

LUDOX® Colloidal Silica Binders for Refractory Fiber Insulation



LUDOX® colloidal silica binders are aqueous, opalescent dispersions of extremely small silica particles. These particles are grown by polymerization from silicic acid. They have chemically active surfaces that bond readily to other silica particles or other oxygen-containing surfaces.

Insulation Uses

The high surface area and reactivity of LUDOX® colloidal silica particles make them very effective inorganic binders and stiffeners for use with refractory fibers for the production of high temperature composites used as:

Sheeting and Block

- appliance insulation
- furnace and duct liners
- expansion joint packing
- catalytic cracker insulation
- catalyst base
- cooking counters
- catalytic converter insulation
- chemical catalysis of acetylene

Papers and Felts

- portable flange covers
- wrapping insulation
- gaskets
- separators
- catalyst base

Special Shapes

- heating element support for cooking counters
- ladle liners
- tapout plugs
- metal transfer
- hot-top liners
- combustion chambers
- riser sleeves for metal casting

Properties of the composites can be varied by the type and amount of fiber or binder, different fabrication processes, post-treatments, and specialty coatings. Advantages of a bonded refractory fiber composite of LUDOX® colloidal silica are: low density

- resistance to thermal shock
- low thermal expansion
- resiliency
- resistance to mechanical shock and vibration
- flexibility in control of product properties
- useful at temperatures up to 1650 °C (3000 °F)

LUDOX® Binder Types

Traditionally, LUDOX® SM, HS-40, and AS-40 colloidal silica have proven to be excellent binders or rigidizers in fiber composite systems. These products form bonds that are inert, insensitive to moisture, and are stable at high temperatures.

LUDOX® SM colloidal silica has a smaller particle size and a higher surface area than HS-40 and is the most efficient binder in most applications. SM has more sodium per unit of silica than HS and should be compared with HS-40 in specific applications to determine if it offers advantages in cost or green strength. Where the sodium level of SM is a problem, HS may be the better choice. If sodium is to be avoided as completely as possible, AS-40 or one of the newer grades described below might be the optimum choice. AS-40 is stabilized with ammonium hydroxide and contains very little sodium.

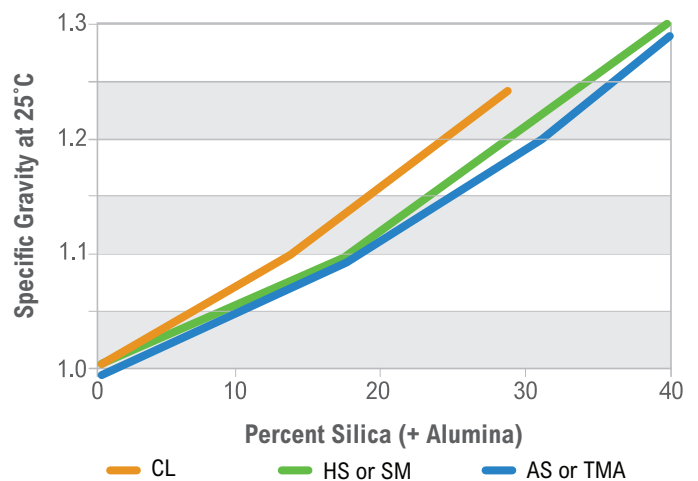


Fig. 1: Specific Gravity of LUDOX® Colloidal Silicas

Figure 1 is a chart of specific gravity versus silica (and alumina) content.

Novel Grades

In all grades, the surface charge of the colloidal particles depends on the pH of the system. Therefore, if run in systems where the pH is neutral or acidic, they lose much of their flocculation ability.

LUDOX® TMA colloidal silica is surface modified to maintain a high charge density independent of pH. Like AS-40 it is deionized to remove sodium, but it is not necessary to add ammonia to stabilize TMA. Thus TMA combines the features of low sodium and can function over the broadest range of pH of any grade.

All the grades discussed above have a negative surface charge, even at acid pH.

LUDOX® CL colloidal silica is unique in that it is positively charged. The surface of the silica particles is completely covered with a monolayer of alumina that causes the surface to be positively charged. It will flocculate all other LUDOX® colloidal silica grades as all other grades are negative. Being cationic, it will very likely be compatible with other cationic components used.

LUDOX® CL colloidal silica is only stable in the pH range below 6 and gels rapidly above this pH.

Aluminosilicate Fibers – Colloid Silica Composites

Selection of the optimum silica binder depends on the nature of the substrate being bonded, the temperature conditions preceding the critical measurement of strength, and also the overall conditions of use.

The inorganic fibers used to make composites are generally aluminosilicate fibers. Depending upon their composition and mode of application, these fibers can be used at temperatures in the range of 1260–1482 °C (2300–2700 °F). Aluminosilicate fibers are composed of 52–55% SiO₂, 40–48% Al₂O₃, and up to 4% other materials. They are available in various grades, lengths (2µm for chopped or milled fibers to 138cm/10 in for long staple) and diameters (submicron to 25µm—most often used is submicron to 10 microns with a 2–3µm mean).

