FUMED METAL OXIDES

General guide: CAB-O-SIL® fumed silica and SpectrAl® fumed alumina
Exceptional performance benefits with CAB-O-SIL® fumed silica and SpectrAl® fumed alumina

Cabot’s cornerstone products: CAB-O-SIL® fumed silica and SpectrAl® fumed alumina 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 of our customers around the world.

Cabot’s Fumed Metal Oxides (FMO) business is made up of two product families:

**Fumed Silica** includes CAB-O-SIL® fumed silicas, which are free-flowing powdered products, available in untreated and treated grades. They are very versatile and used in a variety of applications, ranging from spark plugs and printing inks to pharmaceuticals and cake mixes. CAB-O-SIL®'s versatility is related to its high degree of purity and amorphous structure, both of which lead to excellent performance.

**Fumed Alumina** includes SpectrAl® fumed aluminas, available in untreated and treated grades. These products are unique because of their unusual particle characteristics, crystallinity and high purity. In powder form, fumed alumina is fine, white, and extremely fluffy. However, when finely dispersed in liquids and polymers, it appears colorless and clear. SpectrAl® fumed alumina enhances several different properties in a formulation, such as hardness and positive charge.
CAB-O-SIL® fumed silica

Functions
Manufacturing
Applications:
- Adhesives & sealants
- Silicone elastomers
- Coatings & inks
- Composites
- Pharmaceuticals
- Personal care - Cosmetics
- Fire extinguisher
- Food
CAB-O-SIL® fumed silica

Functions

It is produced with state-of-the-art technology and obtained through a continuous process, resulting in a product with the highest degree of purity. It delivers a unique performance in both liquid and powder form.

Liquids
- Thickening, increased viscosity and thixotropy
- Anti-sag, anti-settling of loads, pigments, heavy active ingredients, etc.

Powders (solids)
- Improves fluidity, anti-caking and anti-moisture
- Increases powder mechanical resistance, providing greater compacting resistance
CHARACTERISTICS
• Amorphous
• Non-porous
• Chemically inert
• Odorless
• White
• Insipid

PROPERTIES
• Degree of purity: > 99.8% SiO₂
• Surface area: 90 to 380 m²/g
• Loss on drying: 0.5 - 1.5% by weight
• Specific weight: 2.2 g/cm³
• X-Ray structure: amorphous
• Index of refraction: 1.46
• Color: white
• PH (4% of water): 3.7 - 4.3

Right choice
Ideal grades of CAB-O-SIL fumed silica
<table>
<thead>
<tr>
<th>CAB-O-SIL M 5</th>
<th>CAB-O-SIL EH 5</th>
<th>CAB-O-SIL TS 720</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAB-O-SIL M 5P</td>
<td>CAB-O-SIL HP 60</td>
<td>CAB-O-SIL CT 1221</td>
</tr>
<tr>
<td>CAB-O-SIL M 5DP</td>
<td>CAB-O-SIL TS 610</td>
<td>CAB-O-SIL CT 1111G</td>
</tr>
<tr>
<td>CAB-O-SIL M 7D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Applications

Adhesives and sealants

CAB-O-SIL fumed silica increases the viscosity of adhesives and sealants, provides thixotropy, improves extrusion properties during application, prevents sagging during curing (drying) and improves adhesive and reinforcing properties. It extends the product’s shelf life and maintains its characteristics during storage.

Right choice

<table>
<thead>
<tr>
<th>Ideal grades of CAB-O-SIL fumed silica</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Most adhesives and sealants</td>
<td>CAB-O-SIL TS 610 &amp; TS 720</td>
</tr>
<tr>
<td>Hot-melt reactive adhesives / UV cured</td>
<td>CAB-O-SIL TS 610</td>
</tr>
<tr>
<td>Epoxy and PUR (polyurethane) systems</td>
<td>CAB-O-SIL TS 720</td>
</tr>
<tr>
<td>with high polarity or moisture-sensitive (moisture cured)</td>
<td></td>
</tr>
</tbody>
</table>

Reasons for using CAB-O-SIL TS 610 and TS 720 in PURs & epoxy

**TS 610**
- Due to its excellent hydrophobicity, it offers great storage stability and an extended product shelf life. TS-610 is an excellent choice for use in reactive/moisture curing systems such as isocyanate or silane. In addition to being moisture resistant, it provides excellent corrosion resistance while remaining process-friendly.

