TECHNICAL INFORMATION 1357

AERODISP® Fumed Silica Dispersions and **HYDREX®** for Anti-Slip Application

EVONIK
Leading Beyond Chemistry

Contents

AEROSIL® AERODISP® AEROXIDE® HYDREX®

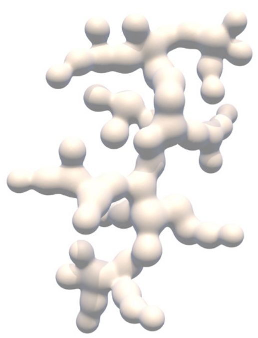
1. Introduction

Many of today's products are packaged in paper bags. With increasing automation, more stringent requirements are needed in the transport and storage of bagged products. It is reasonable for manufacturers, packagers and transporters to expect that bags stacked on a pallet will remain in position and not shift about when the products are transported and warehoused. To enable this, the bag must have an adequate level of static friction at the surface. Over the years, the common brown paper bag has been continuously upgraded to enhance its utility. Nowadays, it is common to see bags printed in various colors, not simply for content identification, but for brand recognition, consumer appeal and advertising. The inks used in the printing process will often reduce the static friction of the paper bag's surface.

To regain the friction, an aqueous colloidal silica dispersion can be applied during or after the printing process to increase the coefficient of static friction to a more suitable level. It is important to realize that colloidal silica consists of small, isolated, spherical particles. Relatively high levels of colloidal silica are often necessary to achieve acceptable anti-slip properties.

Chemically, AERODISP® fumed silica dispersions are quite similar to colloidal silica, but they differ in one important feature: the dispersed AEROSIL® fumed silica particles are highly structured (**Figure 1**).

Figure 1: Structure of fumed silica



Graphical representation of a silicon dioxide particle of AEROSIL® fumed silica

It is this structure that enables a much higher coefficient of friction to be achieved. This in turn allows more flexibility to significantly reduce the amount of silica needed per area of paper surface and thereby reducing the amount of water that is applied to the paper. In addition to the AEROSIL® structure enhancing the coefficient of friction, its fractal structure is also very efficient for absorbing liquids (e.g. inks and water) which prevents print ghosting and reduces encrustation on the machine.

2. Production and properties

AEROSIL® is a synthetic, amorphous silicon dioxide produced by hydrolyzing chlorosilanes in an oxyhydrogen flame, according to the chemical equation.

$$SiCl_4 + 2\ H_2 + O_2 \rightarrow SiO_2 + 4\ HCl$$

The production process was invented more than 70 years ago by Evonik's predecessor company Degussa and has been continuously improved over the years. Because it's produced by flame hydrolysis, AEROSIL® fumed silica is described as fumed silicon dioxide or fumed silica, and because of its fine particles, it is also known as highly dispersed silicon dioxide. The AEROSIL® process can also be used to produce other metal oxides, such as aluminum oxides and titanium dioxide – products that Evonik markets under the brand name AEROXIDE®. Evonik also produces various mixed oxides.

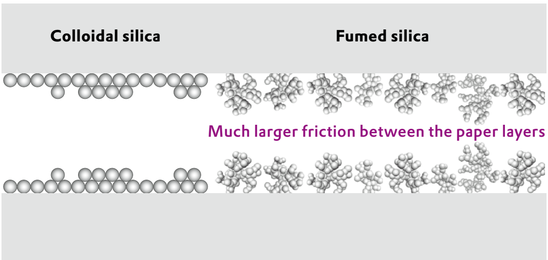
The raw materials used are extremely pure. With a SiO_2 content of more than 99.8% by weight (in relation to the ignited substance), AEROSIL® is one of the purest silica products on the market. Its heavy metal content is generally below the detection limit of conventional analysis methods.

Diverse product modifications

The properties of AEROSIL® and AEROXIDE® can be varied in many areas. For example, the specific area of AEROSIL® OX 50 is just 50 m^2/g, while the surface area of AEROSIL® 380 is almost eight times greater. AEROSIL® 200, the best known product, has a specific surface area of 200 m^2/g.

In addition, customized and stable dispersions of fumed silica are marketed under the brand name of AERODISP® and can be used just like colloidal silica.

