Products for the Paper and Film Industry

Inorganic Materials for Print Media

Industry Information 2243

Evonik. Power to create.

Table of contents

1 Introduction

In today's market, there are numerous types of substrates (papers, films, textiles, etc.) available to the print industry. Print media is purposely designed to function with a specific printing technology and its associated ink or toner.

Printable products are classified by the markets in a wide variety of ways. In general, these grades can be categorized on:

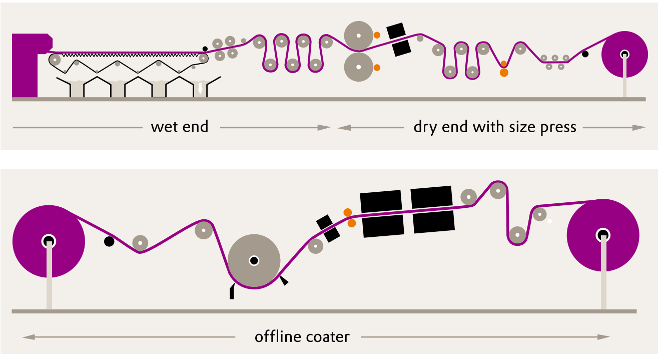
- basis weight & furnish
- aesthetics (color, gloss, texture)
- physical properties
- surface treatment and finish
- print performance
- end use or market segment

The purposes for print media are multi-faceted. Print is commonly used to communicate, entertain, decorate, identify and store information. For decades, fumed and precipitated synthetic amorphous silica have been used in the paper and print industries to achieve unique performance properties.

Although many of these materials are used in off-line coating processes, they also find utility at the paper machine's wet end, size press and on-line coating operations.

The products of Evonik Industries are specifically engineered, using precise controls in the manufacturing process, to meet the requirements and the needs of the papermaker or paper converter.

Figure 1
Schematic diagram of a paper machine and applications where silica can be used.



2 Manufacture and properties of inorganic materials

2.1 Fumed oxides

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

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

The production process was invented more than 60 years ago by Evonik's predecessor company Degussa and has been continuously improved over the years. Because it is produced by flame hydrolysis, AEROSIL® fumed silica is referred to as fumed silicon dioxide or fumed silica, and due to its fine nanostructured particles, it is also known as highly dispersed silicon dioxide.

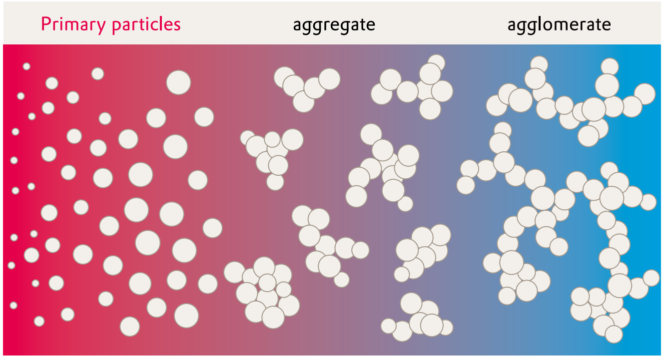
The AEROSIL® process can also be used to produce other metal oxides, including aluminum oxides, titanium dioxides, and many others. These products carry the brand name AEROXIDE®.

AEROSIL® fumed silica and AEROXIDE® metal oxides are fine, light, white powders consisting of primary particles that are approximately 7 to 40 nm in size, depending on the product grade. The primary particles are not isolated, but linked together to form stable aggregates that can be as large as several hundred nanometers. The aggregates, in turn, form loose, micrometer sized agglomerates that can be easily broken down by dispersing.

Fumed silica has the following key properties:

- $>99.8\,\%$ SiO_2 (amorphous)
- primary particle size 7–40 nm
- 50–380 m^2/g specific surface area (BET)

Figure 2
Schematic representation of AEROSIL® fumed silica primary particles, aggregates and agglomerates.



As a complement to the AEROSIL® product line, customized dispersions of these fumed oxides are marketed under the brand name AERODISP®. This offers customers, who prefer not to handle powders, the ability to take advantage of the unique properties fumed silica has to offer.

2.2 Precipitated silica and silicates

Precipitated silica is prepared by a wet process using solutions of alkali silicate, preferably sodium silicate, from which amorphous silica is precipitated by adding acid:

$$Na_2O: xSiO_2 + H_2SO_4 \rightarrow xSiO_2 + Na_2SO_4 + H_2O$$

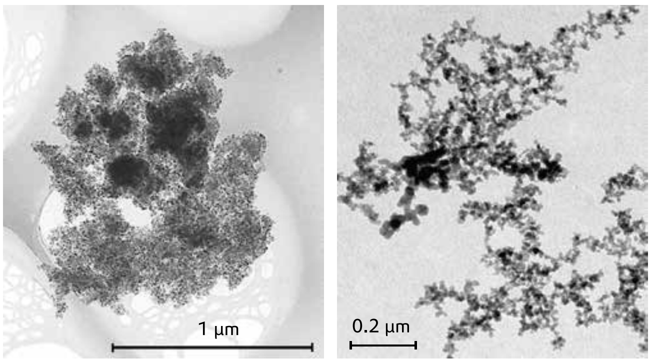
After it has been filtered and washed, the precipitated silica needs to be dried. Drying is carried out differently, depending on the target properties of the end product. The drying step is often followed by grinding classifying and granulating steps.

The resulting product, which is marketed under the brand name SIPERNAT®, has a sponge-like structure and the following key properties:

- 98–99.5 % SiO_2 (amorphous)
- 4.5–320 µm mean particle size (aggregates)
- 45–750 m^2/g specific surface area (BET)
- absorption capacity up to 335 g/100g DBP

Figure 3
Comparison of SIPERNAT® and AEROSIL® structure by TEM photograph:

SIPERNAT® precipitated silica AEROSIL® fumed silica



Metal silicates such as calcium silicate and aluminum silicate are obtained by replacing part or all of the acid with metal salts.

