LUDOX®
Colloidal Silica

Grace Materials Technologies

GRACE
Enriching Lives, *Everywhere.*®

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Grace Product Range

LUDOX®
Colloidal Silica

SYLOID®
Matting Agents for Coatings

SYLOJET®
Pigments for Ink Jet Coatings

SYLOWHITE™
Titanium Dioxide Extenders for Paints and Printing Inks

DURAFILL®
Special Pigments and Fillers for the Paper and Pulp Industry

TRISYL®
Silica Gel for Refining Edible Oil

DARACLAR®
Beer Stabilizers

CRYOSIV®
Desiccant for Refrigerant Drying

PHONOSORB®
Beaded Adsorbents for Insulating Glass

SAFETYSORB®
Desiccants for the Pharmaceutical and Diagnostic Applications

SYLOSIV®
Molecular Sieve Powder for the Polyurethane Industry

SYLOBLANC®/SYLODENT®/ELFADENT®
Abrasive and Thickening Agents for the Toothpaste Industry

SHIELDEX®
Non-toxic Anti-corrosion Pigments

PERKASIL®
Reinforcing Agents for the Tire and Rubber Industry

APPERTA®
Can Coatings

DAREX®
Can and Closure Sealants

SISTIAGA®
Can Coatings

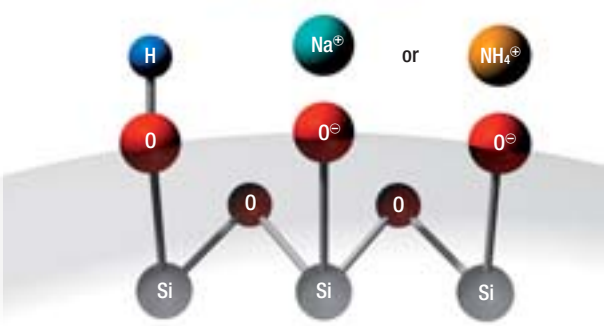
CELOX®
Oxygen Scavengers

SINCERA®
Closure Sealants

Introduction

LUDOX® colloidal silica contains discrete, spherical particles of amorphous silica in the low nanometer size range. The particles are dispersed in water, are non-porous and exhibit no detectable crystallinity.

LUDOX® colloidal silica is especially useful in applications requiring chemical inertness and heat resistance in the final product. The particles develop strong adhesive and cohesive bonds and are effective inorganic binders for all types of granular and fibrous materials, especially where use at elevated temperature is required.

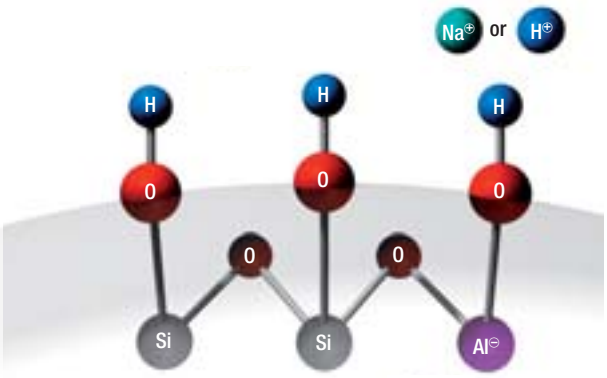


Silica Particle Interior

Alkaline Grades

On smooth surfaces such as flooring and paper, colloidal silica particles increase the surface coefficient of friction, giving antislip properties. Colloidal silica particles can react with a material bearing the opposite charge, resulting in intense flocculation. This effect is useful in the manufacture of insulation articles, paper and beverages.

The LUDOX® particles are charge stabilized; that is, a charge is induced on the particle surfaces so that they repel each other.



Silica Particle Interior

pH Stable Grades

The alkalinity of most grades results in particles that are negatively charged. These grades are stable in the pH 8 - 11 range. Some grades contain surface modified silica particles to give broader stability (pH 4 - 11). Other grades contain particles that have been surface modified to render them positively charged.

