

FUMED METAL OXIDES



CABOT

creating what matters

Fumed Silica and Fumed Alumina in Coatings Applications



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Introduction

Looking for a versatile fine particle that delivers functionality to your most demanding application? Cabot's cornerstone products – CAB-O-SIL® Fumed Silica, SpectrAl™ Fumed Alumina and CAB-O-SPERSE® Fumed Metal Oxide dispersions – provide exceptional performance benefits for a wide variety of applications and industries. Since the early 1950s, our fumed metal oxides (FMO) business has been developing, producing and marketing fumed metal oxides to meet the challenging requirements sought by our customers around the world.

Today we continue to advance our fine particle technologies to bring you unique fumed metal oxides that meet your individual requirements. Our competencies in fine particle technology include:

- advanced manufacturing and handling of carbons, mixed oxides, refractory metals and aerosols;
- surface modification of very fine particles, such as silicas, carbon, color pigments and catalysts;
- manufacture of single and complex multiphase particle-media composites for specific properties, such as color, dispersion stability, charge generation, electrochemical behavior and insulation.

Quite simply, if you need it, we can probably make it.

Functions of fumed metal oxides in coatings applications

Fumed metal oxides are versatile, efficient additives used in coatings to achieve one or more important functions.

In liquids:

- rheology control
- anti-settling

In powders:

- free-flow
- anti-caking
- fluidization

The rheology control function includes thickening (bodying), thixotropy, anti-sag, hold out, edge coverage and pattern control in metallic finishes. Fumed metal oxides prevent the settling and hard caking of pigments in storage. The coating uniformity is improved by preventing the pigment stratification during the curing, even at high temperatures. In powder coatings, fumed silica enhances the free flow, anti-caking and fluidization properties.

By providing a range of physical properties and surface chemistries, the various grades of fumed metal oxides allow the selection of a balance between sag control, flow and leveling and thixotropy. The formulator is offered rheology and performance alternatives, which are well suited to many high solids, low VOC coatings. When used properly, fumed metal oxides will enhance the desired properties of a coating without causing undesirable side effects.

This brochure is intended to help the formulator in selecting the proper grade fumed metal oxides to achieve the desired effects in a coating. It will also explain the mechanism by which fumed silica functions and how to properly disperse it into a coating system.

Grades Available



■ Untreated Fumed Silicas

The properties of CAB-O-SIL untreated fumed silica grades recommended for coatings are shown in Table 1. As the surface area of fumed silica increases, its potential as a rheology control agent increases; therefore grades with surface areas below 200 m²/g are not recommended.

More energy is generally required to disperse the fumed silica as the surface area increases. Grade M-5 (200 m²/g) can be properly dispersed by high speed dispersion equipment such as a Cowles dissolver. Higher surface area grades such as H-5 (300 m²/g), HS-5 (325 m²/g) and EH-5 (380 m²/g) may require higher shear equipment such as a sand mill.

An inadequately dispersed silica will be less effective. For example, the rheological performance of a poorly dispersed high surface area fumed silica can be less than that of a properly dispersed lower surface area fumed silica.

Several untreated grades are available in densified form. The mechanical compression increases bulk density from ~50 g/l tamped density to ~120 g/l tamped density. Because densing reduces the dispersability of the silica, densified grades of CAB-O-SIL fumed silica are not recommended for use in coatings.

The index of refraction for all grades of CAB-O-SIL fumed silica is 1.46. For many systems fumed silica affects neither the color of pigmented systems nor the transparency of clear finishes. Properly dispersed CAB-O-SIL fumed silica has a minimal effect on gloss.

Untreated grades of CAB-O-SIL fumed silica are also available in aqueous dispersions under the name, CAB-O-SPERSE dispersions. Information on these products is available upon request.

■ Treated Fumed Silicas

The properties of the treated grades of CAB-O-SIL fumed silica recommended for coatings are shown in Table 2. The degree of hydrophobicity of the surface treated silicas varies with TS-720 and TS-530 being very hydrophobic and TS-610 less so.

■ Fumed aluminas

The properties of fumed aluminas recommended for powder coatings are shown in Table 3.

Table 1: Typical Properties of Untreated Fumed Silicas

CAB-O-SIL untreated fumed silicas	Surface Area (m ² /g)	pH (4 % slurry)	Loss on Heating (Wt % at 105° C)
M-5	200	4.0	< 1.5
H-5	300	4.0	< 1.5
HS-5	325	4.0	< 1.5
EH-5	380	4.0	< 1.5

Table 2: Typical Properties of Treated Fumed Silicas

CAB-O-SIL treated fumed silica	Treating Agent	Surface Area (m ² /g)	pH (4% slurry)	Carbon Content (Wt %)
TS-720	Dimethylsilicone Fluid	115	NA	5.4
TS-610	Dimethyldichlorosilane	125	> 4.0	0.85
TS-530	Hexamethyldisilazane	225	5.5	4.25
CT-1221	Hexamethyldisilazan	215	5.5	2.35

Table 3: Typical Properties of Fumed Aluminas

SpectrAl Fumed Alumina	Surface Area (m ² /g)	pH (4 % slurry)	Loss on Heating (Wt % at 105° C)
SpectrAl 51	55	4.7	< 1.5
SpectrAl 81	80	4.7	< 1.5
SpectrAl 100	95	4.7	< 1.5

Surface Chemistry

The unique surface chemistry of fumed silica, shown in Figure 1, plays an important role in its performance in coatings systems. Hydroxyl groups cover approximately 40 percent of the surface of the silica making the surface of untreated fumed silicas hydrophilic.