There are a variety of commercial aluminosilicate fibers available. Thermal Ceramics, Inc. and Unifrax Corporation, for example, both supply a number of grades under their respective KAOWOOL® and FIBERFRAX® trademarks.

Other inorganic fibers such as mineral wool, glass, quartz, alumina, zirconia, and mullite can be used in composite systems.

Vacuum-Forming Processes

Table 2 describes typical composite-forming processes using various LUDOX® colloidal silica combinations and bulk aluminosilicate fibers.

Composites formed using less than the recommended binder (Table 2) exhibit lower strengths and densities. If necessary, posttreatments with colloidal silica will increase the strength and density of composites.

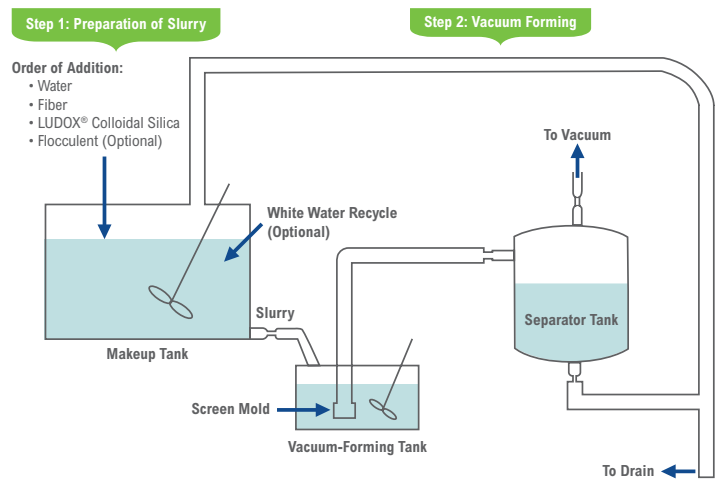


Fig. 2: Vacuum-Forming Process for Bonded Refractory Fibers

Products					
Surface Charge	SM Negative	HS-40 Negative	AS-40 Negative	TMA Negative	CL Positive
Counter Ion	Sodium	Sodium	Ammonium	-	Chloride
Silica (as SiO ₂), wt%	30	40	40	34	30 ²
Alkali (as Na ₂ O), wt%	0.56	0.41	3	None ¹	None
Particle Size, nm	7	12	22	22	12
Surface Area, m ² /g	350	220	140	140	240
pH (25°C / 77°F)	10.0	9.7	9.1	4-7	4.5

Table 1 lists typical properties of the LUDOX® colloidal silica grades discussed in this bulletin.

Table 2: Vacuum-Forming Processes

Binder System					
		LUDOX® SM Colloidal Silica ^a	LUDOX® HS-40 Colloidal Silica starch ^c	Postimpregnation	
Ingredients	Fiber lb	2	2		
	Water lb	149	117		
	Gal	17.9	14		
	LUDOX® Colloidal Silica lb	45	.036	1.0	4.0
Other, lb		–	0.15 starch ^d	Post-treatment	
Properties	Dry Density lb/ft³	8	20	21	32
	Dry Strength M/R lb/in²	–	200	190	460
	Fired^b Strength lb/in²	20	80	260	470
	Fired^b Wt Loss %	0	6	1-2	1-2
	Fired^b Vol. Shrinkage %	1-3	20	12	12
Procedure		<ul style="list-style-type: none"> • Slurry fiber in water. • Add colloidal silica. • Vacuum form. • Dry at 121°C (250° F) or higher 	<ul style="list-style-type: none"> • Slurry fiber in water. • Add colloidal silica. • Dissolve starch in 2-gal cold water. • Add starch to mixture. • Vacuum form. • Dry at 120°C (248° F) or higher 	<ul style="list-style-type: none"> • Postimpregnate by pouring LUDOX® HS-40 over wet shape while stil on vacuum mold. • Remove excess with vacuum. • Dry at 120°C (248°F) or higher. 	
Advantages		<ul style="list-style-type: none"> • Completely inorganic. • Low shrinkage on firing. 	<ul style="list-style-type: none"> • High green strength. • No migration of binder. • Recirculation of white water is unnecessary. 		
Disadvantages		<ul style="list-style-type: none"> • White water must be recirculated. • Migration of binder. • Low unfired strength. 	<ul style="list-style-type: none"> • Starch smokes during burnout. • Loss in strength on firing. • High shrinkage on firing. 		

^a Other grades and formulations can also be used. See Table 1. / ^b 2 hr at 1149°C (2100°F). / ^c U.S. Patent 3,224,927, issued Dec. 21, 1965 DuPont Company. / ^d “Supercharge 150 PG” cationic starch, Stein Hall & Co., Inc. or equivalent. /

^e Mineral Colloid BP, Georgia Kaolin Co.

