% CR: m^2/l	6.6	7.3	7.5	7.9	8.2
Colour (ISO 7724/2), L*	95.7	95.3	96.3	95.5	95.6
a*	-0.67	-0.65	-0.61	-0.59	-0.56
b*	1.11	1.20	1.55	1.28	1.33
Gloss at 85° (ISO 2813): Gloss Units	2.3	2.8	3.9	4.2	5.3
Stain Resistance (Gilsonite) : %	91	87	88	87	86
Mud Crack Resistance (Plasterboard): µm	>2500	>2500	>2500	>2500	>2500
Wet Scrub Resistance (ISO 11998): µm	15	15	16	15	16

TABLE 6: DRY FILM PROPERTIES OF THE MATT EMULSION PAINTS CONTAINING THE EVALUATED HYDROUS KAOLIN GRADES

		Polwhite E™ (d_{50}=3.5µm)	Kaolin (d_{50}=2.6µm)	Polwhite B™ (d_{50}=1.8µm)	Speswhite™ (d_{50}=0.7µm)	Supreme™ (d_{50}=0.4µm)
Opacity @ 20m²/l (ISO6504/2): %		88.9	89.1	89.5	90.8	91.6
Dry Contrast Ratio at 100µm ISO 2814), %		92.6	93.7	94.2	94.5	94.9
Spreading Rate @ 98% CR: m²/l		8.0	8.0	8.2	8.7	9.0
Colour (ISO 7724/2),	L*	95.2	95.3	95.4	96.0	96.3
	a*	-0.51	-0.51	-0.49	-0.53	-0.54
	b*	2.79	2.72	2.51	2.11	1.92
Gloss at 85° (ISO 2813): Gloss Units		2.8	2.9	3.5	5.3	5.8
Stain Resistance (Gilsonite) : %		92	91	93	92	94
Mud Crack Resistance (Plasterboard): µm		>2500	>2500	>2500	>2500	>2500
Wet Scrub Resistance (ISO 11998): µm		14	16	17	20	21

TABLE 7: WET FILM PROPERTIES OF THE MATT EMULSION CONTAINING EVALUATED

	$CaCO_3$ (d_{50}=10µm)	$CaCO_3$ (d_{50}=7.5µm)	$CaCO_3$ (d_{50}=5µm)	$CaCO_3$ (d_{50}=2.5µm)	$CaCO_3$ (d_{50}=1.8µm)	$CaCO_3$ (d_{50}=0.9µm)
Gel Strength: g.cm	15	15	15	15	15	15
1 rpm Brookfield (S6, 0.3s^{-1}) (ASTM D2196): Poise	770	750	670	740	690	810
100 rpm Brookfield (S6, 30s^{-1}) (ASTM D2196): Poise	36.1	35.7	34.2	35.8	34.5	38.3
Krebs Stormer (ASTM D562): Kreb Units	107	108	107	108	106	110
Rotothinner (150s^{-1}) (ISO 2884/2): Poise	7.3	7.7	7.4	7.6	7.3	7.7
Cone and Plate (10^4s^{-1}) (ISO 2884/1): Poise	0.9	0.9	0.9	0.9	0.9	0.9

TABLE 8: WET FILM PROPERTIES OF THE MATT EMULSION CONTAINING EVALUATED TALC

	Talc (d_{50}=9µm)	Talc (d_{50}=4.5µm)	Talc (d_{50}=2.5µm)	Talc (d_{50}=1.9µm)	Talc (d_{50}=1.0µm)
Gel Strength: g.cm	25	23	20	26	28
1 rpm Brookfield (S6, 0.3s^{-1}) (ASTM D2196): Poise	1050	1080	1020	1250	1290
100 rpm Brookfield (S6, 30s^{-1}) (ASTM D2196): Poise	32	36	38	37	37
Krebs Stormer (ASTM D562): Kreb Units	108	107	108	107	106
Rotothinner (150s^{-1}) (ISO 2884/2): Poise	6.8	7.1	6.9	6.5	6.4
Cone and Plate (104s^{-1}) (ISO 2884/1): Poise	0.8	0.9	0.8	0.9	0.9

TABLE 9: WET FILM PROPERTIES OF THE MATT EMULSION CONTAINING HYDROUS KAOLIN

	Polwhite E™ (d_{50}=3.5μm)	Kaolin (d_{50}=2.6μm)	Polwhite B™ (d_{50}=1.8μm)	Speswhite™ (d_{50}=0.7μm)	Supreme™ (d_{50}=0.4μm)
Gel Strength: g.cm	38	42	68	63	130
1 rpm Brookfield (S6, 0.3s^{-1}) (ASTM D2196): Poise	1520	1720	2120	1970	3490
100 rpm Brookfield (S6, 30s^{-1}) (ASTM D2196): Poise	45	46	50	47	58
Krebs Stormer (ASTM D562): Kreb Units	116	118	120	118	123
Rotothinner (150s^{-1}) (ISO 2884/2): Poise	8.2	8.5	8.4	8.3	8.6
Cone and Plate (104s^{-1}) (ISO 2884/1): Poise	0.9	1.1	1.0	1.0	1.0

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