CABOT

FUMED METAL OXIDES

APPLICATION GUIDE

CAB-O-SIL® FUMED SILICA
IN ONE-COMPONENT POLYURETHANE ADHESIVES

Application Description

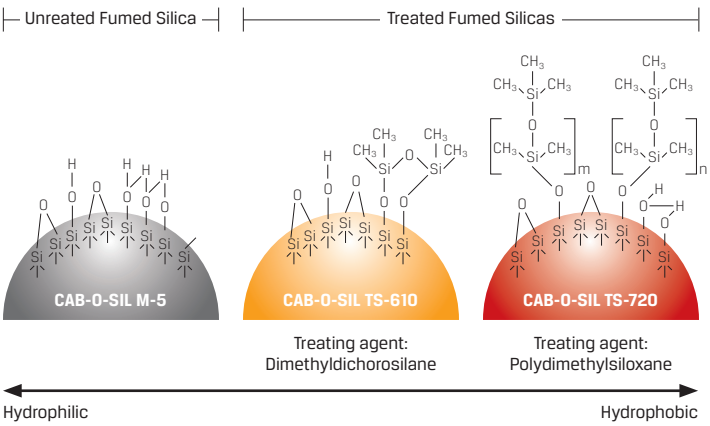
One-component, moisturing-curing polyurethane adhesives used for elastic bonding in construction, industrial assembly and automotive applications require strength and flexibility. Cabot's treated fumed silicas impart thixotropy in adhesives, enabling the adhesives to shear-thin for easy dispensing and application, yet be non-sagging and have stable bond lines until cured. Treated fumed silica can enhance mechanical properties of the cured adhesive, resulting in greater tensile strength, elongation and shear strength.

CABOT PRODUCT OFFERING

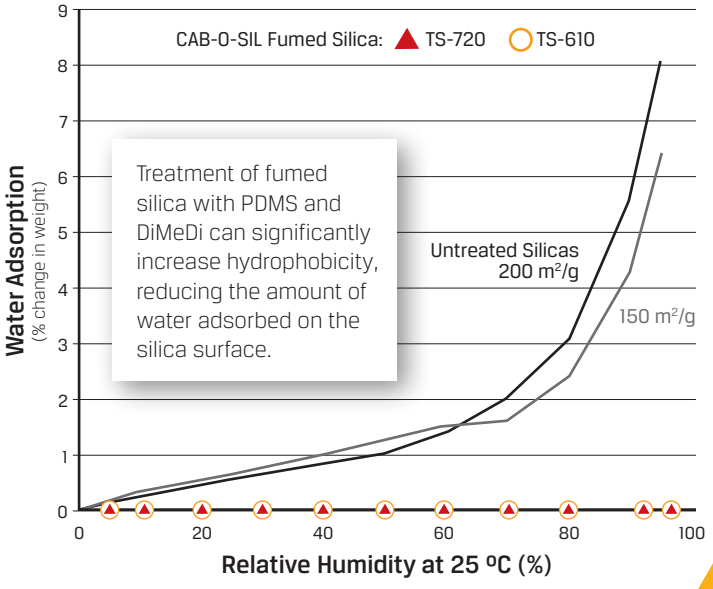
CAB-O-SIL Fumed Silica Products	Base Silica Surface Area (m^2/g)	Treatment Agent	Selection Guidelines
TS-610	130	DiMeDi Dimethyldichlorosilane	Promotes reinforcement with no significant increase in viscosity, suitable for adhesives not requiring sag resistance.
TS-720	200	PDMS Polydimethylsiloxane	Widely used by formulators to create sag-resistant adhesives with shear-thinning behavior.
ULTRABOND™	200	PDMS Polydimethylsiloxane	One of the best commercially available additives to promote sag resistance.

The base silica surface areas in the chart above are typical values only and not product specifications.
Product specifications are available from your Cabot representative.

Untreated fumed silica is hydrophilic, adsorbing undesirable amounts of water in ambient conditions. For this reason, hydrophobic, surface treated fumed silica is suggested for the formulation of moisture-curing polyurethane adhesives to promote good stability and shelf-life.



