

PKN

Product Knowledge Network

*Everything you need to know
about nonstick-coated
houseware products — FREE.*

Sol-Gel “Ceramic” Coating

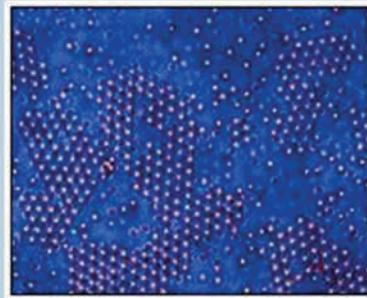
The who, what, where, why, and how
of this new coating option in our market



COATING
INFORMATION



What is sol-gel technology?



Sol (Solution): A colloidal suspension of tiny particles in a liquid medium which undergoes hydrolysis and condensation polymerization to form a “gel”. This occurs in the activation phase (discussed below).



Gel: A solid, jelly-like material that has properties ranging from soft and weak to hard and tough. Gels are defined as a substantially dilute cross-linked system, which exhibits no flow when in the steady state. When the gel is applied as a coating and is dried, a hard, glass-like film is created, with a ceramic appearance.

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Are they really “ceramic” coatings?

Sol-gel technology is a hybrid of organic and inorganic chemistry. Coatings produced using sol-gel technology are more accurately described as ceramic-like; they feature many of the same characteristics as ceramic but to a lesser extent. Compared to PTFE, sol-gel coatings are harder (9H pencil hardness), and can function at higher temperatures (up to 450°C/840°F).

“Ceramic” is a broad term, and such products are usually divided into four sectors: structural (bricks, pipes), refractories (kiln linings), white wares (tableware, pottery) and technical (engineering). That’s why sol-gel coatings are more accurately described as “ceramic-like”.

Sol-gel Technology and Housewares: What’s the connection?

There are many applications for sol-gel products. Scientists have used them to produce very light materials as well as very tough ceramics. One of the largest application areas is coatings. Protective and decorative coatings can be applied to glass, metal and other types of substrates. It is in this area that “ceramic” coatings for cookware and basic housewares have evolved.

What makes sol-gel coatings different from traditional nonstick coatings?

Traditionally, most nonstick coating companies have formulated non-reactive systems. (As formulators, any chemical reaction occurring within the formulations is undesirable, since it could change the quality and performance of the ultimate coating.) The formulators receive pre-polymerized materials from their suppliers and blend them so they are suitable for application as coatings.

With sol-gel, the process is the opposite: the formulators start with the monomers and create the polymer on the pan’s surface once the coating is applied by means of a chemical reaction.

As discussed in the PKN section, “What is a nonstick coating?”, there are five basic elements that make up a liquid coating before it is applied:

- 1.The binder (or resin) adheres to the surface of the pan. It acts as the “glue”, providing adhesion and cohesion. It also determines the fundamental properties of the coating.
- 2.The pigment provides the color.
- 3.The “nonstick” component provides the release.

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4.The reinforcing agents add strength and wear resistance.

5.The carrier (water or solvent), in which the other materials are suspended, which evaporates when the coating is cured.

With sol-gel technology, the binder is synthesized during the curing stage. It provides a hard surface, similar to porcelain enamel, and is formulated in a way that allows good release without the use of fluoropolymers (e.g, PTFE).

If sol-gel coatings have no fluoropolymers, what makes them nonstick?

Sol-gel is a hybrid material. Because of its chemical nature it possesses the strength of silica while achieving excellent smoothness and good release without fluoropolymers. The release or nonstick ingredient is embedded in the coating.

Is special application equipment needed?

Sol-gel coatings can be applied on a conventional spray line. Coaters need surface preparation equipment, either standard mixers or rolling equipment and preheating capability. The pans must be preheated to about 50-70°C/120-160°F. They are then cured at temperatures lower than conventional nonstick coatings.

How is a sol-gel coating processed?

