Highlight

Coating Development

SCHOTT
glass made of ideas

Durable easy-to-clean coating for home appliances

Consumers will soon see the benefits of the new technology as they will no longer need to spend time cleaning the glass panes of ovens or glass baking trays. The new easy-to-clean coated glass products from SCHOTT complement the solutions home appliance manufacturers offer.

Trends that Effect the Appliance Market

New functionalities for surfaces of all kinds have developed into an important trend. Because they simplify daily routines, they fit in well with today's lifestyles, where saving time is often an objective. The market currently offers a number of new coatings that help prevent mould, fight bacteria, hide fingerprints, enable graffiti to be removed more easily, make cleaning easier, or offer easy-to-clean or Lotus Effect[1] that reduce the effort of cleaning. The motivation behind using such functional surfaces often differs. Whereas anti-mould and anti-bacterial functions are closely related to the desire for healthy and hygienic lives, saving time is the reason why people enjoy easy cleaning features. Restoring a clean appearance to dirty surfaces quickly with minimal effort, regardless of what the stain may be, should be made as easy as possible.

This trend has reached kitchens. The results of market research have revealed that cleaning kitchens is viewed to be quite difficult by consumers. In fact, the oven is considered to be the most difficult appliance to clean in the kitchen. Therefore, ease of cleaning has become an extremely important purchase motivator. In Europe especially, easy-to-clean surfaces inside ovens represent an important product characteristic and a unique selling point.

Self-cleaning pyrolytic ovens continue to grow in popularity. But even with ovens that don't offer pyrolytic functions, the question of how easy the oven can be cleaned remains extremely important. Today, the insides of oven doors are often covered with large glass panes that eliminate crevices and edges and make cleaning easier as a result.

Many major vendors offer solutions aimed at making surfaces easier to clean for those who hate cleaning ovens. However, no solution has ever been offered with regard to the glass pane or other transparent glass products inside the oven that offers the durability required to complement refined metal surfaces.

It is essential that such a coating for the inside glass pane needs to be transparent and capable of meeting high demands. In addition to being easy-to-clean, using only normal household cleaning agents, and being capable of standing up to heat, most glass products in the kitchen must also satisfy food safety regulations. Researchers and developers of SCHOTT in Mainz achieved a breakthrough with regard to glass panes for use inside ovens. They came up with an oven door that is made completely of glass. Now, thanks to its so-called SCHOTT Clean Plus®, a new and durable easy-to-clean coated glass, SCHOTT is in the unique position to offer a solution with extraordinary properties that is ready for the market, and that can be applied to an existing heat-reflecting low energy surface. Today, heat-reflecting interior oven panes are offered as a standard feature with higher-priced ovens as a means of lowering energy consumption as much as possible.

The SCHOTT Clean Plus® full glass panes and glass baking trays allow SCHOTT customers to position themselves between traditional ovens and ovens that offer pyrolytic functions.

Each Application Calls for the Right Easy-to-clean Effect

The general approach to solving the problem of stained surfaces calls for completely preventing stains from interacting with the surface, or at least minimising interaction, but also shortening the retention period during which the stain is allowed to rest on the surface. This condition makes it easier for the surface to be cleaned using water. Generally speaking, depending on which type of functional benefit is required, various types of surface characteristics can result in easier cleaning. All of the available easy-to-clean products can be assigned to the following categories based on their individual surface characteristics (figure 1):

- Hydrophilic surfaces, photo-catalytic active surfaces:
  - coniderable surface energy and good wetting
  - eases infiltration and washing away of stains using water
  - decomposes organic stains using photo-catalytic oxidation and/or lasting hydrophilic conditioning of the surface.
- Hydrophobic surfaces:
  - low surface energy and poor wettability
  - minimises the contact surface between stains and the surface itself
- Super-hydrophobic surfaces:
  - low surface energy and the structuring of the surface offers hardly any wettability