Water Adsorption of Fumed Silicas at a Range of Relative Humidities

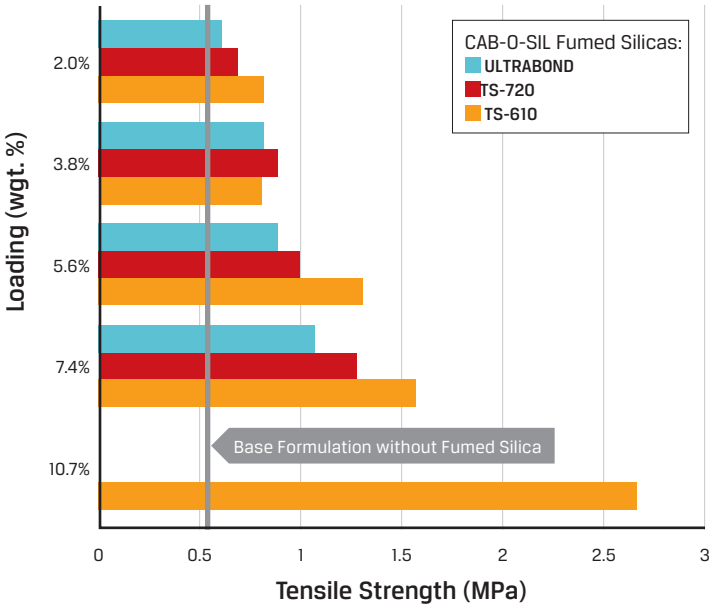


PRODUCT PERFORMANCE – REINFORCEMENT

Treated fumed silica used in formulation of one-component polyurethane (1K PU) adhesives enhances:

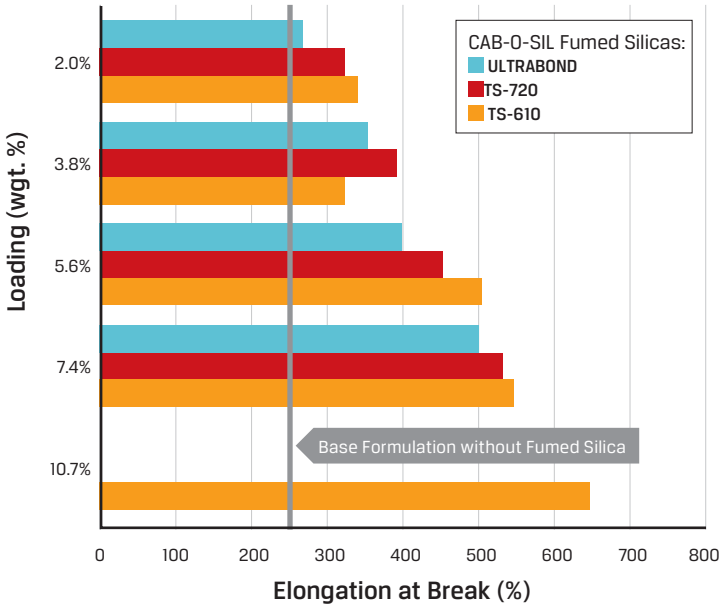
- Tensile Strength
- Shear Strength
- Elongation

Effect of Fumed Silica on Tensile Strength
(in 1K PU Adhesive)



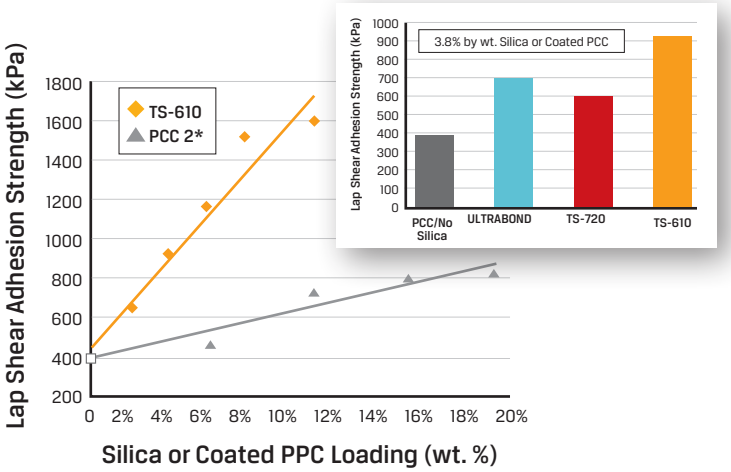
The addition of even low loadings of fumed silica will increase the tensile strength. At higher loading levels, CAB-O-SIL TS-610 DiMeDi treated silica provides greater reinforcement than the PDMS treated silicas.