The differences in particle morphology between fumed and precipitated silica are significant. The agglomerates of precipitated silica have a defined particle size (dependant on precipitation/drying/milling), while fumed silica agglomerates are easily broken down by dispersing with appropriate equipment. However, even extremely high shear forces are not capable of breaking apart the aggregates into primary particles.

2.3 IDISIL™

Colloidal silicas are most often prepared in a multi-step process where an alkali-silicate solution is partially neutralized, leading to the formation of silica nuclei. The sub-units of colloidal silica particles are typically in the range of 1 to 5 nm.

Most colloidal silicas are prepared as mono disperse suspensions with particle sizes ranging from approximately 30 to 100 nm in diameter.The spherical particles are discrete and do not have any internal porosity. Because of the very small size, the surface area of colloidal silica is very high.

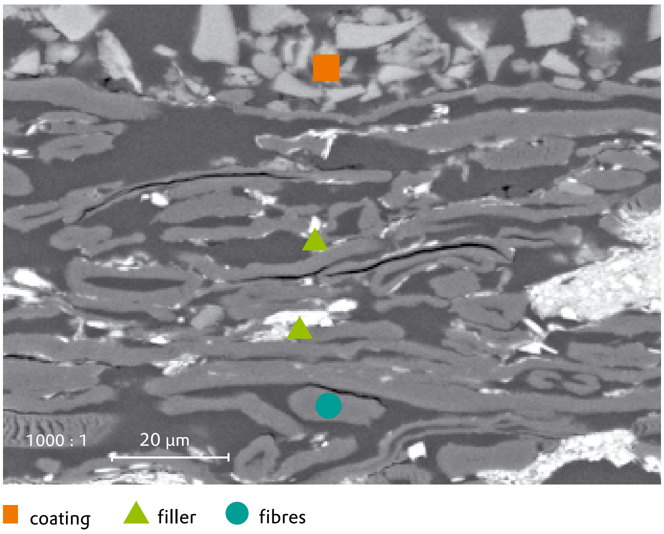
The colloidal suspension is stabilized by pH adjustment and then concentrated, usually by evaporation. The maximum concentration obtainable depends on the on particle size. For example, 50 nm particles can be concentrated to greater than 50 weight % solids while 10 nm particles can only be concentrated to approximately 30 weight % solids before the suspension becomes too unstable.

3 Effects of inorganic materials in paper applications

Many components used in the paper and film industries are applied onto the substrate surface, (e.g. as a coating), or dispersed in the paper or film as a filler.

Other components used in the paper industry are formulated for surface treatment (e.g. sizing) in order to fulfill special quality requirements or to prepare the surface for an after-treatment, such as a coating.

Figure 4
SEM cross-section of paper with inorganic filler and coating.



Most types of print media can be classified as specialty products consisting of uncoated and coated grades.

Uncoated specialty papers include decor papers, photo base paper, silicon base paper, cigarette paper and filter papers. Coated specialty media includes thermal papers, NCR (carbonless copy) paper, inkjet media and various label grades.

Although there is not a standard definition for "specialty paper", these are typically produced for a specific purpose, using unique technologies or raw materials. Furthermore, as the name implies, specialty papers are designed with unique properties for a particular function.

As new technologies evolve, papermakers are searching to improve or create those products which require a special function or property. Inorganic materials can be used to achieve the special performance and quality properties. This section focuses on these effects and describes the physical and chemical attributes of inorganic materials and their impact on an application.

3.1 Porosity

Porosity is created differently for a nano-structured particle like AEROSIL® fumed silica versus the SIPERNAT® precipitated silica.

- Particles of precipitated silica possess internal porosity. The specific pore volume of these materials ranges from 0.7 ml/g up to 1.5 ml/g for special silica gel types.
- AEROSIL® fumed silica or AEROXIDE® fumed alumina are not comprised of porous particles. However the specific fractal aggregate structure enables the formation of a network structure with pores and capillaries within the coating. The specific pore volume of a microporous coating can be formulated to the same range as a coating based on precipitated silica.

The sizes of pores and capillaries – essential for print applications – are in a range between 10 and 50 nm. While the accessible pore volume is important for print properties like mottling and others, the pore size determines capillary forces, which are important for some of the mentioned paper applications.
Pore volume and pore size distribution can be optimized by choosing the right particles from our broad product portfolio.

3.2 Friction

Inorganic particles on a paper surface can increase the friction between two paper layers quite dramatically. The structure of the particles plays a major role for the performance. In comparison to colloidal silica with its single spherical particles, widely used in packaging paper applications, nano-structured particles like AEROSIL® fumed silica show a much higher fractionizing performance. The result is a clear economic advantage over the non-structured system. See section 4.13 and TI 1357 for more details.

3.3 Light scattering

In many paper applications, light scattering at the phase boundaries of inorganic fillers or coating pigments, plays a major role in the optical properties and appearance of the final product. Light scattering is a function of refractive index, particle size and wavelength of the scattered light. The white appearance of most powders is due to diffraction and reflection of light at particle surface.

The higher the refractive index (n_D) the more light is scattered:

silica	1.46
alumina	1.76
titania	2.5–2.6

Inorganic materials are commonly used to affect how light is scattered and to fine tune optical properties.

Precipitated silica and silicates can act as a **white pigment extender**. Depending on the application, between 5–20% of the costly white pigment (titania) can be replaced by SIPERNAT® 820A or other precipitated silica grades without changing whiteness and other optical properties. The same effect can be used with fluorescent whitening agents and other dyes and pigments. Even with colored pigments the brilliance and optical density can benefit from light scattering of the colorless particles.

Particle size and pore size have a strong impact on the **gloss** of surfaces. In photo inkjet paper, a balance has to be found between porosity and gloss. Small particles and small pores lead to very high gloss but the closely packed particles can result in low porosity, which limits ink absorption rates. Small fractions of coarse particles can also decrease coating gloss. However, coarser particles are intentionally used to create semi-matte or matte surfaces.