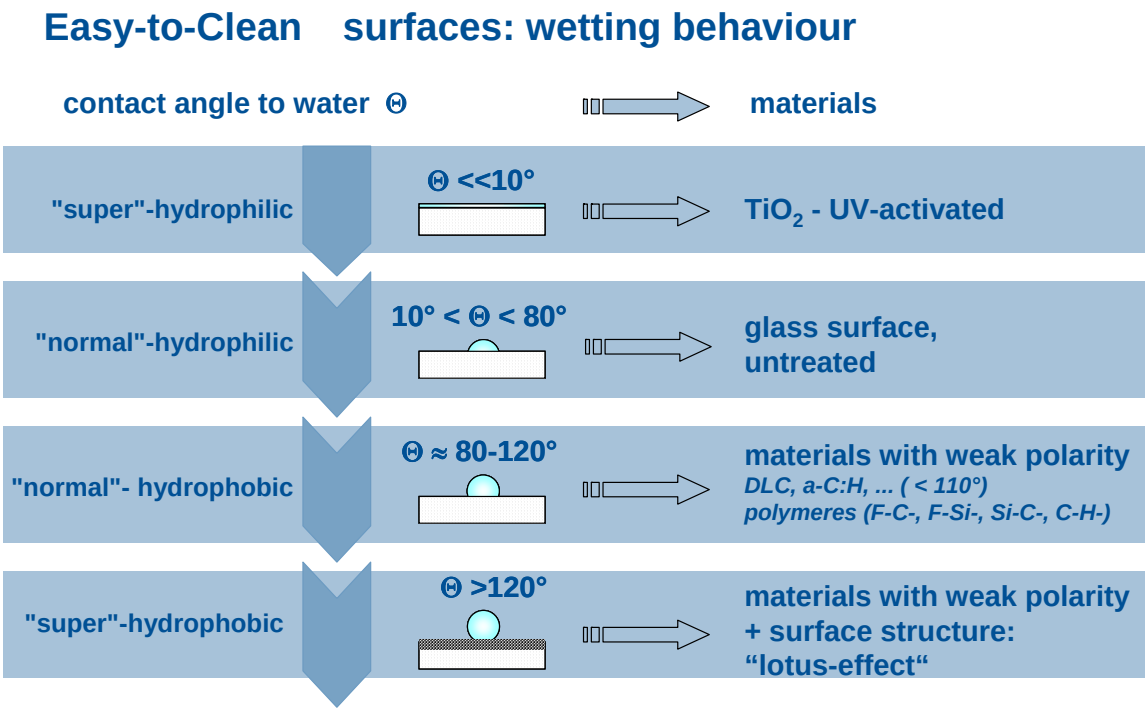


Figure 1: Wetting behaviour of easy-to-clean surfaces

For example, hydrophilic or "super-hydrophilic" surfaces are formed using titanium dioxide coatings that are photo-catalytically active. Such surfaces are completely wet and, therefore, do not allow soil to adhere well to the surface. In addition, by activating the layer in a photo-catalytic manner, it is possible to achieve decomposition reactions to stains on the surfaces. Due to the fact that sunlight (UV radiation) is

required to activate them, such coating layers are typically put to use in outdoor applications. The coating is mostly inappropriate for indoor use, because the UV radiation is only available to a very limited degree. The rate of decomposition is also so low that contact-related stains resulting from food require unacceptably long decomposition times.

Extremely strong effects can be gained with super-hydrophobic surfaces. They result from a combination of structuring and hydrophobic treatment of the surfaces. The most common expression that is used with this type of surface is the Lotus Effect[1]. In flora, one has already seen how hardly any dust remains on the tops of surfaces because it is washed off easily by water drops. The major advantages that such surfaces offer have been put to use thus far in the area of architectural glass. However, super-hydrophobic surfaces are not suited for use inside the kitchen. On the one hand, the structures are not mechanically stable enough to withstand normal wear. On the other hand, the structures suffer when they come into contact with oily stains. Once the super-hydrophobic surface has become contaminated by stains that cannot be removed from its structure, the opposite effect is achieved and one obtains a surface that becomes soiled quite easily and is extremely difficult to clean.

For this reason, hydrophobic surfaces are usually the only ones used in household environments. Hydrophobic coatings that offer numerous chemical structures are available on the market. Thin organic finishes and monolayers can even be purchased at supermarkets. However, they do not provide sufficiently high mechanical and thermal stability to be used inside ovens (figure 2). Therefore, these layers are only effective for a limited period of time.