Effect of Fumed Silica on Elongation
(in 1K PU Adhesive)



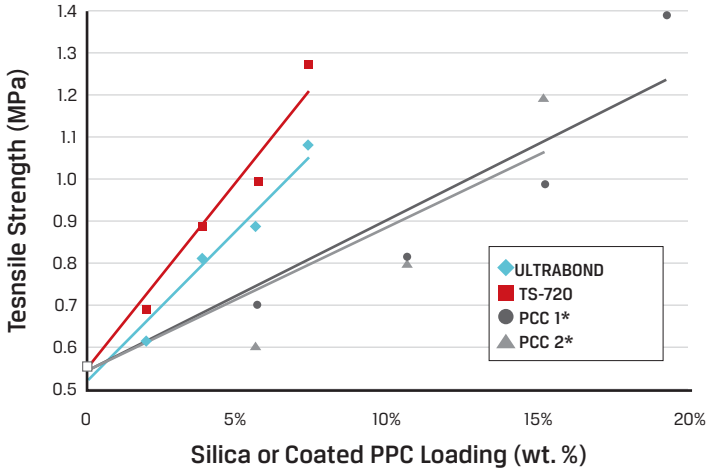
The addition of fumed silica increases elongation.

Effect of Fumed Silica and Coated Precipitated Calcium Carbonate (PCC) on Lap Shear Strength
(in 1K PU Adhesive)



Coated Precipitated Calcium Carbonate (PCC) has only a modest effect on Lap Shear Adhesion Strength, while fumed silica significantly increases this strength.

Performance Comparison of Coated Precipitated Calcium Carbonate (PCC) with PDMS-treated Silicas
(in 1K PU Adhesive)



While both coated Precipitated Calcium Carbonate (PCC) and treated fumed silica can provide thixotropy, enabling formulation of sag-resistant adhesives, coated PCC has only a modest impact on mechanical properties.

*Precipitated $CaCO_3$ (PCC 1); stearic acid coated, average particle size 0.07 microns. Precipitated $CaCO_3$ (PCC 2); fatty acid coated, mean particle diameter 40 -130 nm.

CAB-O-SIL® FUMED SILICA
IN ONE COMPONENT POLYURETHANE ADHESIVES

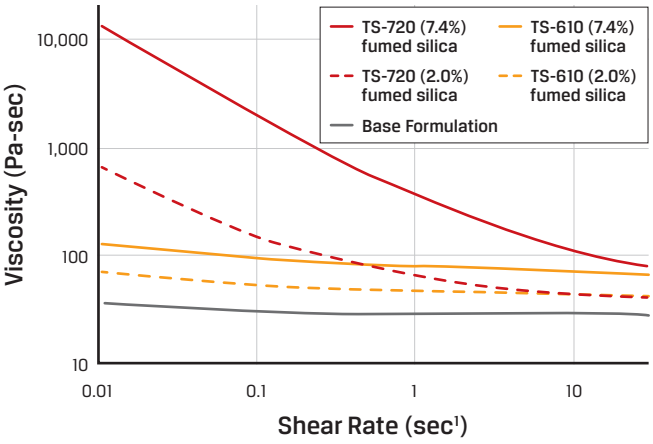
APPLICATION GUIDE

PRODUCT PERFORMANCE – RHEOLOGY CONTROL

Treated Fumed Silica can provide the following performance enhancements for one-component polyurethane adhesives:

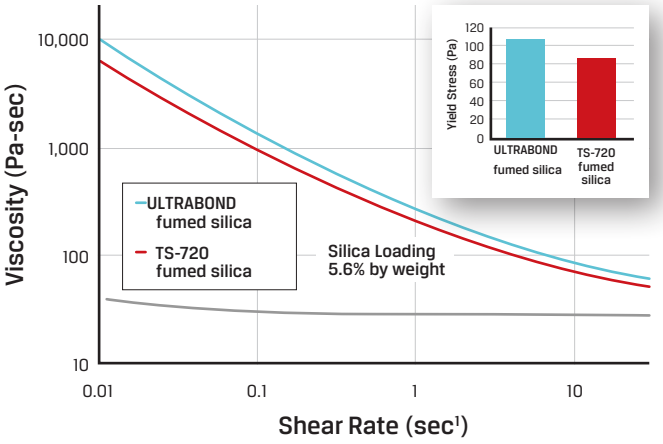
- Non-slumping, sag-resistance
- Anti-settling of fillers
- Shear-thinning for easy application
- Increased viscosity
- Fast recovery/rebuild of viscosity

Effect of Silica Surface Chemistry on Rheology
(in 1K PU Adhesive)



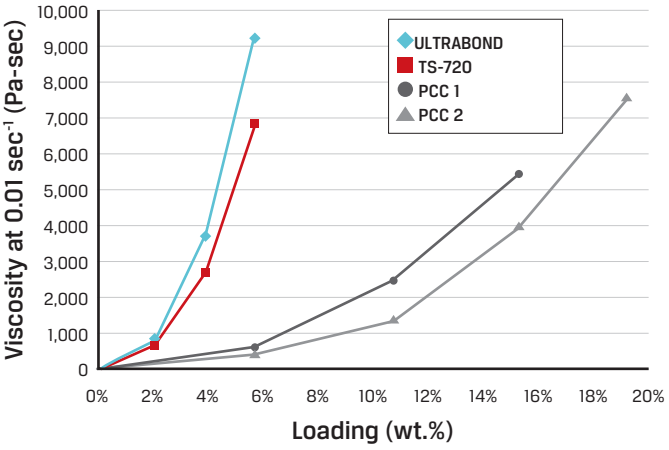
Silica surface treatment strongly influences rheological performance. Selecting a highly hydrophobic silica, such as CAB-O-SIL TS-720 fumed silica, imparts thixotropic or shear-thinning behavior in one-component polyurethane adhesives. In contrast, a moderately hydrophobic silica, such as CAB-O-SIL TS-610 fumed silica, imparts small increases in viscosity without thixotropy or shear-thinning behavior, even at increased loadings.

Cabot PDMS Treated Silicas for Rheology Control
(in 1K PU Adhesive)



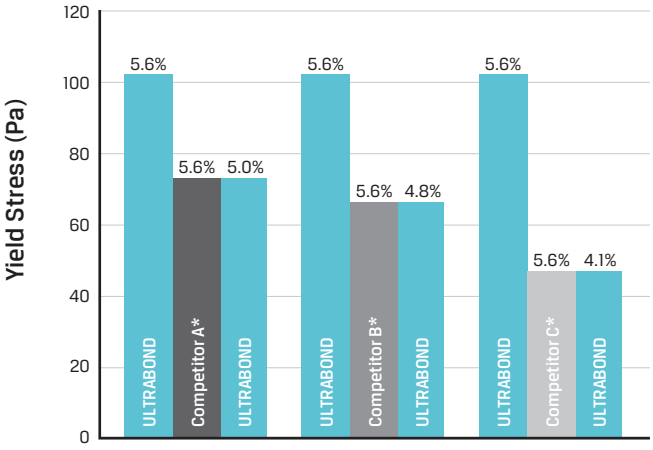
Cabot offers a range of highly hydrophobic, PDMS-treated silicas for rheology control of 1K PU adhesives. Of these, CAB-O-SIL ULTRABOND fumed silica provides the greatest increase in viscocity and sag resistance as predicted by yield stress.

Performance Comparison of Coated Precipitated Calcium Carbonate with PDMS Treated Silica
(in 1K PU Adhesive)



While coated Precipitated Calcium Carbonates (PCC) do increase viscosity and impart thixotropy in 1K PU adhesives, PDMS-treated fumed silicas are more efficient. Using a PDMS-treated fumed silica can provide sag resistance and rheology control without the significant weight (specific gravity) increase encountered with use of coated PCCs.