In most applications, the desired effects of LUDOX® colloidal silica are realized after the sol has been mixed with other components and converted to a dry solid via a special form of sol-gel reaction. These mixtures can be gelled by (1) removing water, (2) changing pH, or (3) adding a salt or water-miscible organic solvent. During drying, the hydroxyl groups on the surfaces of the particles react to form bonds either with other silica particles or with other components of the matrix.

With our broad product offering in terms of particle sizes, distribution and surface modification combined with high quality standards, LUDOX® colloidal silica brings excellent performance in many different applications.

Product Portfolio

Particles

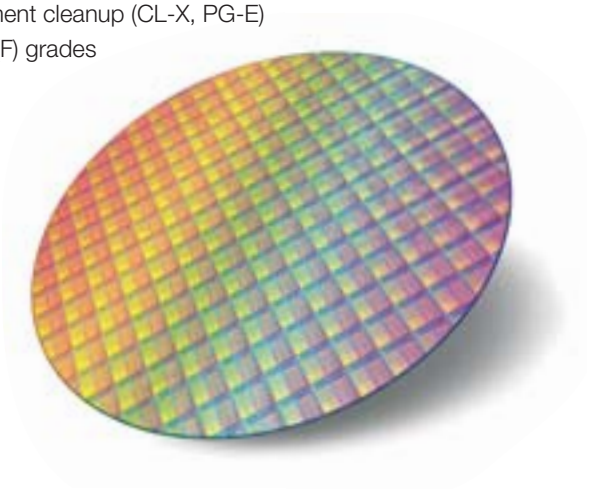
- are discrete, uniform spheres of amorphous silica
- are non-porous
- have no detectable crystallinity

Grades are distinguished by:

- Particle Size/Specific Surface Area
- Particle Size Distribution
  - **M** Monodisperse
  - **P** Polydisperse
- Stabilization
  - Negatively charged particles
    - Alkaline grades with either sodium or ammonium counter ions
    - Surface modified grades for broader pH stability
  - Positively charged particles by surface modification
- Silica content

Specialty Grades

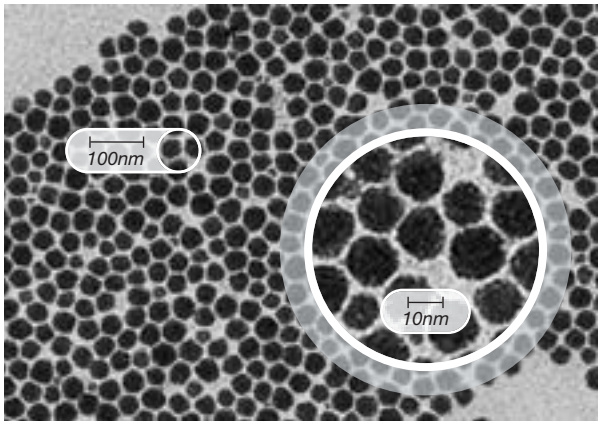
- Grades formulated with ethylene glycol for Freeze Stabilized (FS) grades or for easier equipment cleanup (CL-X, PG-E)
- Fining (F) grades