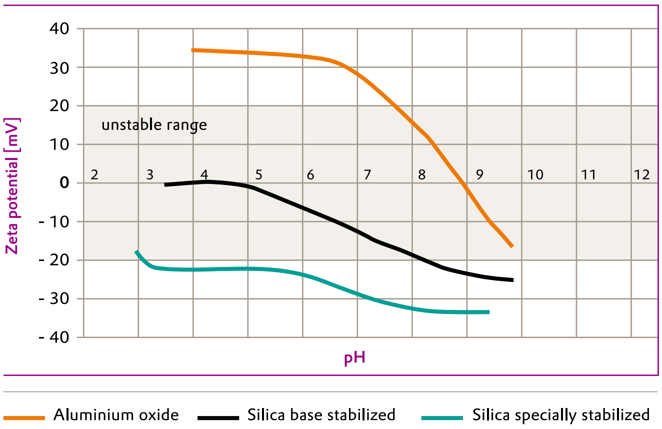
3.4 Surface charge and chemistry

Understanding and controlling surface properties of inorganic materials are keys to maximizing property development in the papermaking and coating processes. Surface charge is an essential consideration for certain paper applications.

Fumed and precipitated silica have Si-OH groups on the surface, which form hydrogen bonds, allowing interactions with similar particles and external additives such as functional silanes (e.g. Dynasylan®), dispersants and polymeric additives. The silanol (-Si-OH) group density varies according to type with ~2 groups per nm^2 for fumed silica and up to 4.6 groups per nm^2 for precipitated silica. The silica surface is charged negatively over the entire pH range due to presence of the silanol groups. At a pH of 10, the negative charge is greatest. Consequently most pure silica dispersions are stabilized in the alkaline region.

In contrast to silica, fumed alumina has a positive (cationic) surface charge at acidic pH values and shows an iso-electric point (point of zero charge) at pH 9.0. Stable, cationic alumina dispersions can be produced at pH 4 to enable a strong interaction between the cationic alumina surface and the anionic colorants of printing inks in an inkjet application. A cationic surface charge can also be developed with silica by using polymeric cationic additives like poly-DADMAC or silanes with the requisite functionality. Evonik offers special technical solutions in form of cationic silica dispersions and functional silane systems.

Figure 5
The zeta potential is a measure of the surface charge. Stable dispersions result when particles of similar charge repel each other.

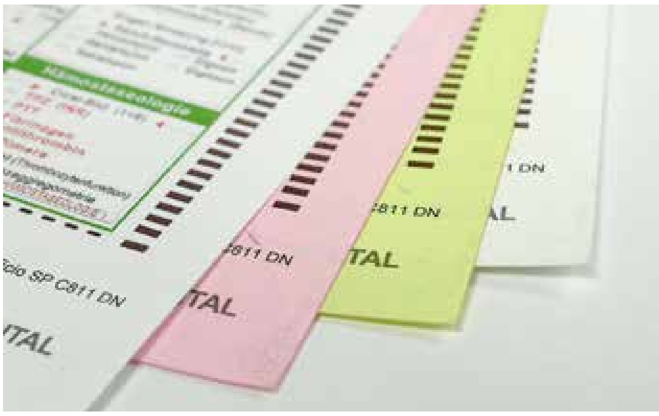


4 Inorganic materials in paper applications

4.1 Carbonless copy paper (NCR)

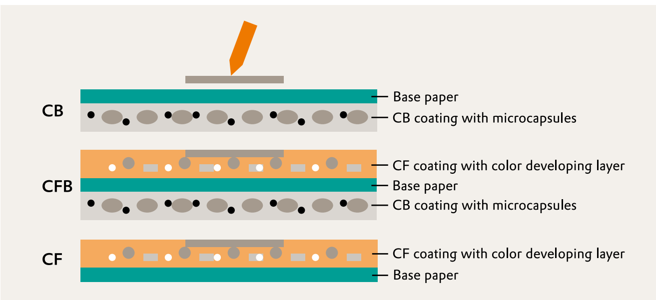
Carbonless copy paper or NCR (no carbon required) permits making multiple copies. The pressure of writing or printing is translated into a dye reaction which transfers the image to the copy. This paper grade is used for vouchers, payments forms, form templates for various purposes and pay slips.

Figure 6
Carbonless copy paper



Carbonless copy paper consists of at least 3 parts; top sheet with coated back (CB) layer, medium sheet with coated front (CF) and CB layer and the lowest sheet with CF layer only.

Figure 7
Three-part carbon copy paper



SIPERNAT® 880 or SIPERNAT® 820 A is a beneficial component in the CF coating layer. The addition of SIPERNAT® leads to:

- improved sharpness and resolution,
- increased absorptivity,
- high whiteness and
- offers effects of rheology control

4.2 Commercial inkjet printing, fine paper, multipurpose inkjet paper

With high speed, commercial inkjet printing presses coming on line, traditional printing processes will face more competitive pressures. While many papers are readily available for offset printing and other impact printing processes, papers that meet the requirements of high speed inkjet printers are just in the infancy of their development.

It is known that high speed inkjet printers such as HP Web Press do require only a surface treatment, whereas Océ Jet-Stream and Kodak Versamark and Kodak PROSOPER printers mostly show better results with coated media.

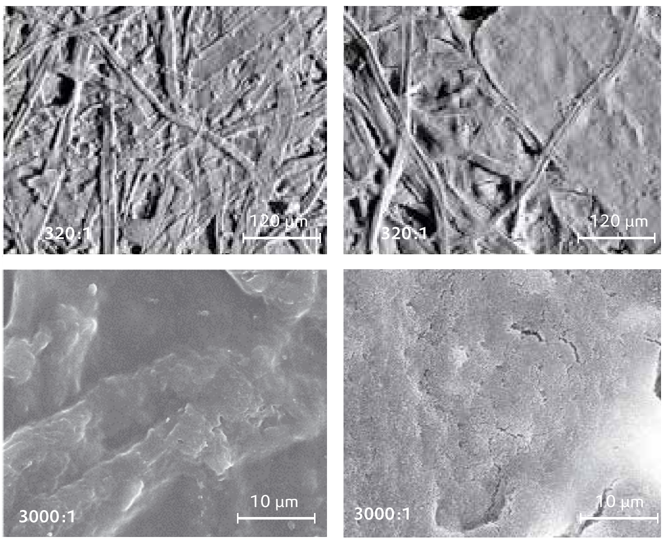
Standard office papers exhibit significant weaknesses in such important properties as optical density, color gamut, and water resistance. Paper sizing with AERODISP® fumed silica dispersions impart a consistent pore structure on the paper surface, allowing ink to be absorbed uniformly and efficiently.
Fumed silica dispersions, when combined with commonly used surface sizing agents such as starch, latex or polyvinyl alcohol, will enhance:

- color gamut and optical density
- print uniformity
- print resolution
- reduction of print-through (strike through)
- speed of ink absorption

Figure 8
Paper surface sized with inorganic pigment (SEM photograph)

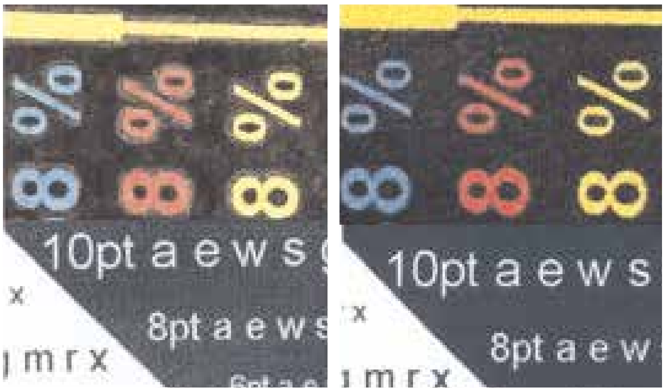
Surface sizing with …

cationic corn starch | AERODISP® WK 7330 + cationic corn starch



AERODISP® WK 7330 or AERODISP® W 7330 N are extremely efficient – coat weights as low as 0.5 – 2.0 g/m^2 are sufficient to achieve high performance characteristics. SIPERNAT® 350 can also be used.

Figure 9
Inkjet prints after surface sizing plain paper with cationic starch (left) and a combination of AERODISP® WK 7330 and cationic starch at a ratio of 2:1 (right). An application of 1.5 g/m^2 was used.



Some types of digital printers and high-speed inkjet presses require a coating. The application of 5 – 10 % AERODISP® to calcium carbonate or clay based coating formulations results in most efficient drying performance at excellent colour properties.

Unlike calcined clay and TiO_2, which absorb UV light and reduce the efficiency of optical brightening agents, amorphous silica does not absorb UV radiation and is compatible with these materials. Therefore, less fluorescent whitening agent may be needed when using silica based pigments. For more detailed technical information, please see TI 1322.

4.3 Decor paper, laminate paper

Decor paper, sometimes even referred to as plastic paper, consists of several different layers of paper. The upper layer should not only be printable but also heat-resistant and ready for impregnation. The lamination papers are covered with a resin, which is often melamine, being cured to form a composite fulfilling the desired final quality targets.

SIPERNAT® 820 A can be used as a filler together with the white pigment TiO_2 to improve the whiteness and opacity. The exchange of 10 – 30 % of the TiO_2 content leads to decreased formulation costs without any loss in whiteness or opacity. In addition to that, amorphous silica are very compatible with fluorescent whitening agents, since they allow the maximum amount of UV radiation to be available for the fluorescent whitening agent. Calcined clay and TiO_2 absorb UV light and reduce the efficiency of some optical brighteners. Therefore, less fluorescent whitening agent may be needed when using siliceous pigments.

Some decor papers are likely to be printed by inkjet. Therefore, an ink receptive layer is needed. Depending on the processing requirements of the decor paper, small layers with either fumed or precipitated silica are coated on the paper. The coating formulation should be water and resin /glue fast. For the coating, all SIPERNAT®, AEROSIL®, AEROXIDE® and AERODISP® grades mentioned in the chapter "4.6 Inkjet Media" can be used with an appropriate coating formulation.

4.4 Diazo paper, blueprint, blueline

Diazo printing was one of the most economic methods of document reproduction of large engineering drawings. The process is based on coating the paper with a diazo solution and a coupler (azo dyes). Ultraviolet light is then transmitted through the original image and onto the coated paper. The final step is to develop the image by alkalinization (e. g. by ammonium vapor).

An application of a silica containing pre-coat on the base paper improves:

- contrast and jetness,
- uniformity of background and
- writing properties

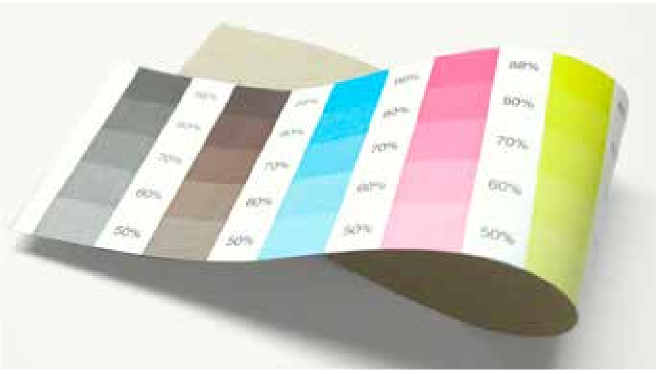
The recommended silica grade is SIPERNAT® 320 DS, which fills the pores of the paper surface, thus leveling out irregularities and preventing the diazo solution from penetrating too deeply into the paper. AERODISP® is an alternative for the pre-coat if a pre-dispersed silica is preferred.

4.5 Flexographic paper and cardboard liner

Many packaging board grades such as foldable cardboards and large format boxes for consumer goods are printed by various techniques.

For water-based flexography, absorption is a key factor in order to obtain high quality text and graphics. The addition of SIPERNAT® 350 or SIPERNAT® 820 A to the commonly used coating pigments increases ink absorption and improves print resolution. The full tone colors are more uniform (less mottle) when compared to coatings without SIPERNAT®. Register deviation at high print speed is decreased due to enhanced printability.