Post-treatments

Bonded composites can be post-treated with LUDOX® colloidal silica and dried. The colloidal silica increases the strength and hardness of the composite and will not shrink, smoke, or lose strength after firing. With colloidal silica-starch composites, the starch is usually removed by firing and the resulting structure is then posttreated with colloidal silica and dried. Migration occurs on drying, resulting in a case hardened exterior and a softer interior. However, composites made with inorganic flocculent posttreated with LUDOX® HS-40 colloidal silica exhibit greatly reduced migration, and strength is more uniform throughout the composite.

Microwave drying can control migration of LUDOX® colloidal silica by immediately evaporating the water before it can move to the surface and pull the colloidal silica particles with it.

A composite impregnated with 400–500% wet pick-up of LUDOX® HS-40 colloidal silica will have a density of about 513 kg/m³ (32 lb/ft³) and a fired modulus of rupture of about 3240 kPa (470 lb/in²).

Storage and Handling

LUDOX® colloidal silica should be stored where temperatures remain above 2° C (35° F). Freezing temperatures cause irreversible precipitation of the silica.

LUDOX® HS-40FS colloidal silica, freeze-stabilized, is available by special request at a slightly higher price.

Drums should be stored in heated buildings. Bulk storage tanks for LUDOX® colloidal silica should, if possible, be located in a heated building. Alternately, a shed structure may be constructed to protect the tank and its piping from freezing. Tanks that must be located outside should be provided with external steam coils and lagging. The temperature of the colloidal silica must be kept high enough so that the air in the tank stays above freezing; otherwise, icicles and frost may form above the liquid.

It is necessary to prevent freezing but it's not desirable to store LUDOX® colloidal silica for lengthy periods at high temperatures. Continuous exposure to high temperatures will shorten the shelf life. Avoid storing the product in areas where the temperature routinely goes above 43 °C (110 °F).

If storage tanks are located outdoors, choose a shaded location or erect a sunscreen over the tanks to avoid solar energy collection.

Storage tanks constructed of cross-linked polyethylene or fiberglass-reinforced plastic have proved satisfactory. For metal storage tanks, stainless steel type 304 is recommended. Mild steel tanks with resin lining can also be used.

Piping can be type 304 stainless steel or polyvinyl chloride (PVC). Valves should be of the same material as the piping.

Diaphragm-type pumps made of stainless steel and equipped with PTFE fluoropolymer resin parts (e.g., pumps of the Wilden Pump and Engineering Company) have given good service.

Self-priming centrifugal pumps constructed of stainless steel or nylon are also recommended for service with LUDOX® colloidal silica.

Spills should be flushed with plenty of water. The piping system should be flushed thoroughly to remove any silica that could form dried deposits between pumpings.

Personal Safety and First Aid

All persons handling LUDOX® colloidal silica should be thoroughly familiar with the Grace Material Safety Data Sheet.

Health Hazards

Contact with LUDOX® colloidal silica may cause transient irritation of the skin and eyes. Dust from spills or deposits may be considered to be amorphous silica, although the particles are normally larger than respirable size. However, when aerosols are intentionally produced, such as in spray applications, respirable droplets or dust may form that may cause irritation of the respiratory system with coughing.

Studies have shown that when applied with the recommended limits, these materials are unlikely to produce health hazards, such as pulmonary fibrosis, as observed with crystalline materials. Users should review the Material Safety Data Sheet provided with each shipment for the various exposure limits.

Safety Precautions

Avoid contact with skin or eyes. Avoid circumstances that cause a mist or spray of the liquid or a dust of dried particles. Application methods using rollers or sponges are preferred rather than sprays that generate fine droplets. Installations for applying colloidal silica should include provisions for sufficient ventilation to control airborne particles and keep exposures below recommended limits.

First Aid

In case of skin or eye contact, flush with plenty of water for at least 15 min. Call a physician. If large amounts are inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Shipping Containers

LUDOX® colloidal silica is available in 55-gal polyethylene drums and 275-gal bulk drums. In North America, these products are also available in tank cars and tank trucks. LUDOX® colloidal silica is not regulated as hazardous materials by DOT or IMO.*

Ordering Information – Product, Literature, or Samples

To order Grace LUDOX® colloidal silica, additional literature, or a product sample, call Customer Service toll free at 888-659-1716. For locations outside the United States, contact the local Grace representatives in your country.

NOTICE: LUDOX® colloidal silica may irritate eyes. Overexposure to mists or dusts may cause a tissue response in the lungs.

**Due to changing governmental regulations, such as those of the Department of Transportation, Department of Labor, U.S. Environmental Protection Agency, and the Food and Drug Administration, references herein to governmental requirements may be superseded. Each user should consult and follow the current governmental regulations, such as Hazard Classification, Labeling Food Use Clearances, Worker Exposure Limitations, and Waste Disposal Procedures for the up-to-date requirements for the product described in this literature.*

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