**TS 720**
- Lower moisture content (prevents adhesive/sealant pre-curing during storage)
- Provides good viscosity in epoxy and PUR (polyurethane) systems, and keeps the system from losing stability and sagging over time.

RHEOLOGY CONTROL

- THIXOTROPY THICKENING
- EXTRUSION CONTROL (During application)
- ANTI-SAG (During curing)
- COHESIVE AND ADHESIVE PROPERTIES / REINFORCEMENT (Improved tearing tension)
Silicone elastomers:

CAB-O-SIL fumed silicas are used for reinforcement of silicone compounds and organic polymers. Cabot fumed silica strengthens rubber, allowing it to be stretched and deformed without breaking. Cabot offers a range of untreated and treated fumed silicas for optimum performance in silicone applications including:

- Room Temperature Vulcanizing (RTV) silicones
- High Temperature Vulcanizing (HTV) silicones
- Liquid Silicone Rubbers (LSR)
- Silicone Defoamers

Fumed silica provides thixotropy and reinforcement for RTV sealants, while its shear-thinning property provides thickening and sag resistance at rest or low shear and thinning at high shear for easy application. In HTVs and LSRs, fumed silica strengthens the cured rubber, increasing hardness, modulus, tensile strength and tear strength. Unlike other reinforcing fillers, fumed silicas can be used in transparent or clear applications.

In general, as the surface area of fumed silica increases, so does thickening and reinforcement. However, high surface area fumed silicas require high shear dispersion equipment to achieve optimal performance.

In moisture curing RTVs, treated fumed silicas have less adsorbed moisture -- offering better shelf-life and compound stability. Their hydrophobic surface treatments are more compatible with silicones, making it easier to wet-in and incorporate and greatly reducing compounding time. Some Cabot treated silicas do not require additional in-situ treatment or processing aids -- which are required for all untreated fumed silicas in HTVs and LSRs to prevent crepe hardening or structuring.

Right choice

Ideal grades of CAB-O-SIL fumed silica:

| CAB-O-SIL H 5 | CAB-O-SIL M 7D |
| CAB-O-SIL H 300 | CAB-O-SIL S 17D |
| CAB-O-SIL LM 150 | CAB-O-SIL TS 530 |
| CAB-O-SIL TS 622 | CAB-O-SIL TS 720 |
| CAB-O-SIL M 5 | CAB-O-SIL TS 610 |
**Coatings and inks**

CAB-O-SIL fumed silica increases ink viscosity, provides thixotropy, prevents its absorption in very porous surfaces, prevents sagging and curing during application and also prevents the settling in heavy loads, such as for pigments.

**Right choice**

**Ideal grades of CAB-O-SIL fumed silica**

<table>
<thead>
<tr>
<th></th>
<th>CAB-O-SIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Inks</td>
<td>M 5 &amp; EH5</td>
</tr>
<tr>
<td>Anti-corrosive Inks</td>
<td>TS 610 &amp; TS 720</td>
</tr>
<tr>
<td>High solid ink</td>
<td>TS 610</td>
</tr>
<tr>
<td>Inks that require low viscosity</td>
<td>TS 610</td>
</tr>
<tr>
<td>PURs and Epoxy systems or systems with high polarity</td>
<td>TS 720</td>
</tr>
<tr>
<td>Powdered Inks</td>
<td>CT 1111G &amp; CT 1221</td>
</tr>
</tbody>
</table>

**Reasons for using CAB-O-SIL TS 610**

The TS 610 grade provides lower viscosity to any system. Since solid inks already have high viscosity, TS 610 is the ideal choice as it prevents pigments and loads from settling, as well as having a good anti-sag effect and decreasing the system's viscosity.
Composites

CAB-O-SIL fumed silica increases polyester/gelcoat resin viscosity, provides thixotropy and prevents sagging primarily during application on vertical surfaces. It also prevents load sedimentation in formulations with heavy elements or in large concentrations.