Figure 10
Application of SIPERNAT® in cardboard liner and folding box coatings for flexographic prints.)



4.6 Inkjet media

The Non-impact printing industry has achieved significant technical advances over a few short years.

This is particularly true for inkjet media, where the number of applications have expanded dramatically, resulting in a large variety of print media offerings for existing markets. Additionally, new products are constantly being developed for emerging markets.

With the drive to accelerate printing speeds and reduce ink drop sizes (to reduce print costs and maintain quality), rapid ink drying, improved resolution, uniform absorption and higher print density values are attributes in greater demand by the industry.

Both silica types and fumed metal oxides offered by Evonik meet requirements for:

- enhanced and defined resolution
- rapid ink absorption
- excellent edge acuity
- high image density and color gamut

The choice of pigment depends on the intended application and surface characteristics of the media. The precipitated silica types SIPERNAT® and ACEMATT® are recommended for matte application or as a base layer for semi-gloss, while AEROSIL®, AEROXIDE® or AERODISP® are recommended for glossy coatings or in topcoats for semi-gloss finishes.

Detailed information regarding inkjet printability and formulations can be found in TI 1331 and TI 1212.

Figure 11
Example of inkjet media (canvas with its specific surface structure)

4.6.1 Matte inkjet media
Precipitated silica or silica gels for matte inkjet coatings have been used for decades. Matte inkjet grades are well-established within the inkjet media market. Lower cost raw materials and more efficient use of these materials are being pursued to decrease formulation and system costs.

For highly absorptive matte coatings on photo paper or film we recommend SIPERNAT® 310. It can be blended with AEROSIL® 130 or AEROXIDE® Alu C in order to achieve higher color density and gamut.

Backlit films coating colors should not be blended with AEROSIL® or AEROXIDE® as the color is then less brilliant on the backside.

For matte coatings on paper we recommend using ACEMATT® HK 125, which provides excellent color properties and quick absorption.

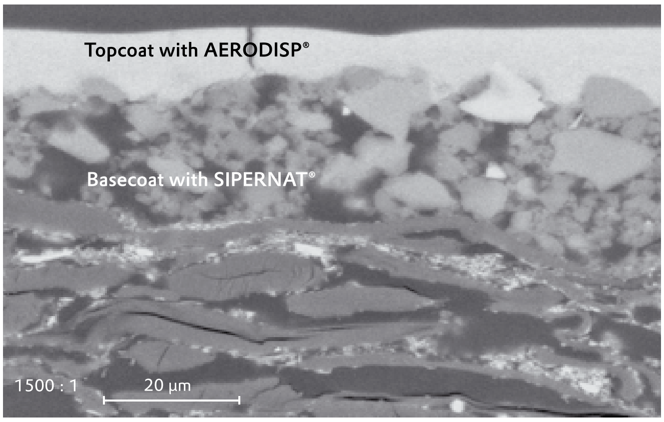
Experimental ("EXP") grades of silica for special requirements are available on request.

For inkjet printable water color paper, AERODISP® WK 7330, AERODISP® W 7330 N or AERODISP® W 1714 are recommended.

For detailed technical information, please refer to TI 1212.

4.6.2 Semi-gloss (silk) inkjet media
Reduced formulation costs for semi-gloss ("silk") inkjet coatings can be achieved by using precipitated silica in the base layer and fumed silica in the top coating layer. Precipitated silica is used for highly absorptive base coatings, while fumed pigments are applied in the top coating in order to adjust the required gloss level and ensure enhanced color properties. In the base coating for photo paper, film or paper, SIPERNAT® 310 is recommended. SIPERNAT® 320 DS or SIPERNAT® 820 A can also be used. Detailed technical information is given in TI 1212.

Figure 12
SEM cross-section of semi-glossy inkjet paper

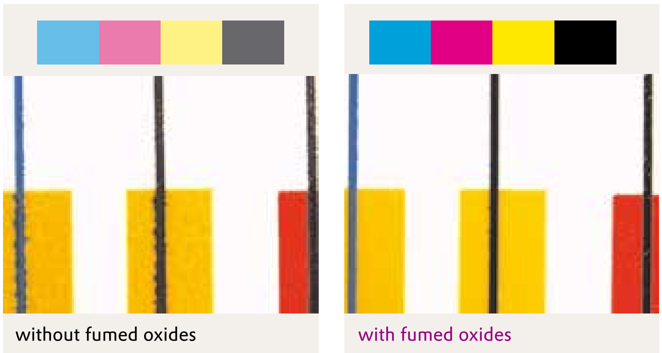


For a semi-gloss finish, AERODISP® WK 7330 is recommended for use in the topcoat. Detailed technical information regarding topcoats and guide formulations are given in TI 1331.

4.6.3 Glossy inkjet photo media
Today two approaches remain for achieving ink receptivity on photographic inkjet media. One approach utilizes traditional swellable polymers while the second approach relies on high surface area pigments to create a microporous system.

It is becoming more common to find that the inks in today's inkjet printers use ultra-fine pigments as the colorant of choice. These pigment particles are not able to penetrate into the polymer coating and are easily wiped off by touching. The faster absorbing microporous systems are gaining more acceptance over the slow drying polymeric based systems.

Figure 13
Brilliant and vivid colors at high resolution due to Evonik´s fumed oxides.



For RC-photo paper or film, AEROXIDE® Alu C or Alu 130 are recommended, as well as AEROSIL® 200 and 300 in order to achieve:

- high gloss
- excellent resolution
- quick absorption
- high image density and color gamut

For detailed technical information, please see TI 1331.

4.7 Label

Labels are mostly one-side coated papers or films, which should be printable by various techniques. Silica can be used either on the backside or the front side of labels, depending on the function required. AERODISP® W 1824 or AERODISP® W 1714 can be applied on the backside of beverage bottle labels to prevent penetration of the adhesive.

On the topside, AERODISP®, AEROSIL® or SIPERNAT® as well as ACEMATT® types can be applied on paper and film labels to adjust printability requirements, gloss and matting effects and even achieve a soft touch effect.