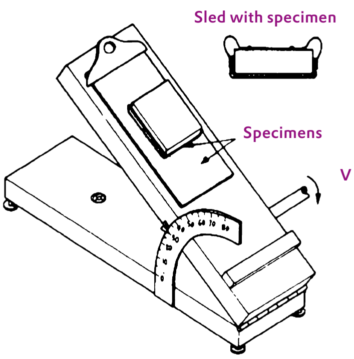
Figure 2: Higher friction with fumed silica



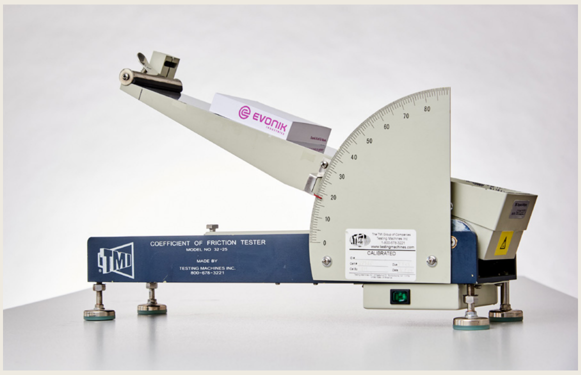
Model for increased static friction of a paper surface coated with AEROSIL® particles as opposed to conventional colloidal silica

3. Measuring the coefficient of friction

Figure 3: Test device for static friction



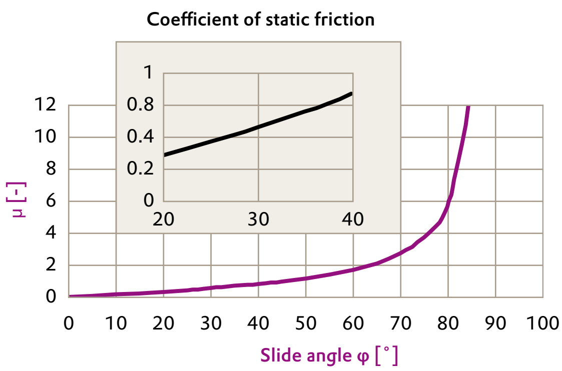
Static friction test device based on the TAPPI T-815 om-1 method



The Coefficient of Friction (μ) can be determined by using TAPPI method T-815 om-01. In this test, an aluminum slide (200 g) wrapped in paper is placed on a surface covered with the same paper. A motor incrementally increases the angle of this surface. When the sled begins to slip the motor is stopped and the angle of inclination ϕ can be read. The static coefficient of friction is defined as the tangent of the angle measured for the paper surface.

$$\mu = \tan(\phi)$$

Figure 4: Coefficient of static friction



Correlation between the friction coefficient μ and the slide angle ϕ for the entire angle range and for the angle range relevant for antislip applications

Alternatively, the dynamic coefficient of friction (coefficient of sliding friction) can be determined. In this case you measure the force needed to keep a horizontal sled in motion. As no more acceleration work is required, the coefficient of sliding friction is always less than the coefficient of static friction.

4. Application methods for AERODISP®

An AERODISP® fumed silica dispersion can be applied to the surface of paper bags in various ways. In the laboratory we have successfully tested spraying, applying by doctor blade and a 2-roller foulard method commonly used in the textile industry. However, in a production environment flexo printing is the method most preferred (**Figure 5**).

Figure 5: Application of AERODISP® on paper

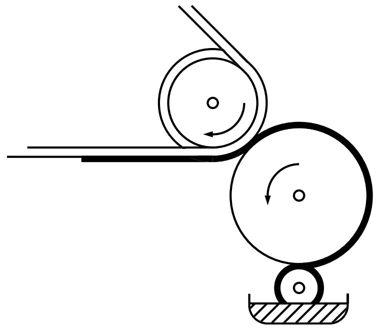
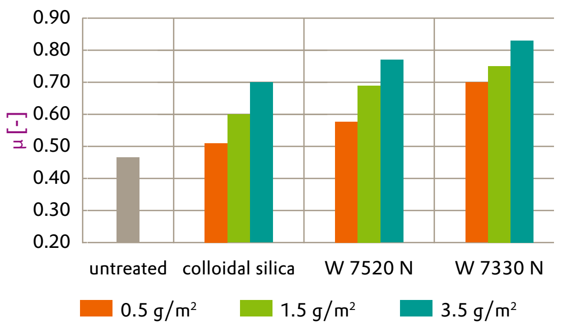


Diagram of a flexo-printing system suitable for applying AERODISP® as an anti-slip agent

Figure 6: Coefficient of static friction



Comparison between the friction coefficients that can be achieved with colloidal silica, AERODISP® W 7520 N and AERODISP® W 7330 N with different weights of application

AERODISP® fumed silica dispersions can be applied as received or diluted to any concentration with de-ionized water. Soft municipal water can also be used, however, hard water containing lime can destabilize most colloidal systems and should be tested in your application first.