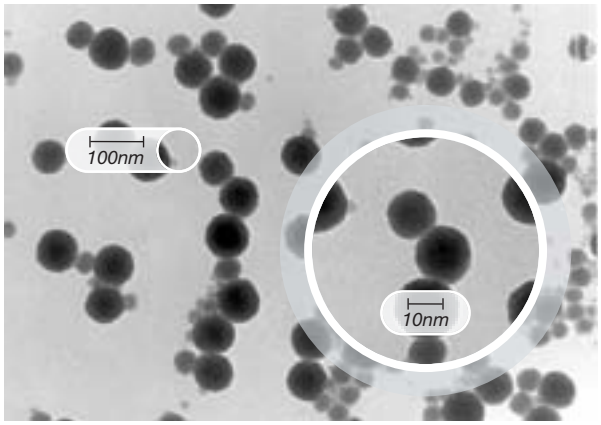
LUDOX® Colloidal Silica Product Range

Particle Characteristics			Negative Sols (Anionic)				PIC [3]	Positive Sols (Cationic)	
Particle Size Relative	Particle Size Distribution [2]	SSA [1] (m^2/g SiO_2)	Sodium Counter Ion	Ammonium Counter Ion	pH Stable Alkaline	pH Stable Acidic	Binders	Chloride Counter Ion	Benefits
Very small	M	320 – 400	SM	SM-AS					Strong binder performance
Small	M	198 – 258	HS-30 [4,5] HS-30HIPH HS-40 [4] LS	AS-30	AM	HSA	SK SK-F SK-R	CL	Excellent combination of binder performance and stability
	P	230 – 290	PX-30 [4,5]						
Intermediate	M	110 – 150	TM-50 CL-X [6]	AS-40		TMA		CL-P	Excellent surface modification performance and formulation stability
	P	130 – 180	PT-40 PG-E [6]	PT-40AS					
Large	P	60 – 90	PW-30 [4] PW-50 [4]						Optimum surface modification and polishing performance
Benefits			Cost effective, large product range	Fugitive counter ion, low sodium content	Broad pH stability	Broad pH stability, low sodium content	Stable, enhanced binders, see SK brochure for details	Adsorbs to negatively charged surfaces	

(1) M = Monodisperse, P = Polydisperse / (2) Specific Surface Area / (3) PIC = Precision Investment Casting / (4) Freeze stabilized (FS) grade available / (5) Fining (F) grade available
(6) Formulated for easier clean up in paper frictionizing



TEM picture of monodisperse LUDOX® colloidal silica



TEM picture of polydisperse LUDOX® colloidal silica

Function and Applications

Binder for granular & fibrous material

- Strong ionic or hydrogen bonding with polymers
- Temperature resistant and chemically inert
  - Precision Investment Casting
  - Vacuum formed refractory shapes
  - Insulation board
  - Catalysts
  - Specialty Coatings

Surface Modifier

- Particles increase coefficient of friction of surfaces
  - Paper, cardboard
  - Coatings
  - Flooring
  - Surface polishing

Flocculant

- Particles ionically bond with polymers or other particles of opposite charge
  - Paper retention & drainage
  - Beverage fining (wine, beer)
  - Insulation board

Typical Product Recommendations by Application

Binder Applications

Colloidal silica is the preferred binder for making ceramic molds in the precision investment casting process. Water based colloidal silica is a safer alternative to ethyl silicate binders. Its high temperature characteristics and chemical inertness makes it ideal for binding a wide variety of refractory materials for the casting of many metals and alloys. Colloidal silica may also be used to bind materials made from ceramic fibers, such as insulation and ceramic parts, and in catalysts and molecular sieves where it increases strength and reduces attrition.

	LUDOX® Colloidal Silica Grades								
Uses	**SM**	**HS**	**AM**	**AS**	**SK**	**TM**	**PX-30**	**PT-40**	**PT-40AS**
High temperature binder									
Precision Investment Casting	✓	✓			✓		✓		
Vacuum formed fibrous shapes	✓	✓		✓		✓	✓	✓	✓
Refractory cements		✓					✓		
Stool and mold coatings		✓					✓		
Insulation board		✓					✓		
Catalysts, molecular sieves		✓		✓				✓	✓
Reinforcing agent									
Adhesives, caulks	✓	✓	✓			✓	✓	✓	✓
Elastomeric foams	✓	✓					✓		

Coatings

LUDOX® colloidal silica offers broad flexibility for specific performance targets in anti-corrosive coatings and pre-treatments, hardcoats and architectural paints. Because of its small particle size, LUDOX® colloidal silica can play multiple roles in many water-borne coating formulations. Particles in the smaller size range act as binders or co-binders to add strength and durability to the coating due to silica reactivity with other silica particles, metal surfaces, fillers or organic polymers. Larger particle grades are mainly used as surface modifiers.