4.8 Metallized media

Metallized media or foils require an ink receptive layer to be printable.

For matte surfaces SIPERNAT® 310, ACEMATT® OK 412 or ACEMATT® HK 125 are recommended.

AERODISP® WK 7330 or AEROSIL® 200 are recommended for transparent or glossy layers.

For matt inkjet coatings, please refer to TI 1212 or chapter 4.6.1. For glossy or transparent inkjet coatings, please refer to TI 1331 or chapter 4.6.3.

4.9 Newspaper, newsprint

Most newsprint paper is made from recycled waste paper. A variety of properties can be improved by adding silica to the recycled furnish.

Qualities that can be enhanced by adding up to 2.5 % of SIPERNAT® 820 A or SIPERNAT® 22 S include:

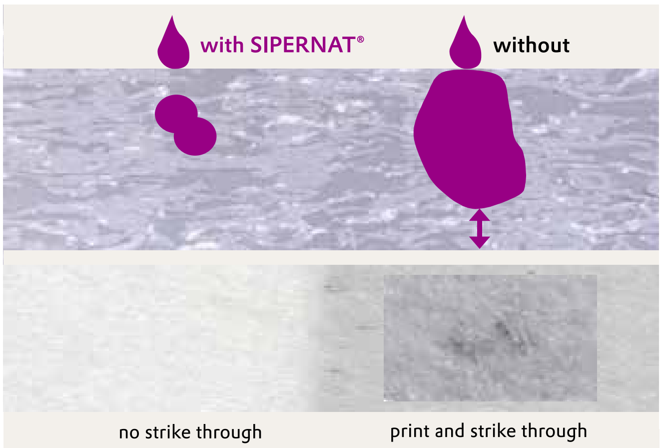
- high brightness and opacity,
- high print quality and increased ink absorption,
- low strike through (print through) after offset printing

SIPERNAT® 820 A, synthetic sodium silicate, can influence:

- reduction of strike through and
- improvement of adsorption

As in security, newsprint or fine papers, SIPERNAT® 820 A can combined with TiO_2 to further improve the paper's whiteness and opacity. Replacing from 10–30 % of the TiO_2 content with SIPERNAT® reduces formulation costs, without any loss in whiteness or opacity.

Figure 14
Increased prevention of strike through due to addition of SIPERNAT® 820 A in the pulp.



4.10 Packaging, paper bags

Many of today´s products are packaged in paper bags or corrugated boxes.. With increasing automation, more stringent requirements are needed in the transport and storage of packaged 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 during transport and warehousing. To enable this, the bag should have an adequate level of static friction at the surface.

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 often reduce the static friction of the paper bag's surface.

To regain friction, aqueous fumed silica dispersion can be applied during or after the printing process to increase the coefficient of static friction to a more suitable level. In addition, print ghosting and encrusting on the machine are reduced by using AERODISP® or IDISIL™.

The grades IDISIL™ LPH-35, IDISIL™ B35, IDISIL™ M60 and IDISIL™ M70 are commonly utilized in bag and box plants as a surface frictionizer. The dispersion is typically diluted and can be sprayed onto the surface or applied with rollers or rods. These grades are specifically formulated to minimize encrustation (spray nozzles) and enhance equipment clean-up. This allows consistent application rates, encourages long run times and requires minimal clean-up time afterwards.

Figure 15
AERODISP® for increased paper friction (**left**) and to prevent unwanted ghosting.

In general, an application of 0.5 g/m² (dry) silica, such as AERODISP® W 7330 N or AERODISP® W 7520 N, is sufficient to provide the required anti-slip performance. For more detailed technical information, please refer to TI 1357.

4.11 Security paper

Security paper, safety paper and banknote paper incorporate special features for identification, fraud detection or protection against imitation. Combinations of these features are common. Most of the safeguards are used during paper production, while some additional features and special requirements are added later in the process.

As in decor, newsprint or fine papers, SIPERNAT® 820 A can be used as a filler together with white pigments such as TiO_2 to improve whiteness or opacity. A blend of 1 : 1 of SIPERNAT® 820 A with TiO_2 provides excellent reflection index as well as good opacity; a ratio of 1 : 2 is nearly comparable to pure titanium dioxide. Exchanging part of the TiO_2 leads to significant cost advantages, without losing quality.

For special effects and enabling the use of multiple printing techniques, the entire range of AEROSIL®, AEROXIDE® and AERODISP® products are available for use as surface treatment pigments. AERODISP® grades and AEROXIDE® TiO_2 P25 have been successfully used for many years to contribute further increasing the quality of security papers.

4.12 Thermographic media

Thermography is divided into two major types:
direct thermal and thermal transfer. Thermal transfer itself is subdivided into thermal transfer (mass transfer) and thermal sublimation (diffusion, sublimation).

Figure 16
Examples of direct thermal media

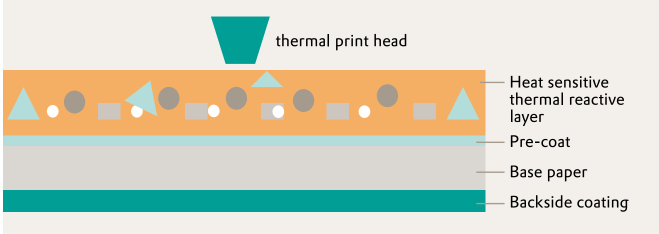
4.12.1 Thermal paper, direct thermal

Several years ago, thermal paper was mainly used for fax transmission printouts. Currently, direct thermal paper is used for receipts, tickets, price labels, baggage labels, parking tickets, etc.

The structure of direct thermal paper depends on its intended use. For tickets, it is composed of a protective backside layer, base paper, pre-coat, functional coat (heat-sensitive coating) and protective front coating layer.

For creating a printed image, heat is applied on the surface of the thermal paper. The solid dyes melt and react with acid or another developer: the dye is chemically transformed into the colored form. Typically, the print image color is black. However, red and blue are common, too.