These hydroxyl groups provide the distinguishing feature of the surface chemistry. When fumed silica is added to a liquid coating, hydroxyl groups will form interaggregate hydrogen bonds with hydroxyl groups on adjacent fumed silica particles. The formation of interaggregate hydrogen bonds allows CAB-O-SIL fumed silica to provide rheology control in liquid systems. This is particularly important in non-polar liquids. For further information, refer to the sections entitled Mechanism in Liquid Systems and Factors Affecting the Performance in Liquid Systems (Pages 6 and 8 respectively).

Figure 2 shows the organosilicon groups of CAB-O-SIL treated fumed silica grades. In the CAB-O-SIL TS-720 treatment process, the silicone fluid reacts with the surface hydroxyls. The polymer breaks up in the reaction and the fragmented polymer chains attach to the surface. This silica does not provide rheology control via hydrogen bonding but rather relies on the modified surface chemistry.

The dimethyldichlorosilane reacts with the surface hydroxyl groups in the CAB-O-SIL TS-610 treatment process. This reaction reduces the hydroxyl population thus lessening the ability to form interaggregate hydrogen bonds.

In the CAB-O-SIL TS-530 and CT-1221 treatment process, hexamethyldisilazane reacts with most of the surface hydroxyl groups. This significantly reduces its ability to thicken by way of interaggregate hydrogen bonds.

Fig. 1: Typical Groups on the Surface of CAB-O-SIL Fumed Silica Particles

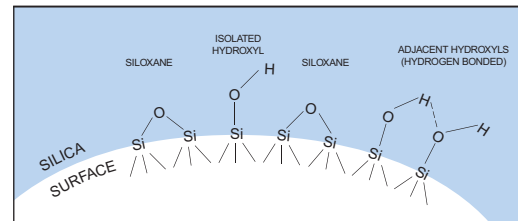
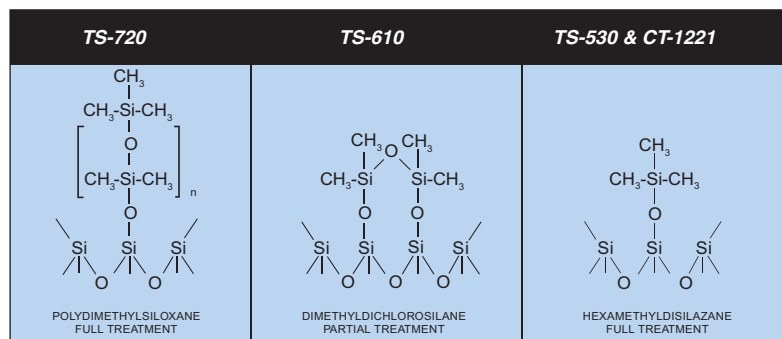


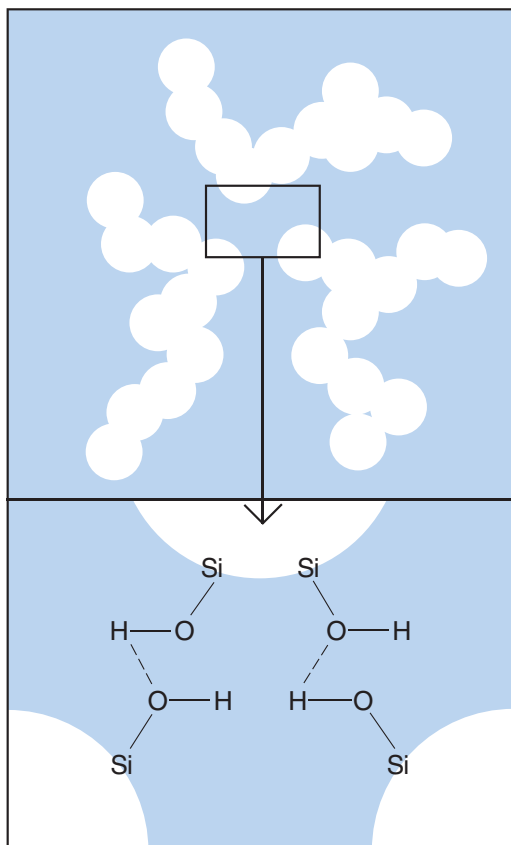
Fig. 2: Organo-silicon groups on the surface of various treated CAB-O-SIL fumed silicas (TS-720, TS-610, TS-530, CT-1221)



Mechanism in Liquid Systems

■ Untreated Fumed Silicas

Fig. 3: Hydrogen bonding between neighboring CAB-O-SIL untreated fumed silica aggregates strengthening silica network formation



The exceptional ability of CAB-O-SIL fumed silica to provide rheology control in liquid systems depends upon the combination of the unique surface chemistry and the chain-like particle morphology. The aggregates are able to link together via hydrogen bonds formed between the surface hydroxyl groups (Figure 3). A three dimensional silica network is formed and liquid becomes trapped in the resulting structure. This phenomenon results in increased viscosity and yield value. The interaggregate hydrogen bonds are weak and can easily be broken by the application of shear forces. The bonds will, however, quickly reform when the shear is removed. This allows the structure to rebuild rapidly and the viscosity and yield value of the system to return to their original values. This shear thinning behavior with its time dependent recovery is termed thixotropy. Thixotropic behavior is the key to the many benefits CAB-O-SIL fumed silica can impart to a coating. The three dimensional silica structure present in the coating prevents the settling of pigments in storage. When the coating is applied, the structure is quickly broken down by the shear forces of the application method. Brushing, spraying, dip and flow coating all generate sufficient levels of shear to break down the silica structure in a coating. Once the shear forces from the application are removed, the structure begins to rebuild. This rebuilding requires a short amount of time. While the structure is rebuilding, the yield value and viscosity are low enough to allow flow and leveling and entrapped air to escape. The coating becomes sag resistant when the yield value and viscosity become high enough to stop movement in the material.