Performance Comparison of Cabot and Competitive PDMS Treated Silica
(in 1K PU Adhesive)



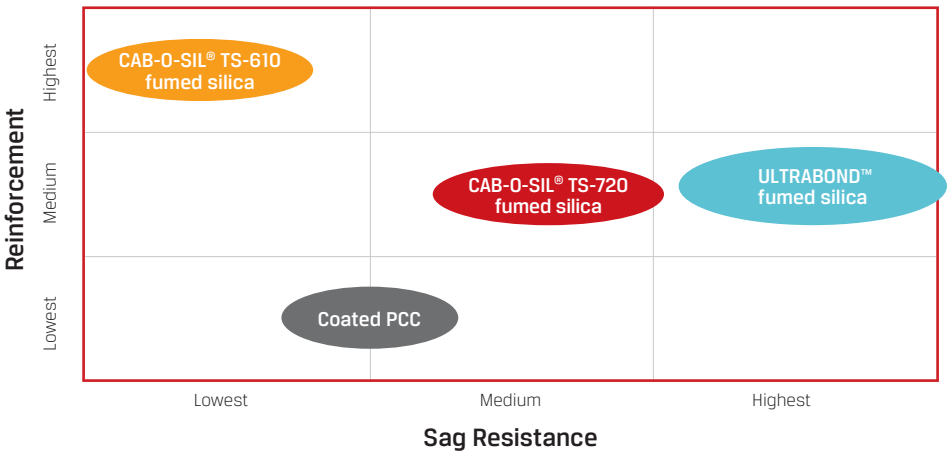
ULTRABOND fumed silica is one of the best thixotropes on the market for 1K PU adhesives. With ULTRABOND fumed silica, significantly lower loadings are required to achieve excellent sag resistance when compared with competitive PDMS-treated silica.

*Competitive A, B and C; polydimethylsiloxane surface modified fumed silicas

CAB-O-SIL® FUMED SILICA
IN ONE COMPONENT POLYURETHANE ADHESIVES

APPLICATION GUIDE

PRODUCT PERFORMANCE



Cabot's portfolio of treated fumed silicas for use in 1K PU adhesives enables the formulator to readily optimize:

- Sag-Resistance
- Reinforcement

CAB-O-SIL ULTRABOND fumed silica offers superior performance with respect to sag resistance.

MODEL FORMULATION

Base Formulation

Prepolymer	100 phr
DIDP Plasticizer	50 phr
Calcium Carbonate	100 phr
Tin Catalyst	1 phr

Raw Materials

- Polyurethane prepolymer; NCO content 〈 2.0%, viscosity ~22,000 cps
- Diisodecyl Phthalate
- Ground Calcium Carbonate; median particle size 20 microns
- Dibutyltin Dilaurate

Thixotropes

Treated Fumed Silica	5 phr 2.0%	10 phr 3.8%	15 phr 5.6%	20 phr 7.4%	30 phr 10.7%		
Coated Precipitated Calcium Carbonate			15 phr 5.6%		30 phr 10.7%	45 phr 15.2%	60 phr 19.3%

Compounding

- Silica and ground $CaCO_3$ dried under vacuum at 200 °C
- Coated PCC dried under vacuum at 100 °C
- Mixed in centrifugal orbital mixer
- Vacuum applied to remove entrained air
- Moisture scavenger, p-Toluenesulfonyl Isocyanate (PTSI), used to adjust H_2O content of adhesive to 〈 500 ppm

Uncured Property Testing

- Controlled stress rheometer using 20 mm parallel plates with dry N_2 gas purge around Peltier plate
- Yield Stress determined using Herschel-Bulkley Model: $\tau = \tau_o + K\gamma^n$ where τ is shear stress, τ_o is yield stress, γ is shear rate and K and n are model factors

Cured Property Testing

- All test specimens cured 14 days at 25 °C/50% RH
- Tensile Strength and Elongation per ASTM D412
- Lap Shear Adhesion per ASTM D1002 on silane treated aluminum substrate, 1" x 1" bond area, 1.7 mm bond thickness

CABOT

www.cabotcorp.com

Technical Support
North America: 1 800 462 2313
South America: +55 11 2144 6400
Europe: +31 71 888 4132
Asia Pacific: +86 21 5175 8800