Right choice

<table>
<thead>
<tr>
<th>Ideal grades of CAB-O-SIL fumed silica</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Most composites</td>
<td>CAB-O-SIL M 5</td>
</tr>
<tr>
<td>Polyester resins</td>
<td>CAB-O-SIL HP 60</td>
</tr>
<tr>
<td>Requires higher thixotropy</td>
<td>CAB-O-SIL HP 60</td>
</tr>
<tr>
<td>Vinyl ester systems</td>
<td>CAB-O-SIL TS 720</td>
</tr>
</tbody>
</table>

 Reasons for using CAB-O-SIL TS 720 instead of M 5 in vinyl ester

Vinyl ester system possesses high polarity. M 5 does offer good viscosity at the beginning, however, over time, the gelcoat loses stability, especially at high temperatures. Viscosity therefore falls, which may lead to sagging.

Reasons for using CAB-O-SIL HP 60

- 10-15% increased thixotropy as compared to CAB-O-SIL M 5.
- Conservation of viscosity / thixotropy or even higher value after a certain period of time (see graph at the side).
Pharmaceuticals

CAB-O-SIL fumed silica promotes the free-flow of the formulation’s powdered components and increases tablets’ mechanical resistance through direct compression. This increases the productivity of the pharmaceutical industry, thus creating more accurate dosages and reducing loss rates from tablet breakage during pressing. In liquid systems (syrups, etc.), CAB-O-SIL fumed silica improves the uniform distribution of the active ingredients, enhances system viscosity and prevents the sedimentation of formulation components.

Right choice

Ideal grades of CAB-O-SIL fumed silica

- Most products: CAB-O-SIL M 5P
- Companies that follow the international Pharmacopeias, the USP EU or JP: CAB-O-SIL M 5P
- Fewer dust particles: CAB-O-SIL M 5P & M 5DP

Why and when to use CAB-O-SIL M 5P

M 5P is produced under a process oriented to the use of medicines; it comes out of the factory with a complete analysis certificate that meets international pharmacopeias required parameters, such as USP (American) and EU (European).

What is CAB-O-SIL M 5DP grade

M 5DP is a compacted version of the M 5P grade. The advantage of using this grade is that it generates less dust in the environment, because M 5DP is heavier than M 5P. This grade also complies with international pharmacopeias.

Performance in acetaminophen tablets

The influence of CAB-SIL M 5P’s mixing time and concentration on an acetaminophen (n=10) tablet hardness.

Comparison CAB-O-SIL M 5P & M 5DP

Process conditions: 40rpm, 1.5mt for tablet compression.
CAB-O-SIL is the most versatile fumed silica for the cosmetics and personal care sector, including hair products, antiperspirants, nail polishes, make-up, creams, lotions, lipsticks, etc. This versatility is due to its high purity and amorphous structure which provides excellent performance in liquid and powder systems in several applications.

Among the CAB-O-SIL fumed silica product line, there are two different families: hydrophilic silicas (with a surface area ranging from 90 to 380 m²/g) and hydrophobic silicas, such as the TS 610, TS 720 and TS 530.

New formulations appear every day, which shows the versatility that only the one-of-a-kind CAB-O-SIL fumed silica features provide.

<table>
<thead>
<tr>
<th>Right choice</th>
<th>Ideal grades of CAB-O-SIL fumed silica</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most cosmetics</td>
</tr>
<tr>
<td></td>
<td>Need for increased thixotropy and viscosity</td>
</tr>
<tr>
<td></td>
<td>Need for greater transparency</td>
</tr>
<tr>
<td></td>
<td>Need for better moisture resistance</td>
</tr>
</tbody>
</table>

### POWDERS
- Anti-caking fluidity
- Prevents spray valve blockage
- Increased mechanical resistance / hardness

### LIQUIDS
- Increased viscosity
- Tixotropic agent enhances thickening
- Anti-settling of loads and pigments
- Maintains stability at high temperatures
**Tip**

CAB-O-SIL fumed silica is an excellent agent for keeping oil/water emulsions stable. Due to its high water polarity, optimal performance is ideally achieved if you first add CAB-O-SIL fumed silica in the oily phase.