In addition to the thixotropic function of CAB-O-SIL fumed silica, the silica will also control “picture framing” or “fat edges”. These terms refer to a thick bead of a coating that has formed adjacent to the edge of a flat surface. The faster evaporation of the solvents from the coating at the edges causes an uneven surface tension. The silica structure is able to sufficiently rebuild before material can flow to the edges. Fumed silica will also improve the “hold out” of the coating. Hold out refers to the amount of the coating not absorbed into a porous substrate. This is beneficial for coatings applications on wood, masonry and concrete and for most primers. The silica structure is able to rebuild quickly and prevents the movement of the coating into the pores of the substrate.

In polychromatic finishes, thixotropy restricts the movement of the metallic pigment flakes. Color differences resulting from differing application methods, such as air and airless spray techniques, are minimized. These applications require different solvent blends, which affect the time the metallic flakes are able to move and orient themselves in the film, causing variation in color. The thixotropic behavior imparted by fumed silica can reduce the color differences

caused by varied operator and application styles.

In hammer finishes, thixotropy improves control pattern development. The pattern in a hammer finish is cratering caused by the addition of an incompatible silicone fluid. By controlling the flow time of the coating, fumed silica can make the cratering pattern more uniform. This helps to alleviate operator-to-operator differences as it does in metallic finishes.

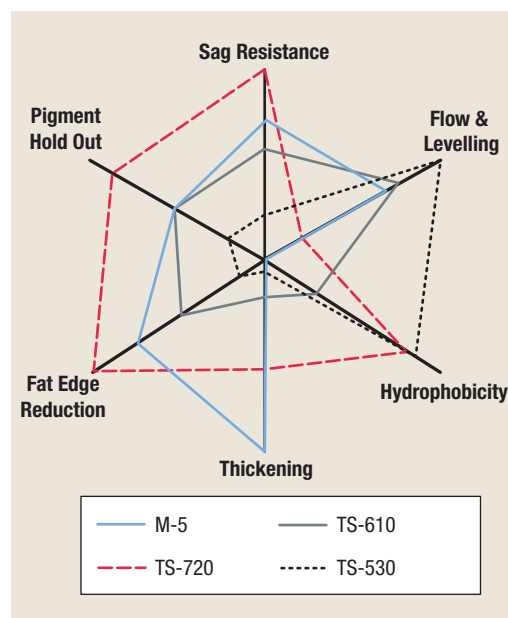
■ Treated Fumed Silicas

CAB-O-SIL TS-720 treated fumed silica builds structure in liquid systems due to its modified surface chemistry. TS-720 provides a similar thixotropic behavior to the untreated grades but reforms its structure faster. This faster recovery rate results in less flow and leveling behavior and greater sag resistance values in many coatings systems. The rheological control performance of TS-720 varies significantly from that of the untreated silicas. The effectiveness of modified surface chemistry is dependent upon its compatibility with the system. For more information, refer to the section entitled Factors Affecting the Performance in Liquid Systems, Treated Fumed Silicas (Page 9).

CAB-O-SIL TS-610 treated fumed silica provides rheology control in liquids via hydrogen bonding. The dimethyldichlorosilane groups react with the surface hydroxyl groups. This reaction reduces the hydroxyl population thus lessening the ability to form inter-aggregate hydrogen bonds. The thickening efficiency of TS-610 is less than that of M-5 (200 m²/g) because of (1) the lower surface area of the starting silica, LM-130 (130 m²/g), and (2) the reduced hydrogen bonding ability. With this reduced bonding ability, the time required to reform structure after shearing is extended. This improves the flow and leveling behavior, resulting in less “orange peel” in the film. Grade TS-610 will require a slightly higher loading than M-5 (200 m²/g) to achieve the same sag resistance.

CAB-O-SIL TS-530 treated fumed silica is an excellent anti-settling agent and will cause minimal viscosity increases in a coatings system. This feature can be especially useful in high solids systems. TS-530 is generally not recommended as a rheology control agent. The reaction of hexamethyldisilazane with most of the surface hydroxyl groups significantly reduces the ability of TS-530 to quickly build the needed structure.

Fig. 4: Treated and Untreated Fumed Silica Performance in Coatings



Relative performance improves away from the center of the chart

Factors Affecting the Performance in Liquid Systems

■ Untreated Fumed Silicas

There are four main factors which influence the performance of the untreated grades of CAB-O-SIL fumed silica in coatings. They are:

1. The polarity of the system
2. The degree of dispersion of the silica
3. The presence of other hydrogen bonding materials in the coating
4. The pH in an aqueous coating

Polarity: In a coating system, the overall polarity and hydrogen bonding ability of the system is determined by the polymer system used and the solvents used to dissolve the polymers. Almost all of the polymers incorporated in coating systems are under the medium hydrogen bonding classification. The presence of crosslinking groups such as hydroxyl, carboxyl, epoxide or isocyanate renders these polymers polar. The molecular weight of the polymers and the location of these chemical groups determine the extent of the polarity.