The process involves: Activation, Filtration, Surface Preparation and Application.

Activation: Prior to activation, the individual components must be mixed thoroughly since there is a tendency for the fillers to settle.



Once properly mixed, components are combined in specific ratios in a mixing vessel for a specific time. During mixing, the chemical reaction causes an increase in the temperature of the mixture. Note: most manufacturers package the components in the proper ratios to help avoid problems.

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Filtration: As with any coating, it is necessary to filter the mixed product prior to application.

Surface Prep: The most common substrates used with sol-gel coatings are aluminum and stainless steel. Special primers are under development for the use of this technology on carbon steel and cast iron.

As with any coating, surface preparation is critical, and must be done properly to ensure adhesion. First, the pans must be degreased/cleaned to assure the surface is free of oils, since grit-blasting and other methods do not always remove all the oil. Any oil or grease can contaminate the blasting material and interfere with adhesion, especially with repeated use of the material.



Most pans to be coated with sol-gel have the surface grit-blasted, which roughens the surface and provides more “tooth” for the coating to grab on to. Note: Improper surface preparation can cause problems with performance. If the surface is too smooth, it can negatively affect both adhesion and mechanical performance. If the surface is too rough, it can cause the coating to be drawn into the surface profile, resulting in a dry, rough finish.

At this point, the pans are preheated to a specific temperature, another important step.

Application: With sol-gel coatings, there is a specific time by which the activated and filtered coating should be applied to achieve maximum effectiveness. The coatings are applied via conventional spray equipment. They are available in one- and two-coat systems.

Sol-gels must be applied only to preheated parts that maintain about 50-70°C/120-160°F throughout the spraying process. If parts are not heated and kept at this temperature, the coating could sag, cause wetting defects or dry spray. An IR thermometer can help check the pans to ensure proper temperature.

Another critical step: As with all coatings, there is a required dry-film thickness that must be applied to ensure proper performance. The pans are then cured in conveyor or batch ovens.

How does the performance of sol-gel coatings differ from PTFE coatings?

Sol-gel coatings have good initial release, high gloss and good stain resistance. Because they are ceramic-like, they also offer high continuous working temperatures with good abrasion and surface hardness.

Release: Initial nonstick properties of sol-gel coatings are excellent, even better than many conventional nonstick PTFE coatings. However, ceramics rely on siloxane chemistry for nonstick properties, so the release



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characteristic may diminish over time. Proper use and care can significantly affect the rate of decline of nonstick properties. By comparison, conventional nonstick PTFE coatings provide very good release for a longer period of time.

Abrasion Resistance: Ceramic systems are harder and less ductile than PTFE coatings.

Temperature Resistance: Ceramic coatings will survive 450°C/840°F. However, the release properties begin to diminish when exposed to temperatures above 350°C/660°F for extended periods of time. The coating remains functional because the matrix is very hard. In comparison, conventional PTFE coatings begin to deteriorate at 260°C/500°F.

Stain Resistance: When properly applied, ceramics have very good stain resistance, even in white. In contrast, PTFE coatings have less stain resistance, especially in light colors.

Colors: Ceramics can be made in a variety of colors like blue, green, red and even “Appliance White.” They will maintain color at high temperatures. This is not the case with PTFE coatings and the reason why most are black or grey.

Application: sol-gel coatings are easy to apply if you follow the manufacturing guidelines. This involves good process control and achieving accurate temperature and residence-time targets. These parameters influence adhesion, coating thickness and aesthetics. Many problems with adhesion or staining can be traced back to improper temperatures during the application process.

Why have sol-gel coatings gained acceptance in the market?

These new coatings provided a new look for cookware, with white and light colors, high gloss and the ability to withstand higher temperatures than conventional coatings. The media attention given to the EPA’s concern about PFOA also presented a marketing opportunity for coatings that did not contain PFOA and PTFE, principally sol-gel coatings.

Are PFOA and PTFE the same thing?