5. Test results

AERODISP® fumed silica dispersions are composed of structured particles that are lacking in colloidal silica products. In laboratory testing, concentrations ranging from 30 to 50 % by weight (both diluted and undiluted) were evaluated. Paper treated with AERODISP® required considerably lower quantities of silica per square meter of paper to achieve the same coefficient of friction as obtained with colloidal silica.

The high efficiencies of AERODISP® dispersions are particularly obvious when compared to colloidal silica at lower concentrations (**Figure 6**). To achieve a coefficient of friction of 0.7 ($\phi = 35°$) with colloidal silica, it requires 3.5 g/m^2 of SiO_2 (dry) to be applied to the paper as compared to only 1.5 g/m^2 when using AERODISP® W 7520 N. This is a 57 % reduction in the amount of silica required, providing a significant potential cost savings. AERODISP® W 7330 N is even more efficient with just 0.5 g/m^2 SiO_2 (dry) needed to achieve the same effect.

6. Economic benefits

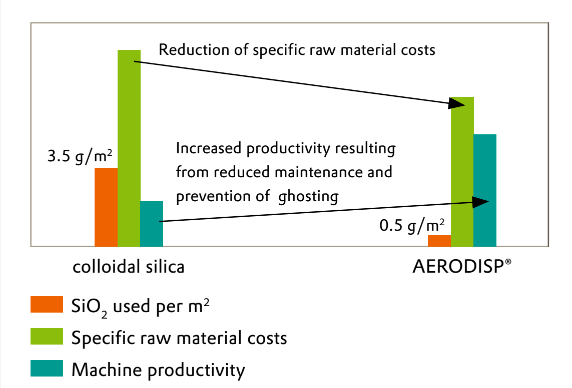
Although colloidal silica products are generally less expensive than AERODISP® fumed silica dispersions, they are also much less efficient as demonstrated in **figure 7**. The higher coefficients of friction that are achieved with AERODISP® allow for significant reductions in the amount of silica. Dramatic savings can be achieved by reducing raw material usage, storage and handling.

Additional savings can be gained through the following technical benefits

- Less downtime and maintenance, increased productivity and throughput: Reducing the amount of SiO_2 needed will lessen problems with soiling and incrustation of the application system. This can translate to less down time for maintenance issues and increase productivity and throughput.
- Prevent ghosting and maintain press speeds: The structure of AERODISP® fumed silica particles does inhibit ghosting (**Figure 8**) on the flexo-printing press. When high coefficients of friction are required, it is common to use high quantities of colloidal silica. The problem can sometimes be solved by slowing down the press speed leading to reduced productivity and increased costs. These issues can be avoided by utilizing the structure of fumed silica to achieve friction targets, prevent ghosting and maintain press speeds.

Table 1 lists AERODISP® products which we especially recommend as anti-slip agents. The primary particle size is for reference purposes only since AERODISP® particles do not exist in this form. For Anti-Slip applications, the average aggregate size provided above is a more appropriate property. In addition, we have many products in our portfolio not listed here which may be of unique interest for more specialized anti-slip applications. Further information can be found in our product overview, technical literature or on our website **www.silica-specialist.com**

Figure 7: Economic benefit using AERODISP® for anti-slip



Relative economic benefits of AERODISP® compared to colloidal silicas at a glance