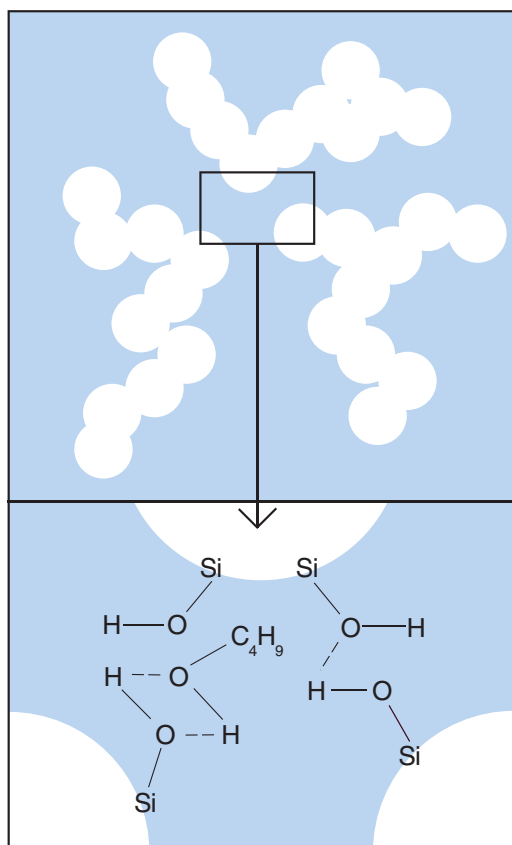
The solvents also may have a great or greater influence on the functioning of fumed silica than the polymer. Oxygenated solvents such as ketones, ethers, esters and alcohols are very polar and can adversely affect the efficiency of CAB-O-SIL fumed silica. Figure 5 illustrates this effect using n-butanol as an example. The hydroxyl group of the alcohol hydrogen bonds with the surface hydroxyl on the silica. However, the butyl group on the alcohol will not hydrogen bond. This interferes with the silica structure formation and results in a loss of critical properties such as sag resistance and antisetling behavior.

Dispersion: CAB-O-SIL fumed silica must be properly dispersed to obtain efficient rheology control and to maximize effectiveness. Fumed silica should be dispersed to a Hegman grind of 4 to 7.5 NS (8-33 micrometers) for maximum efficiency. If the fumed silica is under-dispersed, the network will not develop sufficiently.

Hydrogen Bonding Materials: Coatings formulations can be very complex, containing many materials which will interact with fumed silica. These materials may either hinder or enhance the ability of the silica to provide the needed rheology control. Many materials which are used as dispersants and wetting agents can enhance the efficiency of fumed silica. These materials often have multiple hydrogen bonding sites, such as hydroxyl, carboxyl or amine functionality. Any material that contains a single active hydrogen bonding site can hinder the effectiveness of CAB-O-SIL fumed silica.

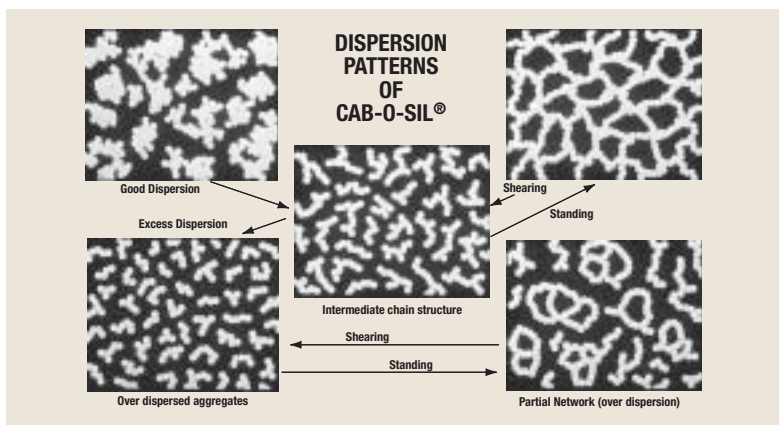
Figure 6 illustrates over-dispersion, a major concern in the use of CAB-O-SIL fumed silica. The center graphic represents the silica when it is properly dispersed. After application (top right graphic), the network is able to reform throughout the coating film in the short period of time required to stop sagging. Lower left graphic represents

Fig. 5: Hydrogen bonding of n-butanol molecules on CAB-O-SIL hydrophilic fumed silica reducing silica network formation



the chain structure when the silica has been over-dispersed. After application (lower right graphic), only a partial network is able to reform in the time required to forestall sagging. This is due to the greater number of inter-aggregate hydrogen bonds needed to reform the entire network when starting with a smaller agglomerate size. It is recommended that CAB-O-SIL fumed silica be dispersed to a maximum Hegman grind of 7.5 NS (8 micrometers).

Fig. 6:

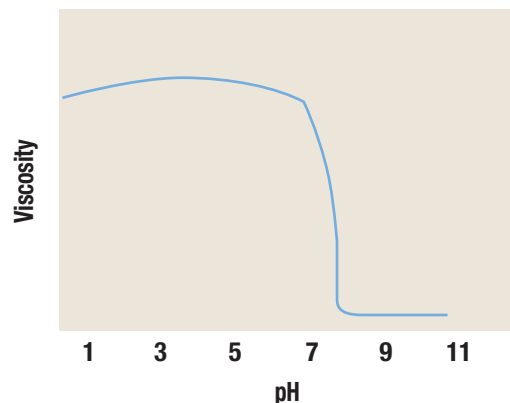


pH in Aqueous Systems: In aqueous systems, the pH has a profound effect on the ability of fumed silica to provide rheology control (Figure 7). Fumed silicas do not have a net surface charge. The surface hydroxyl groups can be ionized, depending upon the pH of the water. At a pH of 2.3, the iso-electric point of fumed silica, no ionization takes place. When the pH is below 2.3 the surface takes on a positive charge. At a pH above 2.3, the silica takes on a negative surface charge. Above a pH of 8.5, the surface charge on the silica generates sufficient electrostatic repulsion to hold the particles far enough apart to stop inter-particle hydrogen bonding. Above the 8.5 pH, fumed silica cannot perform effectively as a rheology control agent without the addition of an additive. At a pH over 10.8, the silica goes into solution.

■ **Treated Fumed Silicas**

CAB-O-SIL TS-610 and TS-530 treated fumed silicas function via hydrogen bonding, and the same factors which affect the untreated grades will influence their performance. The performance of TS-720 is influenced by different factors (refer to the section entitled Mechanism in Liquid Systems - Treated Fumed Silicas, page 7). The rheological control performance of TS-720 is much less sensitive to the polarity of the system than are the untreated grades. TS-720 will perform poorly in a coating using low molecular weight alcohols or aliphatic hydrocarbons. Reactive diluents used in epoxy systems will affect the efficiency and viscosity stability of TS-720 in these systems.