Figure 17
Composition of direct thermal paper



The use of SIPERNAT® 350 or SIPERNAT® 360 in the functional coating layer has beneficial effects on the print image and print process:

- increased heat isolation prevents pre-development
- improved sharpness
- increased whiteness
- reduced sticking and incrustation of print head

In some cases, AEROSIL® 200 may be used for special benefits in the top coating or protective layer.

4.12.2 Thermal transfer media

When increased age-resistance or durability is needed or when printing on heat-sensitive substrates, thermal transfer printing can be used.

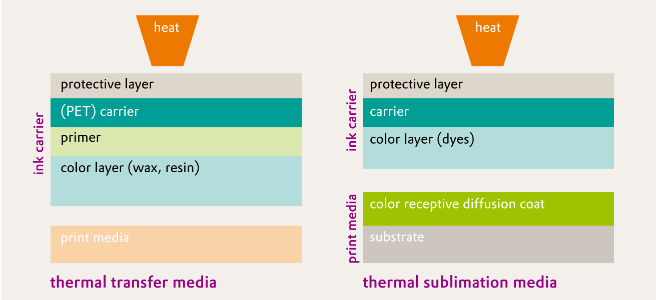
The thermal transfer process, often referred to as traditional transfer printing is used for textile and plastic card printing. The printing process entails heat being applied on the surface of the carrier substrate, which contains wax-based "inks". The wax melts and the ink dots are transferred onto the surface of the print media. This printing technique does not always require a special coated surface. Prints on plain paper or film are also common.

When coatings are applied, either for printability or for special release effects, SIPERNAT® 310 or SIPERNAT® 50 S are recommended and highly effective.

4.12.3 Thermal sublimation media, dye diffusion thermal transfer media

For dye sublimation printing (sometimes referred to as digital transfer printing), heat is also used to transfer dye on the print medium, which is made of fabric, ceramics, plastic or paper. However, the color is transferred by diffusion or sublimation processes. Since the transformation of the melted ink goes directly from solid to the gas phase without going through the liquid state, the system is called dye diffusion.

Figure 18
Thermal transfer media (left) versus thermal sublimation media



One of the applications for thermal sublimation is photographic printing, using continuous-tone technology.

SIPERNAT® 500 LS, SIPERNAT® 50 S or AEROSIL® 200 are recommended for a smooth, absorptive coating layer for thermal sublimation or dye diffusion transfer print media.

The silica leads to

- improved sharpness and resolution
- increased color gamut
- increased whiteness
- enhanced transfer yield
- short drying times
- possible adjustment of matte effect and
- provides the use of multiple printing methods

5 Product recommendation at a glance

Media type	Application	Function / Effect	Recommended products	Remarks
Carbonless copy paper (NCR)	Coating (CF layer)	Absorbency, enhanced resolution	SIPERNAT® 880, SIPERNAT® 820 A, SIPERNAT® 350	Up to 6 % based on CF coating layer
Commercial inkjet printing	Surface sizing	Ink uniformity, color gamut	AERODISP® WK 7330, AERODISP® W 7330 N, SIPERNAT® 350	For further information see TI 1322
Decor paper	Filler (paper mass)	Extender for TiO_2	SIPERNAT® 820 A	10–30 % based on TiO_2 content
	Coating	Printability	ACEMATT®, AERODISP®, AEROSIL®, AEROXIDE®, SIPERNAT®	
Diazo paper (blue line)	Surface treatment/ coating	Contrast, jetness, writing properties	SIPERNAT® 320 DS	up to 2 g/m^2
Digital print paper	Surface treatment/ coating	Absorbency, enhanced resolution	SIPERNAT® 350, SIPERNAT® 820 A, AERODISP® W 7330 N	5–10 % based on pigment content (plotter paper, special offset grades etc.)
Fine paper (photocopying, offset, laser, inkjet)	Filler (paper mass)	reduced print through	SIPERNAT® 820 A	1–3 % based on paper weight
	Surface sizing	enhanced color gamut and ink uniformity	AERODISP® W 7330 N, AERODISP® WK 7330	For detailed information see TI 1322
Flexographic paper, cardboard liner	Coating	Absorbency, increased resolution	SIPERNAT® 350, SIPERNAT® 820 A	5–10 % based on calcium carbonate content
Inkjet media matte (paper/film/fabric)	Coating	Absorbency, resolution, color gamut	SIPERNAT® 310, ACEMATT® HK 125, AEROSIL® 130, AEROXIDE® Alu C, EXP grades available on request	55–80 % based on coating color; for detailed information see TI 1212
Inkjet media semi-matte/ semi-glossy (silk)	Basecoat	Absorbency	SIPERNAT® 310, SIPERNAT® 820 A, SIPERNAT® 320 DS	25–80 % of the total coating color, for detailed information see TI 1212
	Topcoat	Resolution, color gamut, defined gloss level	AERODISP® WK 7330	50–90 % of the total coating color, for detailed information see TI 1331
Inkjet photo media glossy (PE-paper/paper/film)	Coating	Absorbency, resolution, color gamut, gloss	AEROXIDE® Alu C, AEROXIDE® Alu 130, AEROSIL® 200, AEROSIL® 300, AERODISP® W 630	For detailed information see TI 1331
Label paper	Surface treatment (backside)	Prevention of glue penetration	AERODISP® W 1714, AERODISP® W 1824, AERODISP® W 1836	
	Surface treatment/ coating (front side)	Ink receptive layer, adjusted matte or soft touch effect	ACEMATT®, AERODISP®, AEROSIL®, SIPERNAT®	
Metallized media (foil etc.)	Coating	Ink receptive layer	ACEMATT® HK 125, ACEMATT® OK 412, AERODISP® WK 7330, AEROSIL® 200, SIPERNAT® 310	For matt coatings see TI 1212, for glossy or transparent coatings see TI 1331
Multipurpose paper	Surface sizing	Ink uniformity, color gamut	AERODISP® WK 7330, AERODISP® W 7330 N	For further information see TI 1322
Newspaper	Filler (paper mass)	Prevention of strike-through and print through	SIPERNAT® 820 A, SIPERNAT® 22 S	1–3 % based on paper weight
Packaging paper, paper bags	Surface treatment	Anti-slip/friction, printability	AERODISP® W 7330 N, AERODISP® W 7520 N, IDISIL™ B35, IDISIL™ M60, IDISIL™ M70, IDISIL™ LPH-35	For further information see TI 1357
Security paper	Filler	Extender for TiO_2	SIPERNAT® 820 A	10–30 % based on TiO_2 content
	Surface sizing/ coating	Printability, special modifications	ACEMATT®, AERODISP®, AEROSIL®, AEROXIDE®, SIPERNAT®	
Thermal paper	Coating	Heat isolation, resolution, sharpness	SIPERNAT® 350, SIPERNAT® 360, SIPERNAT® 101 M	5–30 % of the total amount of pigments (combination with $CaCO_3$)
Thermal transfer media	Coating	Heat isolation, resolution, sharpness, special effects	SIPERNAT® 50 S, SIPERNAT® 310	
Thermal sublimation media/dye diffusion thermal transfer media	Coating	Absorbency, color gamut, resolution, transfer yield	SIPERNAT® 500 LS, SIPERNAT® 50 S, AEROSIL® 200	