Figure 8: Undesired ghosting can be prevented with AERODISP®

Table 1: Physico-chemical data

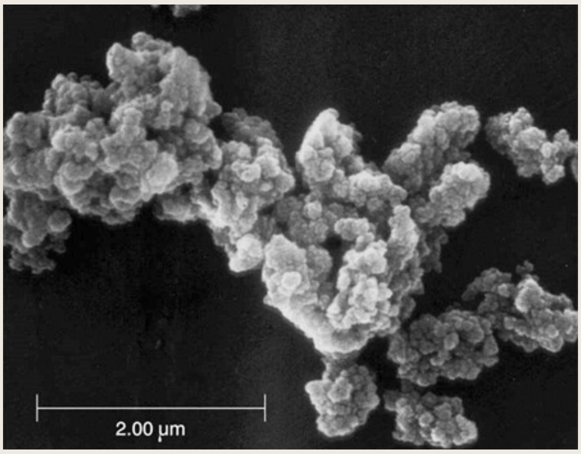
	Unit	AERODISP® W 7520 N	AERODISP® W 7330 N
Silica contents	wt. %	20	30
Stabilizing agent		NaOH	NaOH
pH		9.5 – 10.5	9.5 – 10.5
Viscosity	mPas	< 10	< 100
Average primary particle size	nm	12	16
Average aggregate size	µm	0.12	0.12
Density	g/cm^3	1.12	1.20

AERODISP® fumed silica dispersions especially recommended as anti-slip agents

7. HYDREX® P product characteristics

HYDREX® P is a synthetic magnesium-aluminum silicate which is suitable for both acid and alkaline paper making. It is available in both dry and slurry forms. HYDREX® P is manufactured by precipitating sodium silicate solution with a mixture of magnesium and aluminium sulphate. The resultant fine particle size amorphous pigment with unique pore structure is shown in the **figure 9**.

Figure 9
Microporous structure of HYDREX® P



HYDREX® P is mainly used as a wet end additive in various woodcontaining and woodfree paper grades as well as in multilayer paperboard to improve optical performance, printability and friction properties. The precipitating conditions for HYDREX® P are carefully engineered and controlled. Thus, the size and form of the primary particle of the agglomerates are carefully designed and maintained. HYDREX® P is manufactured using raw materials thoroughly approved by Evonik in order to ensure a consistent high-quality product free of contaminants. HYDREX® P maintains a Food and Drug industry level of purity. Due to the pigment precipitation technique, no dispersion aids are required. The synthetic origin of HYDREX® P allows long shelf life without the need for biocides.

8. Importance of paper friction control

Paper and paperboard friction properties are plying important role in production, converting and end-use operations. Paper friction properties are influenced by many factors, such as fiber source, pulp bleaching and washing processes, amount of recycled fiber in stock and residues from multiple sources (extractives, pitch, dirt, wax, cold and hot melt adhesives, ink oils, latexes). Also, wet end chemicals and fillers have a major role on paper friction properties as well as paper grammage, calendering conditions and relative humidity.

Poor or non-uniform coefficient of friction (COF) can increase costs because of…

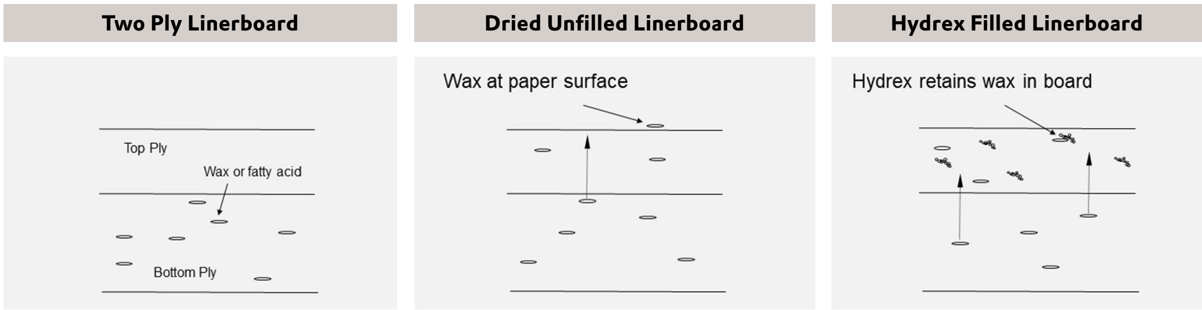
- Roll winding problems like loose winding, crepe wrinkles, snaking, telescoping of the reels.
- Unpractical sliding behavior on conveyor.
- No feed or multiple feed during sheet feeding.
- Web tracking problems and print misregister.
- Registration errors in die cutting or converting.
- Corrugator runnability problems.
- Stack or pallet instability including for example cartons, sheets, sacks, printed material.