Fig. 7: The effect of pH on the viscosity of highly dispersed CAB-O-SIL M-5 fumed silica in water

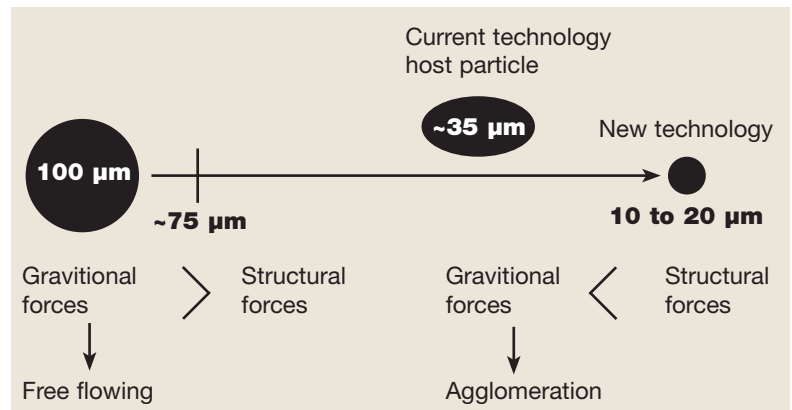


Mechanism in Powder Coatings

All powder coating systems that use either tribo-charging or corona-ion equipment require a flow additive to optimize performance during spraying and handling also to prolong the stability of the coating material in storage.

Powder cohesion is the result of structural forces within the material that compete in various ways, depending on particle size, humidity and particle composition, with the gravitational forces experienced by the particles (Figure 8). When dry particles are larger than 75 microns, gravitational forces are greater than the structural or inter-particle forces, and particle-particle attractions are negligible. As a result, powder can fluidize and flow with much less energy, since the particles can move independently of one another.

Fig. 8: Structural and gravitational forces

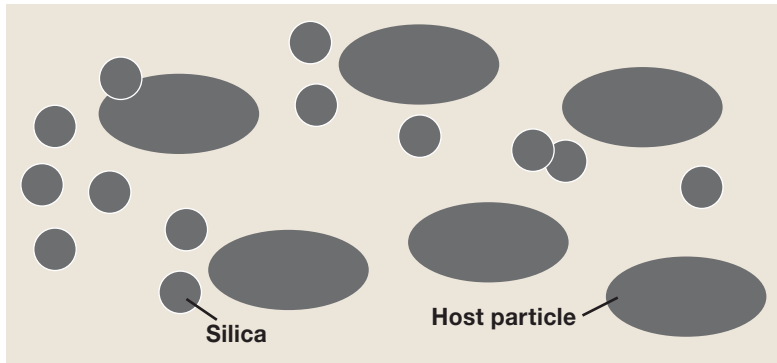


- **Overall goal:**
Achieve thinner films through reduction of host particle size
- **Approach:**
Addition of fluidization agent/flow conditioner

When particles are less than 75 microns, structural forces tend to dominate and the resultant particle-particle interactions lead to a powder that is usually cohesive and will fluidize and flow poorly. This is particularly the case with particles of 25 microns or less. Flow additives, such as fumed silica or fumed alumina, overcome this problem if they have the appropriate size distribution and an affinity for the surface of the host particle.

If the flow additive is too large or has a poor affinity with the host particle's surface, it results in a random mixture (Figure 9). In this case, the flow additive and host particle tend to self-associate and produce pockets of additive within a matrix of host particles.

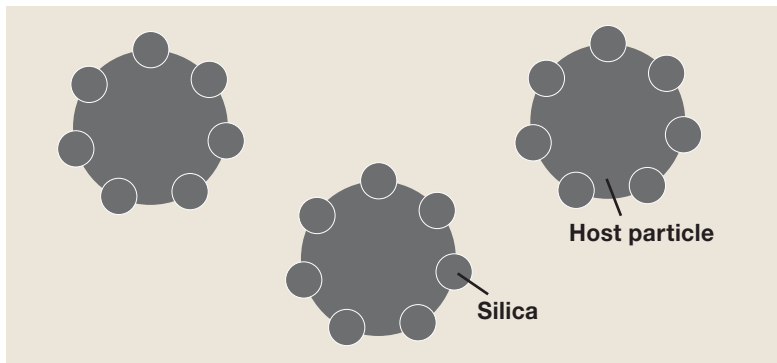
Fig. 9: Random mixture



- **Segregation / demixing of all components**
- **Host particles tend to agglomerate**
 - More energy to fluidize
 - Settling during transportation
 - Poor flow of powder

The opposite of random mixtures are ordered mixtures, where the additive coats the host particles so that they move as one unit, and all components are evenly distributed on the host particle surface (Figure 10). This additive 'coating' prevents the particles from agglomerating and reduces the cohesiveness of a powder caused by van der Waals forces, moisture adsorption, electrostatic charging or inter-particle friction.

Fig. 10: Ordered mixture



- **Uniform distribution of all components**
- **Host particles act independently of each other**
 - Less energy to fluidize
 - Less settling during transportation
 - Better flow of powder
 - Increased aerated bulk density

The van der Waals forces, which are attractive, decrease with particle separation, which additives can promote. These forces are particularly important when smaller particles – such as those found in today’s fine coatings – are involved.

At low levels of moisture adsorption additives can again act as a spacer to prevent adsorbed layer contact. At high moisture levels, when liquid bridging can occur and cause powder caking, additives (particularly if they are hydrophobic) can reduce moisture adsorption on the paint powders.

The appropriate additives can also reduce electrostatic bonding by changing the charging properties of the powder and act as dry lubricants or glidants to reduce inter-particle friction.