	LUDOX® Colloidal Silica Grades										
Uses	**SM**	**HS**	**LS**	**AM**	**AS**	**TM**	**TMA**	**CL**	**CL-P**	**PX-30**	**PW**
Coatings											
Paper and film			✓	✓	✓			✓	✓		
Duplicating paper		✓	✓	✓							
Latex films	✓	✓		✓	✓					✓	
Inorganic coatings											
Electrical steel	✓		✓		✓					✓	
Bricks	✓	✓								✓	
Steam promotor		✓								✓	
Surface Modifiers											
Antiblocking		✓		✓		✓				✓	✓
Antisoil	✓	✓		✓			✓			✓	✓
Adhesion promotor	✓	✓		✓			✓			✓	✓
Wetting promotor	✓	✓								✓	

Other Applications

Due to its unique properties, LUDOX® colloidal silica can be used in a variety of applications that take advantage of its range of particle size and ionic charge characteristics. These are a few examples:

- Colloidal silica can help to remove undesirable proteins in wine, beer and fruit juices to improve taste, appearance and shelf life.
- Applying colloidal silica to paper products such as linerboard and cardboard will increase coefficient of friction and enhance antislip characteristics. Surface treating uncoated papers will also improve gloss and printability.
- Colloidal silica based slurry formulations are gaining popularity in electronics polishing applications. These slurries are easy to handle and give good removal rates with low defect and scratch levels due to tight particle distribution control.

	LUDOX® Colloidal Silica Grades											
Uses	**SM**	**HS**	**DF**	**AM**	**TM**	**TMA**	**CL**	**CL-X**	**CL-P**	**PX-30**	**PGE**	**PW**
As antislip and delustrant		✓		✓	✓		✓			✓		✓
Antislip for floors and polishes		✓	✓		✓	✓	✓		✓	✓		
Fining of wine, beer, fruit juices		✓								✓		
Packaging frictionizing					✓			✓	✓		✓	
Soil retardant rug shampoo	✓	✓		✓		✓				✓		
Polishing applications	✓	✓			✓	✓			✓			✓

Shipping Containers, Packaging

LUDOX® colloidal silica is available in 220 liter/55 gallon polyethylene non-returnable drums and 1100 liter/275 gallon bulk drums. In North America it is also available in tank trucks.

Safety Issues

LUDOX® colloidal silica products are not considered hazardous by international transport regulations. Freeze-stabilized grades are available, when the presence of ethylene glycol is compatible with the end use.