9. Use of HYDREX® P for friction control

HYDREX® P precipitated silicate can be used as a wet end additive to increase coefficient of friction and slide angle of various paper grades and linerboard. Mill trials have demonstrated its effectiveness in paper and paperboard with various levels of recycled fiber.

High surface area and fine particle size combine to make HYDREX® P effective in adsorbing for example fatty acids or waxes that reduce slide angle. This adsorption locks the slippery agents inside the paper or board, preventing them from getting to the surface during pressing and drying. HYDREX® P is just as effective in virgin paper and linerboard as it is in paper and board containing recycled fiber (**Figure 10**).

Figure 10: Locking of slippery agents with HYDREX® P



Recycled fiber in bottom ply brings wax and "slipperies" into the board

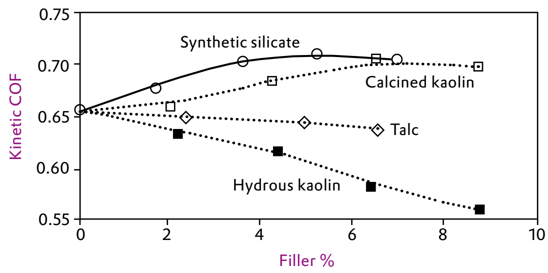
Migration of wax to the surface lowers slide angle and COF

Hydrex inhibits wax migration maintaining slide angle and COF

HYDREX® P silicate can increase slide angle when used as a wet end filler or as a size press additive. In the wet end, slide angle increases of more than 10° are possible with 2 % or less HYDREX® P in the top liner.

Only 0.5-1.5 % of HYDREX® P in newsprint is needed to increase the friction of paper to the desired level and reduce the amount of winder reject (**Figure 11**).

Figure 11: Frictionizing efficiency of different fillers



The effect of HYDREX® P on friction is evident already with minor addition level (**Figure 12**). Negative effect of filler clay on COF can be eliminated in paper production when used together with HYDREX® P.

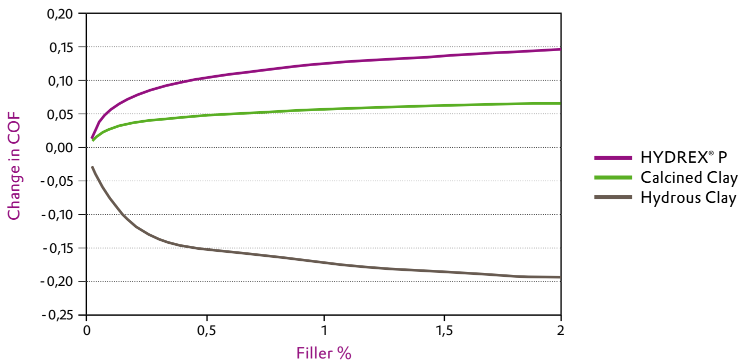
HYDREX® P synthetic magnesium silicate gives the operator control of the process by offering friction control vs. non-containing paper. This enhances both the production process and final product:

- Less crepe wrinkles
- Less winder bursts
- Less broke
- Increased production efficiency
- Improved functionality in converting and printing processes

Additional benefits of HYDREX® P in paper making:

- Higher bulk
- Increased opacity and brightness
- Better shade
- Low abrasion
- Improved printing performance

Figure 12: Change in coefficient of friction vs filler loading in mechanical printing paper



EUROPE/MIDDLE-EAST/ AFRICA

Evonik Operations GmbH
Smart Effects business line
Rodenbacher Chaussee 4
63457 Hanau
Germany

ask-se@evonik.com
www.evonik.com
www.evonik.com/smarteffects

AMERICAS

Evonik Corporation
Smart Effects business line
2 Turner Place
Piscataway, NJ 08804
USA

ask-se-americas@evonik.com

ASIA/PACIFIC

Evonik (SEA) Pte. Ltd.
Smart Effects business line
3 International Business Park
#07–18, Nordic European Centre
Singapore 609927

ask-se-asia@evonik.com

TI-1357-EN-02-2025/04-RAU

The Silica and Silanes experts at Evonik – From elements to excellence.

Leading Beyond Chemistry