The fundamental purpose of fluidizing additives is to achieve a highly ordered mixture by increasing the host-particle-to-additive size ratio and/or increasing the affinity of the additive to the host-particle surface. As a general rule, the host particle size should be at least six times greater than the particle size of the additive, preferably higher. Since most paint powder is of the order of 35 microns, the maximum particle size of the additive should be about 5 to 6 microns. In recent years Cabot Corporation has put considerable effort into developing materials that meet this requirement, and the latest CAB-O-SIL fumed silica and SpectrAl fumed alumina grades have a mean aggregate size which is well over an order of magnitude smaller. With the smallest individual units measuring only 0.1 to 0.2 microns, these materials are well suited for use in formulations for very thin coatings.

To encourage additive adhesion to the host particle, specially treated silicas are often required. However, the treatment must not affect the aggregate size of these silicas or the advantage of the treatment is reduced.



Recommendations for Use in Coatings

■ Rheology Control

The thixotropic behavior which CAB-O-SIL fumed silica imparts to coatings systems is the key to solving many coatings application problems. Sag control is achieved through the three dimensional structure the silica builds in the film. Good flow and leveling behavior is possible because the structure is temporarily destroyed during the application, such as spraying, brushing, flow coat, etc. The structure requires a short amount of time to rebuild after the application shear forces are removed. The coating is able to flow readily enabling leveling to take place. As the structure rebuilds, all movement stops and the film resists the pull of gravity. Even the thinning of coating resins at baking oven temperatures will not disrupt the structure and cause sagging.

In addition to this anti-sag function, the thixotropic behavior imparted by fumed silica will benefit other coatings' properties as discussed in the section entitled Mechanism in Liquid Systems (Page 6).

Fumed silica reduces the tendency for "picture framing" or "fat edges". It can control flake orientation in metallic finishes and improve the hold out of coatings. Also, it can control the development and size of the pattern in hammer finishes.

Use levels: The amount of fumed silica needed to provide rheology control is dependent upon several factors. The most important elements are the polarity of the system, the amount of dispersion energy available in manufacturing the coating, and the coating application film thickness. The influence of polarity and its interdependence with dispersion energy in manufacturing was discussed in the previous section entitled Factors Affecting the Performance in Liquid Systems (Page 8). In general, sufficient anti-sag behavior at 1 to 3 mil (2.5 to 7.5 micrometers) film thickness will require a fumed silica loading of between 0.25 and 0.5 wt.% of the total formula weight. For high build coatings in the 15 to 30 mil (38 to 75 micrometers) film thickness range, loadings of 2 to 3 wt.% may be required. Picture framing is also dependent on the film thickness, requiring the same usage levels as sag resistance. For proper control of the flake orientation in polychromatic finishes, the level of CAB-0-SIL fumed silica should be between 15 and 20% of the weight of the metallic flake pigment. A level of 0.3 to 0.6 wt.% fumed silica is recommended to improve the pattern control in hammer finishes. Hold out of a coating applied to a porous substrate will be improved with the addition of 0.25 to 0.75 wt. % CAB-0-SIL fumed silica.



Grade selection: Selection of the best grade of CAB-0-SIL fumed silica is dependent upon matching the dispersability of the fumed silica with:

- The dispersion energy available in manufacturing
- The other pigments present

These factors are all interdependent. In addition, CAB-0-SIL TS-720 treated fumed silica is especially useful in epoxy/polyamide and urethane coatings.

The dispersability of the silica should always match the dispersion equipment to be used. If high speed dispersion equipment is used, such as a Cowles dissolver, grade M-5 (200 m²/g) is recommended. It disperses easily (approximately the same as most untreated grades of rutile titanium dioxide). Grades H-5 (300 m²/g) or HS-5 (325 m²/g) are recommended if a sand mill is used for grinding. It will not be overdispersed by the higher shear in this type of equipment. Grade EH-5 (380 m²/g) is recommended if a long dwell time in a sand mill, a horizontal bead mill, or closed mill (such as a ball or pebble mill) is used to manufacture the coating. This grade will stand up to the dispersion forces generated by this equipment.

CAB-O-SIL treated fumed silicas require more shear or dispersion energy than the untreated silicas. TS-720 can be dispersed to a Hegman grind of 2 to 3 NS (65 to 75 micrometers) using a high speed disperser. A sand mill or ball mill is needed to achieve Hegman grinds of 5.5 to 6.5 NS (18 to 33 micrometers). TS-610 and TS-530 are somewhat easier to disperse but a sand mill is still required to obtain Hegman grinds finer than 7 NS (15 micrometers).

The dispersability of the grade of CAB-O-SIL fumed silica selected should also match the dispersability of other pigments in the grind portion of the coating. For example, grade M-5 (200 m²/g) should not be paired with a pigment such as a yellow iron oxide. In obtaining the desired Hegman grind on the slower dispersing iron oxide, the M-5 (200 m²/g) will be overdispersed. This will be detrimental to its performance as a rheology control agent. Grades H-5 (300 m²/g) and HS-5 (325 m²/g) are comparable in dispersability to synthetic red and yellow iron oxides, treated titanium dioxides, and many mineral filler pigments. Grade EH-5 (380 m²/g) is comparable to many organic pigments. As an alternative, a master batch dispersion of only the fumed silica may be made in the desired resin and solvent system. This can then be post added to the formulation to give the desired rheology control.

CAB-O-SIL TS-720 treated fumed silica is especially suited for use in two package epoxy/polyamide and urethane coatings. It will provide very stable viscosity and sag resistance to the coating during both the

shelf and pot life of these systems. In epoxy/polyamide coatings, the untreated grades are stable for approximately the first hour of pot life and then begin to lose sag resistance and viscosity rapidly.