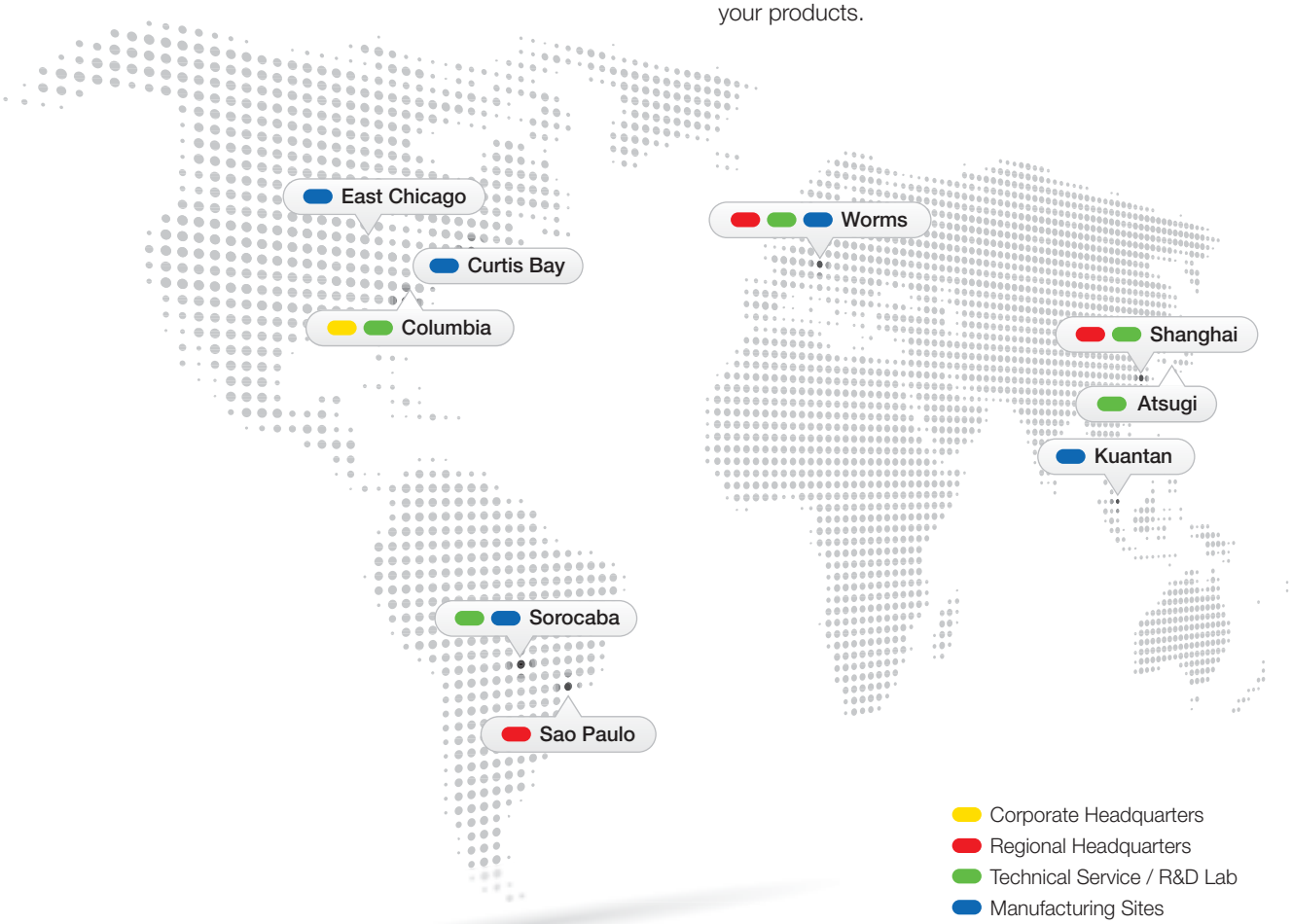
LUDOX® colloidal silica normally contains an antimicrobial additive to inhibit the development of bacterial growth. For applications in which this may cause problems, special arrangements can be made on request.

Full EH & S information is available by requesting a MSDS from any Grace Davison representative.

REACH

As a premier specialty chemicals company, it is one of Grace's utmost priorities to comply with all relevant legislation, including REACH. Therefore, in November of 2008 we undertook extensive efforts to achieve compliance of all our products, substances and formulations. Since the beginning of 2010, our main products, including synthetic amorphous silica, zeolites and synthetic amorphous silicates, are all registered under REACH. Regardless of which product you buy from us in the EU, you can be assured that all necessary steps have been taken to ensure continuous and smooth supply of your products.

Global Scope



Grace is a leading global supplier of catalysts; engineered and packaging materials; and, specialty construction chemicals and building materials. The company's three industry-leading business segments – Grace Catalysts Technologies, Grace Materials Technologies and Grace Construction Products – provide innovative products, technologies and services that enhance the quality of life. Grace employs approximately 6,000 people in over 40 countries.

Grace has met all REACH requirements for the given deadline for Tier 1, December 1, 2010, and can hereby assure today's and future customers full REACH compliance of its products. This assurance also includes the very diverse use of a spectrum of our products.

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