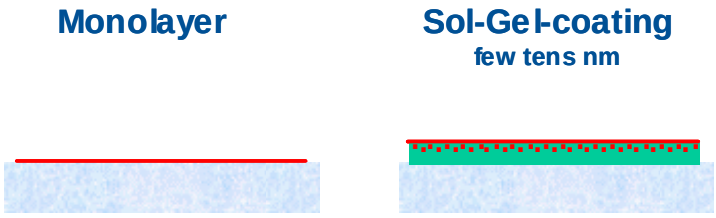


Figure 2: Approaches for easy-to-clean coatings

Ormocer[2], often found in household applications, is the brand name of a product that is not thermally stable enough to stand up to the required temperature of 300° C over longer periods of time, without losing its characteristics. This is why the focus of development has been on sol-gel based layer systems (figure 2). These are capable of offering the desired characteristics with the help of functional silane and, therefore, offer significant advantages. Mechanical stability is achieved through the inorganic network of the Sol-Gel. The functional characteristics result from the functional, organically based silane. However, the functional components of the layer do not reside completely in the surface, as is the case with monolayers, but rather in deeper lying areas of the inorganic carrying layer. Should the surface ever become damaged as a result of improper use, enough functional components can still be found in the underlying layer to ensure the desired properties. In addition, these layers can withstand higher temperatures because the hydrophobic silane is attached firmly to the network.

[1] Lotus Effect is a registered trademark of Wilhelm Barthlott, Botanisches Institut Meckenheimer Allee 170, Bonn, 53115, Germany (FRG)

[2] Ormocer is a registered trademark of Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V. Muenchen, Germany (FRG)

SCHOTT Clean Plus® Coating Development

In general, depending on the exact application, several different surface characteristics can be selected that deliver the desired functions and result in an easy-to-clean effect (figure 1). Based on their various individual surface properties, all available easy-to-clean products can be placed into hydrophilic, hydrophobic and super-hydrophobic layer categories. Due to the fact that they require UV radiation (sunlight, for example), the hydrophilic layers are inappropriate for use in ovens. On the other hand, super-hydrophobic layers are mechanically instable. With regard to ease of cleaning, they do not behave very well. Stains, such as fingerprints, for example, can nullify the desired effect. In the area of hydrophobic coatings, there are now numerous products on the market that do not meet the high demands placed on glass panes inside ovens.

The coating developed by SCHOTT that consists of a hydrophobic sol-gel layer, a glass-like network builder and hydrophobic siloxanes, is sprayed on and it's thickness is in the range of nanometres. The inorganic network ensures that the layer offers sufficient mechanical stability. The organic functional siloxanes are linked chemically to the network in order to ensure that the functionality is retained, despite thermal and mechanical stress. As a result of the thin nano-scale composition, there are no impairments to vision and there is always an unclouded view of food.

Coating Properties

In order for a product to be used as a glass component inside ovens, it must offer resistance to high temperatures, surface stains and abrasion in order to stand up to normal household cleaning products and utensils. Identifying and fulfilling the various country-specific and market-related demands were major challenges. This applies to both, how measurement methods are defined (e.g. a determination of surface energy using a contact angle measurement tool) and the choice of practice-oriented tests (e.g. using baking and grilling procedures).

Most notably, organic coatings are generally unable to offer the required temperature stability of 300° C for more than 100 hours. For instance, PTFE-like coatings used for frying pans turn brown and delaminate at high temperatures during long-term usage. It is highly probable that monolayers vaporise or disintegrate. By contrast, inorganic coatings that would offer sufficient temperature stability are not stain-resistant enough to be used as panes or glass baking trays inside ovens. The SCHOTT Clean Plus® coating offers the best of both worlds: the necessary heat resistance and hydrophobic characteristics. Because the hydrophobic molecules are chemically bound to the matrix, they remain part of the layer and do not vaporise (figure 3).