■ Anti-settling

CAB-O-SIL fumed silica's development of a three-dimensional structure in a coating prevents the settling of any other pigments in the system. Once the silica network is formed, it will support the other pigment particles and prevent their migration to the bottom of the container. This action is useful for both the shelf storage of the coating and in preventing separation and stratification of pigments between application and final curing of the coating. Some materials, such as metallic powders and flakes, are very prone to settling and cannot be completely suspended. However, they can be prevented from forming a hard cake on the bottom of the container. Fumed silica will keep the sediment soft and easy to re-disperse by simple stirring and shaking.

Use Levels: The level of fumed silica needed for adequate antissettling behavior is dependent upon the type and amount of material to be suspended. Materials with very fine particle sizes, even though they may have high densities, are easy to suspend with CAB-O-SIL fumed silica. Most organic pigments, titanium dioxide, synthetic iron oxides and synthetic calcium carbonates can be suspended with a level of fumed silica between 0.2 and 0.4 wt. % of the total formula. Systems with high pigment concentrations, such as primers and fillers, may require slightly higher levels. Larger sized materials, such as natural filler pigments and natural iron oxides, require use levels between 0.25 and 0.5 wt. % of total coating weight for effective control of settling. Metallic powders such as zinc dust require use levels of 2.0 to 2.5 wt. %. This will prevent hard settling but will not stop stratification of the zinc dust in the container during storage.

Grade Selection: In order to prevent settling, the fumed silica grade used must be properly dispersed. The minimum Hegman grind needed is 3.0 to 4.0 NS (50 to 65 micrometers). Therefore, a grade should be selected which matches the capabilities of the dispersion equipment used. Over-dispersion is much less of a concern in anti-settling uses than in rheology control applications. The phenomenon of anti-settling is a long-term function. The structure does not need to reform completely in a short period of time, as it would in anti-sag behavior. For use in these applications, the fumed silica can be dispersed right along with the other pigments without concern of over-dispersion. Grades M-5 (200 m²/g), H-5 (300 m²/g), HS-5 (325 m²/g), EH-5 (380 m²/g), TS-720, TS-610 and TS-530 are all generally effective. TS-530 can provide adequate anti-settling with a minimal increase in the viscosity. This may be an advantage in high solids coatings.



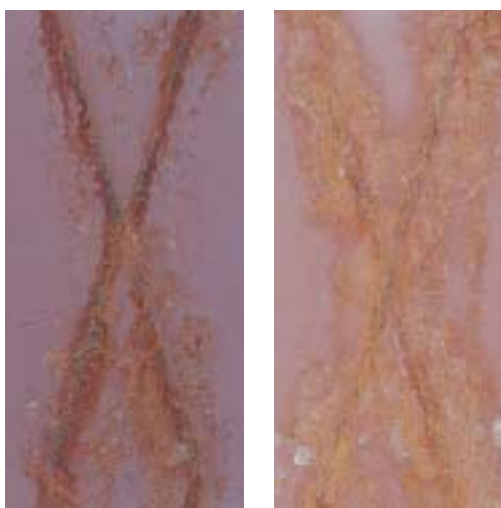
Corrosion resistant coatings

CAB-O-SIL TS-720 fumed silica is an excellent thixotrope for coatings and has superior water resistance compared to many competitive thixotropes.

The hydrophobicity of CAB-O-SIL TS-720 fumed silica can be important in coatings used to prevent the corrosion of ferrous metals. The permeation of moisture and ions (e.g. sodium and calcium) through a protective coating plays an integral part in the corrosion process. The use of an anti-sag or anti-settling agent with a polar surface can provide a path for the transmission of water and ions to the metal surface. The accumulation of water at the metal surface breaks the adhesion of the coatings causing osmotic blisters which in turn expose more of the metal surface to rapid corrosion. The ions present greatly increase the electrolyte strength at the interface and accelerate the corrosion rate. The hydrophobic surface treatment on CAB-O-SIL TS-720 fumed silica will not provide a pathway for moisture and ion transmission to the metal surface. Hence, the use of CAB-O-SIL TS-720 fumed silica can reduce the amount of osmotic blistering and corrosion compared to other thixotropes such as treated clays and to other less completely treated hydrophobic fumed silicas.

CAB-O-SIL TS-720 fumed silica was tested against a treated clay in an air-dry alkyd primer. The primers were applied to steel panels and exposed for 200 hours in a salt spray cabinet. The primer with CAB-O-SIL TS-720 showed significantly less blistering compared to the treated clay. The panels are shown in Figure 11.

Fig. 11: CAB-O-SIL TS-720 Improves Corrosion Resistance



Air-dried alkyd coating with CAB-O-SIL TS-720 exposed for 200 hours in salt spray cabinet.

Air-dried alkyd coating with treated clay exposed for 200 hours in a salt spray cabinet.

■ Fluidization in Powder Coatings

CAB-O-SIL fumed silicas and SpectrAl fumed aluminas can provide free flow and anti-caking properties to powder coatings. These properties promote trouble-free electrostatic spray and fluidized bed applications. In addition, the fumed silica can provide rheology control to the coating while it fuses and control edge coverage, sags, runs and drips.

The materials may be incorporated either before or after the powder has been ground. A variety of powder mixers including twin shell blenders, motionless mixers and sigma blade mixers may be used to post mix the fumed silica into the powder. The material may also be easily metered into materials using screw feed hoppers.

Use Levels:

Figure 12 shows the results of tests on five Cabot grades to determine the flow performance achieved at different loading levels in a polyester TGIC powder formulation at 0.1-0.6 weight percentage.

CT-1221 provides exceptional fluidization performance at very low loadings, typically 0.1% or less. Higher loadings are required with other fumed silicas and fumed aluminas.

Grade Selection:

Fumed alumina is primarily added to improve tribo-charging functions in tribo-coating applications. It also improves the flow properties of these powder mixes. This performance generally improves with smaller alumina particle size (such as found in SpectrAl 100) and at higher loadings, although very effective flow enhancement is obtained with all alumina grades at relatively low loadings (~0.2 weight %).