### APPLICATIONS

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>Deodorant</th>
<th>Talcum Powder</th>
<th>Hair Care</th>
<th>Toothpaste</th>
<th>Nail Polish</th>
<th>Lipstick</th>
<th>Sun Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free-flow agent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspension agent</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-blockage (nozzles)</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature stabilizer</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-bleeding</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid thickening</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thixotropic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture-resistant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-exudation agent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
When developing an efficient formulation for powdered fire extinguishers, the greatest challenge comes from the ingredients because they possess high hygroscopicity. Otherwise, the poor flow may cause lumps to form.

CAB-O-SIL fumed silica provides excellent flow for fire-fighting equipment by preventing any agglomeration, even after long storage time.

### Right choice

<table>
<thead>
<tr>
<th>Ideal grades of CAB-O-SIL fumed silica</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC and BC powders</td>
<td>CAB-O-SIL M 5</td>
</tr>
<tr>
<td>Need for Better Flow</td>
<td>CAB-O-SIL TS 610</td>
</tr>
</tbody>
</table>

### Tip

The use of CAB-O-SIL M 5 (hydrophilic silica) at 1% concentration or CAB-O-SIL TS 610 (hydrophobic silica) at 0.5% concentration will result in better flow, preventing the agglomeration of particles. Silica is mixed right after the addition of silicone oil to the powder, forming a protective film that prevents moisture absorption and improves flow and overall performance.
CAB-O-SIL fumed silica provides excellent flow and stability in powdered food, even in products with poor flow, such as HVP (Hydrolyzed Vegetable Protein), Xantana Gum and Guar Gum.

**Performance of flow in additives**

<table>
<thead>
<tr>
<th>% of use of CAB-O-SIL M5 in</th>
<th>FLODEX Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>0.10%</td>
<td>50</td>
</tr>
<tr>
<td>0.25%</td>
<td>70</td>
</tr>
<tr>
<td>0.50%</td>
<td>100</td>
</tr>
<tr>
<td>1.00%</td>
<td>140</td>
</tr>
</tbody>
</table>

Guar Gum
Flow Improvement max. 130%

HPV
Flow Improvement max. 290%

Xantana Gum
Flow Improvement max. 40%

**Performance of flow in HVP**

<table>
<thead>
<tr>
<th>% of use of CAB-O-SIL M5 in</th>
<th>FLODEX Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>0.10%</td>
<td>50</td>
</tr>
<tr>
<td>0.25%</td>
<td>70</td>
</tr>
<tr>
<td>0.50%</td>
<td>100</td>
</tr>
<tr>
<td>1.00%</td>
<td>140</td>
</tr>
</tbody>
</table>

**Right choice**

Ideal grade of CAB-O-SIL fumed silica

Most food CAB-O-SIL M5

**Applications**

- Seasonings and Spices
- Powders and Powdered Spices
- Sweeteners
- Powders and Powdered Soaps
- Vitamins and Pre-Mixes
- Poor Flow of Intermediate Solid Products
- Xantana Gum and Guar Gum

**Characteristics**

- Improves flow
- Prevents the formation of chumps
- Correct dosage
- Improved stability (during storage)
SpectrAl® fumed alumina

Functions
Manufacturing
Applications:
  Powder coatings
  Cosmetics
  Lighting
SpectrAl® fumed alumina

Functions

SpectrAl is the commercial name of Cabot’s fumed alumina family. It is produced with cutting edge technology which results in a product for several applications with the highest purity content.

Manufacturing

CHARACTERISTICS

• Semi-crystalline
• High Index of refraction
• High thermal conductivity
• Cationic

PROPERTIES

• B.E.T. surface area: 55 m²/g - 95 m²/g
• PH (4% aqueous slurry): > 4.7
• Density*: 110 - 60 g/l
• [ Densed ]: 120 g/l
• Loss on drying*: < 1.5% max.
• Loss on ignition: (1.000°C), < 3 wt. %
• Specific weight: 3.6 g/cm³
• Weight per gallon: 30.0 lb
• Index of refraction: 1.77
• X-Ray structure (°)
  THETA ..........56%
  DELTA ..........20%
  AMORPHOUS ..24%
• Purity (% Al2O3): > 99.8 %

* At manufacturing time

Ideal grades of SpectrAl fumed alumina:

SpectrAl 51
SpectrAl 81
SpectrAl 100
SpectrAl PC 401

Pyrogenic process

2 AlCl₃ + 3 H₂ + 1,5 O₂  →  Al₂O₃ + 6 HCl
2400°C
Applications

Powder coatings

The manufacturing process for powder coatings requires a consistent flow in its formulation. For this application, Cabot offers the SpectrAl fumed aluminas that provide this performance.