No, although some have incorrectly classified PFOA and PTFE as if they were the same. PFOA was used in small concentrations as a surfactant when manufacturing PTFE. This has largely stopped and reputable manufacturers will stop entirely by the end of 2015. Nonstick PTFE coatings continue to enjoy a track record of over seven decades of safe use, and are one of the safest products ever put into commerce.

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Are all sol-gel coatings the same?

No, they are not - just as not all conventional PTFE coatings are the same.

There are, in fact, many differences. Sol-gel systems are typically multipack systems. Each coating can have 2 or more packs to be mixed to achieve the final coating. So, for example, a one-coat sol-gel coating will have 2 or more packs to mix to achieve that coating. For a two-coat, each layer of the coating has multiple packs to mix, separately for each layer, and then applied as directed by the manufacturer. The number of packs per layer is determined by the coating manufacturer and varies from product to product. Also, some require a full 24 hours of mixing, while others as little as 3 hours.

Some of the newer sol-gels have more than twice the release of other coatings.

A few form tighter, more cohesive coatings, which improve their stain resistance. These few also provide greater eye-catching gloss at point-of-sale for the same reason. There is even one brand of sol-gel “ceramic” coatings that has been fully checked for regulatory compliance, supported by a legal letter verifying that it is compliant with the EU and US regulations for food contact.

It’s important to talk with your supplier to make sure you get the sol-gel coating that is precisely what you need, because they are not all the same.

Why are sol-gel or “ceramic” coatings also often referred to as “green” or “environmentally friendly” coatings?

Many lines of cookware that use a sol-gel “ceramic” coating claim that they are “green” or “environmentally friendly” because they use a coating that contains no PFOA and no PTFE.

Normally, “green credentials” would consider all factors including the life span of the article. Most sol-gel “ceramic”-coated pans have a shorter nonstick life than conventional PTFE-coated pans, so they will wear out sooner, leaving the consumer to buy several sol-gel pans in the same lifespan as one pan coated with one of the better conventional PTFE coatings.

Implications of this would include:

- More raw materials used in manufacture of pans
- Additional energy used in manufacture and transportation. More pans going to landfill or reprocessing

Furthermore, most PTFE coatings from reputable coating manufacturers are available in formulations that are made without PFOA, already meeting all EPA guidelines.

All these factors can be considered when expressing “Green credentials” of a type of coating.

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What's the best way to clean sol-gel/”ceramic” coatings ?

Actual in-home tests were conducted to evaluate a variety of cleaners and how they perform on ceramics. Obviously, if what gets cooked gets burned, it can impact the results. Nevertheless, the following methods and cleaners were found to be the best options:

- First, as with any cookware, try soaking the pan in hot soapy water; sometimes overnight. (In-home tests were conducted using Dawn®).
- If you are in a hurry, try heating the pan with soapy water on low, then scrubbing with a sponge. Make sure to use caution and pot holders when scrubbing the pan, as the water will get hot.
- For some foods, simmering 1/2 cup of vinegar and scrubbing with a sponge works better.
- For really tough stains like barbecue sauce, use 1/2 cup of Cascade Dishwasher Detergent Gel mixed with two cups of hot water. Let that stand overnight. The next morning, rinse out and wash thoroughly.
- For fingerprints, try Windex. Wash the pan thoroughly after Windex has been applied.

Each one of these techniques is gentle on the sol-gel ceramic surface.

What are the best cooking tips for sol-gel “ceramic” coatings?

- Use the lowest cooking temperature to get the job done.
- Do not let foods get burned; carbonization will be difficult to remove.
- Sol-gel ceramics brown and sear much faster than nonsticks and at lower temperatures; be sure to adjust your cooking times and temperatures accordingly.
- Sol-gel ceramic coatings cook differently from conventional nonsticks; experiment and conduct some of your own tests.
- Use wood or plastic utensils when cooking and or cleaning.