For corona coating applications, CAB-O-SIL CT-1221 fumed silica shows exceptional fluidization performance at extremely low loading (0.1 % or less).

Both CAB-O-SIL CT-1221 and the fumed alumina grades also provide anti-blocking benefits. Hydrophilic fumed silica, however, provides flow but is more delicate to formulate at higher loadings.

These additives were also tested for their effect on fluidization pressure and aerated and tap (packed) bulk density. Each additive had an effect on fluidization pressure as well as aerated and tap bulk density, and matching the theory, the additives that increased the aerated bulk density required less pressure to fluidize the powder.

These observations are typical and have also been made in a wide range of powder coating chemistries, such as epoxies, polyester/ epoxy hybrids, acrylics and urethanes.

Fig. 12: Flow performance at different loading levels in a polyester TGIC powder formulation at 0.1-0.6 weight percentage

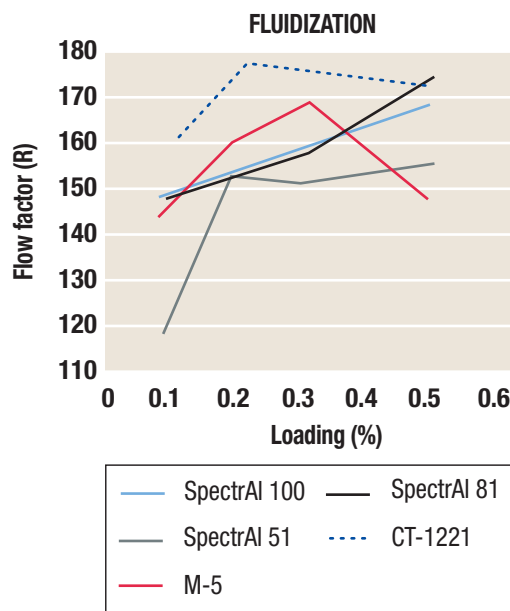
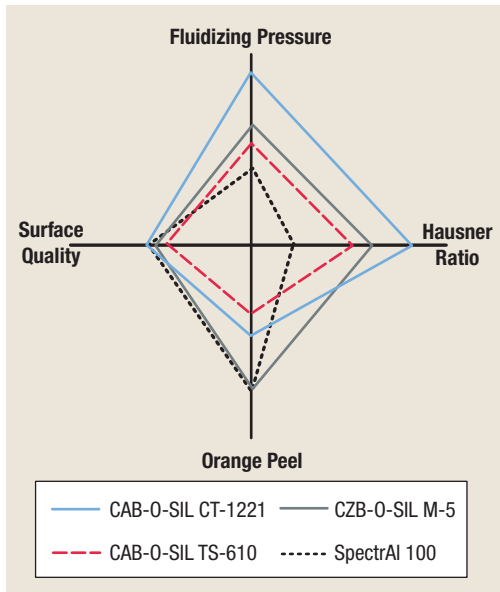


Fig. 13: Fumed Alumina and Fumed Silica Performance in Powder Coatings



Performance improves away from centre of chart

In fluidization and Hausner Ratio measurements, CAB-O-SIL CT-1221 treated fumed silica performed considerably better than other fumed silicas as well as the high-surface-area SpectrAl fumed alumina. Furthermore, CAB-O-SIL CT-1221 fumed silica is also specially treated to adhere to a range of host particle surfaces so as to minimize inter-particle interactions in order to improve fluidization and free flow.

The star diagram (Figure 13) shows also that both SpectrAl fumed alumina and CAB-O-SIL CT-1221 give strong surface quality performance. Therefore, fumed alumina is the additive of choice with respect to finish and, specifically, to reduction in orange-peel effect.

Cabot's CT-1221 fumed silica and SpectrAl fumed alumina range have brought a number of improvements in the area of powder fluidization, producing ordered mixtures, which have the added benefit of enhancing flowability and fluidize as well as transfer efficiency and reclaim. They add robustness to paint powder and do not have any adverse effects on film properties. In addition, they are effective in a range of chemistries encompassing both thermoplastic and thermoset powders.

CAB-O-SIL Fumed Silica and SpectrAl Fumed Alumina Grade

■ Selection Guide

Coatings	Application	Carrier/System	Primary Performance Criteria	Best Grade Fit
	Powder coating	Corona charging	Fluidization (free-flow), surface smoothness, stability and transfer efficiency at low loading	CAB-O-SIL CT-1221, TS-530, TS-610, M-5, H-5, HS-5, EH-5
		Tribo-charging	Surface quality, orange peel reduction, anti-caking, gloss and stability	SpectrAl 51, 81, 100
	Clear coat	Polyurethane, acrylic, epoxy ester, amino	High gloss, rheology control, sag resistance, levelling, scratch resistance	CAB-O-SIL TS-530, TS-610, M-5, EH-5, SpectrAl 51, 81, 100
	Liquid coating	Solvent-based or high solid coating	Anti-settling, sag resistance, flattening	CAB-O-SIL M-5, H-5, HS-5, EH-5, M-7D, TS-720
		Acrylic, polyester, nitrocellulose	Sag resistance, rheology control, anti-settling	CAB-O-SIL M-5, EH-5, CAB-O-SPERSE 2020K
		Epoxy, vinyl ester, polyurethane	Sag resistance, rheology control, anti-settling	CAB-O-SIL TS-610, TS-720
		Polychromatic finishes (metal flakes)	Metallic flake orientation Corrosion	CAB-O-SIL M-5, H-5, HS-5, EH-5, TS-720, TS-610, TS-530
		Industrial and marine	protection, moisture resistance	CAB-O-SIL TS-610, TS-720, TS-530
	UV-curing	All systems	Sag resistance, coating rheology control	CAB-O-SIL M-5, TS-610

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