Additional products are available on request. Please contact our technical experts at any time for a detailed discussion of your formulation needs.

6 Physico-chemical properties of recommended products

ACEMATT® grades

	Particle size d_{50} [µm]	Tamped density [g/l]	pH	Oil absorption [g/100g]
HK 125	10.5	130	6	180
OK 412	6.0	130	6	220

AERODISP® grades

	Viscosity [mPa • s]	pH	Solids content [%]	Aggregate size d_{50} [µm]
W 1714	≤100	5 – 6	14	0.16
W 1824	≤150	5 – 6	24	0.20
W 1836	≤200	4 – 6	34	0.3
W 630	≤2000	3 – 5	30	0.14
W 7330 N	≤1000	9.5 – 10.5	30	0.12
W 740 X	≤10000	5-7	40	≤0.1
W 7520 N	≤100	9.5 – 10.5	20	0.12
WK 7330	≤1000	2.5 – 4.0	30	0.12

AEROSIL® grades

	Specific surface area (BET) [m²/g]	Loss on drying [%]	Tapped density [g/l]	pH
130	130 ± 25	≤1.5	50	3.7 – 4.7
200	200 ± 25	≤1.5	50	3.7 – 4.7
300	300 ± 30	≤1.5	50	3.7 – 4.7

AEROXIDE® grades

	Specific surface area (BET) [m²/g]	Loss on drying [%]	Tapped density [g/l]	pH
Alu C	100 ± 15	≤5.0	50	4.5 – 5.5
Alu 130	130 ± 20	≤5.0	50	4.4 – 5.4
TiO_2 P25	50 ± 15	≤1.5	130	3.5 – 4.5

IDISIL™ grades

	Particle size d_{50} DLS [nm]	Refractive Index [Brix]	pH [abs]	Conductivity [mS/cm]
IDISIL™ B35	70–110	appr. 20	8.5–10.5	≤4.0
IDISIL™ M60	90–110	appr. 32	8.5–10.5	≤6.5
IDISIL™ M70	70–110	22.0–26.0	8.5–10.5	1
IDISIL™ LPH-35	70–110	16.0–19.0	2.0–4.0	0–4.0

SIPERNAT® grades

	Surface area [m²/g]	Particle size d_{50} [µm]	Tamped density [g/l]	pH	SiO_2 content [%]	DBP absorption [g/100g]
22 S	190	11.5	90	6.5	98	265
310	750	7.5	150	6	99	260
320 DS	175	7.5	75	6.3	98	235
350	50	4.5	110	9	98.5	210
360	50	18	210	9	98	245
50 S	475	16	100	6	98.5	325
500 LS	475	6	75	6	98.5	325
820 A	85	7.5	300	10.1	82[1]	200
880	35	9	300	10.5	91[2]	185

[1] 9.5 % Al, [2] 6 % Ca

ACEMATT®, AERODISP®, AEROSIL®, AEROXIDE®, SIPERNAT® and IDISIL™ are registered trademarks of Evonik Degussa GmbH.
All data in these tables represent typical values, not specified parameters.

7 References, Literature

1 Brochure "Specialty Silica", Company Publication Evonik Degussa GmbH

2 Brochure "AEROSIL®", Company Publication Evonik Degussa GmbH

3 Industry Brochure "Dispersions", Company Publication, Evonik Degussa GmbH

4 Industry Brochure "Inkjet Media Coatings", Company Publication, Evonik Degussa GmbH

5 Technical Information No. 1212, "Silica for Matte and Semi-matte Inkjet Media", Evonik Degussa GmbH, 2010

6 Technical Information No. 1331 "AEROSIL® Fumed Silica and AEROXIDE® Fumed Alumina for Glossy Photo Inkjet Media", Evonik Degussa GmbH

7 Technical Information No. 1322 "Paper Sizing with AERODISP® Fumed Silica Dispersions", Evonik Degussa GmbH

8 Technical Information No. 1357 "AERODISP® Fumed Silica as Anti-Slip Agent for Paper Bags", Evonik Degussa GmbH

Authors: Astrid Müller and Christoph Batz-Sohn

Europe / Middle-East / Africa / Latin America

Evonik Resource Efficiency GmbH
Business Line Silica
Rodenbacher Chaussee 4
63457 Hanau
Germany

PHONE +49 6181 59-12532
FAX +49 6181 59-712532
ask-si@evonik.com
www.evonik.com

North America

Evonik Corporation
Business Line Silica
299 Jefferson Road
Parsippany, NJ 07054-0677
USA

PHONE +1 800 233-8052
FAX +1 973 929-8502
ask-si-nafta@evonik.com

Asia Pacific

Evonik (SEA) Pte. Ltd.
Business Line Silica
3 International Business Park
#07-18, Nordic European Centre
Singapore 609927

PHONE +65 6809-6877
FAX +65 6809-6677
ask-si-asia@evonik.com

II 2243-1-JUL15

Evonik. Power to create.