As SpectrAl fumed alumina has a cationic load, it becomes an effective additive in manufacturing powder coatings for use in tribocharge systems and works remarkably in various types of resins, such as hybrid (epoxy-polyester), polyester-TGIC, and others.

Applied methods

Flow

Right choice
Ideal grades of SpectrAl fumed alumina:
- SpectrAl 51
- SpectrAl 81
- SpectrAl 100
Cosmetics

SpectrAl fumed alumina is an excellent wrinkle reducer and performs particularly well in liquids, anhydrous bases and eye shadows. It is also a perfect matting agent in shadows and eye masks. Its perfect tone diffusion of natural skin color greatly reduces wrinkle visibility, resulting in a smoothing effect and high performance for this application.

<table>
<thead>
<tr>
<th>AVERAGE DATA</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>THICKENING</td>
<td>Total transmission</td>
</tr>
<tr>
<td>Boron nitride</td>
<td>74</td>
</tr>
<tr>
<td>Nylon 12</td>
<td>84</td>
</tr>
<tr>
<td>SpectrAl PC 401</td>
<td>85</td>
</tr>
<tr>
<td>Coated particles</td>
<td>86</td>
</tr>
</tbody>
</table>

- **High Tone Transmission**
- **Perfect & Uniform Diffusion**
- **Matting Agent**
- **Cationic Load** (Allows better adhesion to skin)

Right choice
Ideal grade of SpectrAl fumed alumina:
SpectrAl PC 401
Lighting

SpectrAl fumed alumina has a key role in fluorescent lamp manufacturing since it works as a phosphate inorganic (binder) carrier enhancing their performance and improving the service life of lamps.

It can be used not only as an inorganic carrier, but also as a glass coating, helping UV light absorption and refraction.

Key requirements in lamp manufacturing

<table>
<thead>
<tr>
<th>Requirement</th>
<th>SpectrAl fumed alumina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumen output</td>
<td>Strong or preferred</td>
</tr>
<tr>
<td>Service life (lumen)</td>
<td></td>
</tr>
<tr>
<td>Mercury consumption</td>
<td></td>
</tr>
<tr>
<td>Phosphorous concentration</td>
<td></td>
</tr>
<tr>
<td>Coating strength</td>
<td>Moderate or in stabilization process</td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
</tr>
<tr>
<td>Color output</td>
<td>Weak</td>
</tr>
</tbody>
</table>

Key functions

In the barrier layer
- Prevents migration of sodium into the phosphor during production of lamps and mercury into the glass tube
- Forms a chemical barrier for alkali metals (aluminates) and a physical barrier for Mercury (Hg)

In the reflector layer
- Maximizes the necessary phosphor effectiveness in capturing UV light

As an inorganic carrier
- Aids phosphor components manipulation because of its highest surface area.

Right choice

Ideal grades of SpectrAl fumed alumina:
- SpectrAl 81
- SpectrAl 100
The information contained here is provided as a convenience and for informational purposes only. No guarantee or warranty as to this information, or any product to which it relates, is given or implied. Cabot disclaims all warranties express or implied, including merchantability or fitness for a particular purpose as to (i) such information, (ii) any product or (iii) intellectual property infringement. In no event is Cabot responsible for, and Cabot does not accept and hereby disclaims liability for, any damages whatsoever in connection with the use of or reliance on this information or any product to which it relates.

© Cabot Corporation, MA, U.S.A. All rights reserved worldwide 2011. CAB-O-SIL® fumed silica and SpectrAl® fumed alumina are registered trademarks of Cabot corporation.