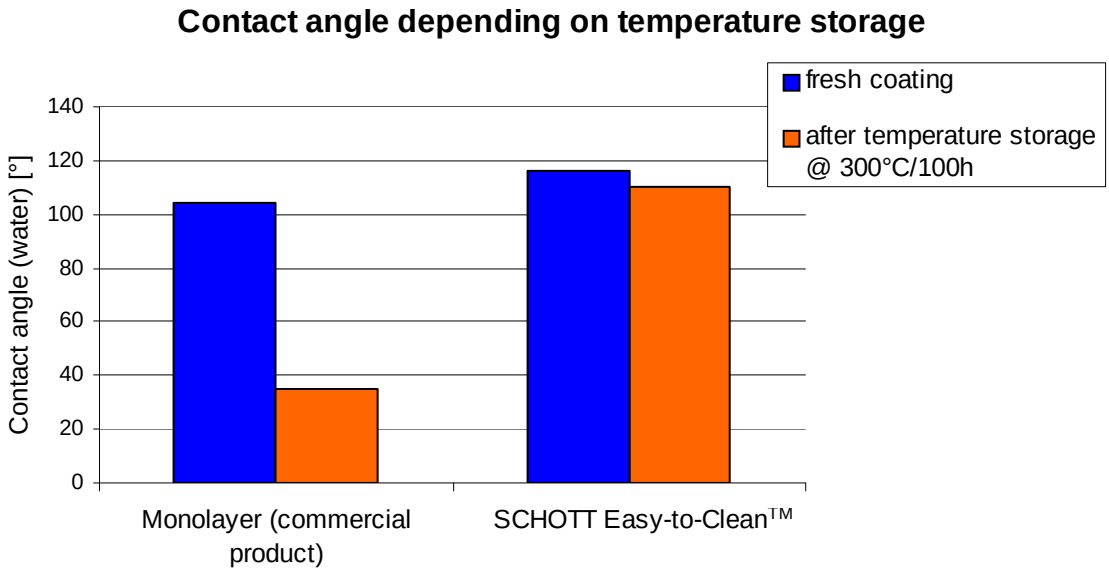


Figure 3: Comparison of surface properties under thermal stress

Standing up to cleaning agents, utensils and contact stains related to food or cleaning products are difficult challenges for coatings to meet, because the ingredients contained in stains can migrate into the layers, dissolve them or change their visual appearance. The layer developed by SCHOTT stands up extremely well to such aggressive attacks. In a mechanical scrubbing test, normal conditions were simulated with the help of a wet felt towel. The test is designed to re-enact normal wiping pressures that take place in homes with wet /damp sponge cloths. A weight was placed on top of the cloth and the same position was rubbed back and forth up to 1,500 times. Figure 4 shows how the contact angle declines with added stress.

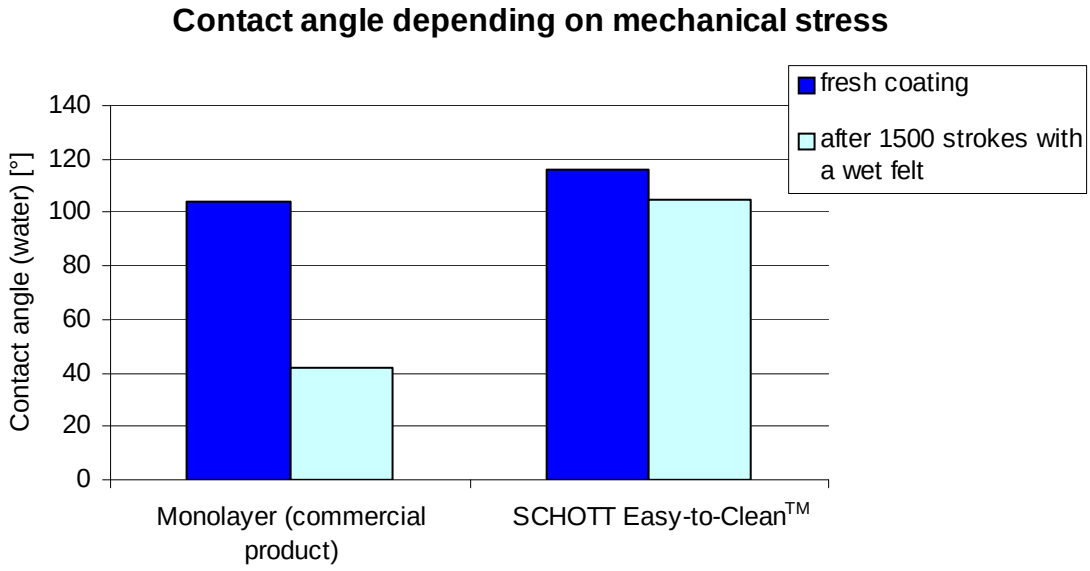
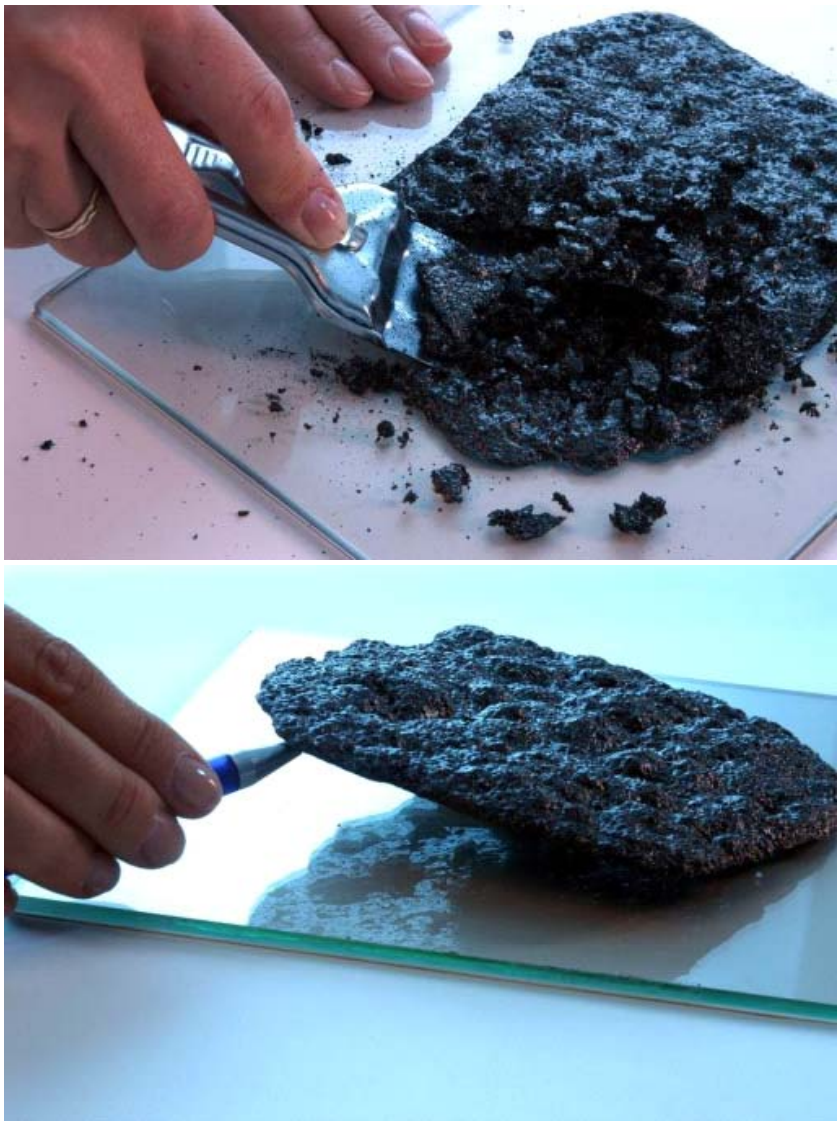


Figure 4: Progression of the contact angle following the stress of the scrubbing test

With scorched food on the surface, the layer reveals astounding characteristics. For example, the easy cleaning characteristics can be demonstrated especially well with plum-jam stains. This test simulates the type of stains that commonly occur when cakes that contain fruits are baked. Considerable stains can be seen on top of two different glass samples (figure 5).



(a)

(b)

Figure 5: Stains from burned-in plums; (a) without easy-to-clean layer, (b) with SCHOTT Clean Plus® coating.

Two nearly identical stains can be seen on top of two sample glass panes. Both contain plum-jam burned onto the panes. The uncoated pane resists being cleaned with either a cleaning agent or a scraper. In order to remove even parts of the stain from the glass, considerable physical cleaning efforts are required that could result in scratches on the glass surface.

The stain can easily be removed from the glass sample that was treated with the SCHOTT coating. The jam that appears to have been burned into the surface now slips off easily, leaving the demonstration sample perfectly clean. The same test was repeated 40 times on exactly the same position of the coated glass, and no changes to the functional properties were observed.

In the in-depth application tests that SCHOTT customers have performed thus far, the SCHOTT Clean Plus® coating stood up to the demands to the greatest possible extent. Not only does it offer substantially easier cleaning than conventional materials, it also fulfils strict market specific demands and satisfies legal requirements. In addition, the visual appearance does not change as a result of use. The fact that the coating also supports and rounds off existing “easy-to-clean programs” represents yet another advantage.

Conclusion

With the SCHOTT Clean Plus® easy-to-clean coating, SCHOTT has succeeded in becoming the first vendor to offer a stable coating that satisfies market requirements and appeals to the eye. This coating fits in perfectly with the trend towards modern convenience products. This article illustrates that the coating possesses exceptional physical and thermal properties. Exceptional results were also obtained with food-related stains. For example, it was possible to remove plum-jam stains completely, on a repeated basis. The market introduction of this additional feature leads to an increase in value and a new positioning of oven models above normal quality ovens and below pyrolytic ovens. Therefore, it is now possible to close the gap that has existed in product lines.

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