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SEALED AGAINST STAINING

Hybrid polymer provides reliable protection for cementitious flooring. By Udo Goedecke and Udo Anders, Wacker.

A novel silane-terminated binder can provide cement-bound floors with highly effective protection from stains. The binder can be readily applied as a one-component impregnation system. Its performance has been verified in practical tests.

Architects, planners and property developers are increasingly choosing to use floors with a visible concrete or cementitious, flowing screed surface. Once ground and polished, these types of floors meet exacting aesthetic requirements. Designer floors such as these can be found today in many fashion stores, exhibition and sales rooms, shopping malls, bistros, galleries, museums and even in homes. Cement-bound terrazzo floors are also attracting renewed interest.

Concrete, cement-bound screeds and cementitious terrazzo floors all have a disadvantage, however: their surfaces are porous, allowing liquids to penetrate. They can thus soil quickly, and liquids are very difficult to remove once they have soaked in. The porosity also reduces the floors' mechanical strength.

If cementitious floors are to retain their value and appearance for years to come, they have to be protected from dirt and abrasion before being put into use. The methods available for preserving them depend on the anticipated level of wear and on aesthetic demands. Impregnation is the technique generally used.

Impregnation agents for cement-bound floors employ a variety of different technologies. Very common options include water-borne agents based on waterglass (silicates), and solvent-containing products based on silanes. However, practical experience and laboratory tests both indicate that many common stain types push both of these technologies to their limits.

NEW BINDER OFFERS FAST, EFFECTIVE IMPREGNATION

A new impregnation binder marketed as "Silres BS 6920" has been developed that belongs to a class of materials known as α-silane-terminated polyethers. These hybrid polymers have silane units located at the ends of their polyether chains; these units, in turn, contain alkoxy groups (*Figure 1*) and cure via silane crosslinking.

In this product, the two silane termini are each bound to a polyether backbone via a methylene group and a urethane unit. In this type of bond, the silicon atom is in the α-position to the urethane-nitrogen atom. Their structure allows these polymers to crosslink very quickly, even when little catalyst is present [1-3].

As soon as atmospheric moisture acts on the polymers, catalysed formulations of α-silane-terminated polyethers quickly form a siloxane network by setting from the outside in. In actual practice, the crosslinking speed of the new binder is sufficient if the formulation contains an aminosilane catalyst. *N*-(2-aminoethyl)-3-aminopropyl-trimethoxysilane ("Geniosil GF 9") is an amino-functional silane that has been shown to be an excellent choice. The compound also functions as an adhesion promoter.

The new α-silane-terminated polyether has been optimised for use in impregnation agents for cementitious floors. The parameters that could be adjusted were the chemical structure of the silane blocks and the lengths of the polyether chains. The silane blocks, for instance, were modified in such a way that curing would form a particularly close-meshed network of quartz-like structural units.

This optimisation work resulted in a new, low-viscosity binder that penetrates deep into the pores of the cementitious substrate, fills

RESULTS AT A GLANCE

→ An α-silane-terminated polyether has been optimised for use as a crosslinking binder in impregnation agents for cement-bound floors.

→ The new binder can be easily and safely incorporated into one-component formulations for impregnating cementitious flooring or for applying a thin coating to these substrates.

→ The products are easy to apply and generate a visually appealing surface. After 24 hours, floors treated in this way can either be processed further, or can be walked or driven on.

→ Initial tests indicate a very high level of resistance to stains can be achieved, accompanied by an intensification of the colour of the flooring and improved resistance to abrasion, making it suitable for a wide range of interior applications.

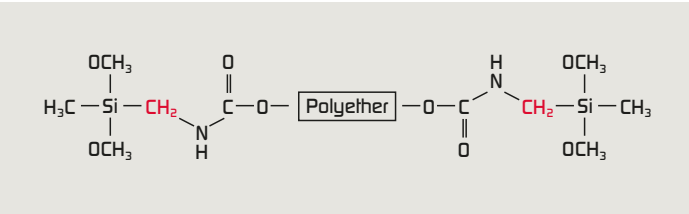
→ Work is ongoing to evaluate its use in exterior applications

these pores and crosslinks to form a hard material. The cured product is non-combustible.
The chemical structure of the binder makes the treated cementitious surface both hydrophobic (water-repellent) and oleophobic (oil-repellent), which significantly reduces the tendency of the surface to stain. The quartz-like structure of the crosslinked binder mechanically reinforces the substrate, making the treated floor resistant to heavy pedestrian traffic and it can even be driven on by fork lifts, cars and trucks.

SAFE AND SIMPLE TO FORMULATE AND PROCESS

The viscosity of the new α-silane binder – 75 mPa·s – is equivalent to that of olive oil. Its concentration of volatile organic compounds (VOCs) is less than 0.5%. Even this low VOC content is due to the

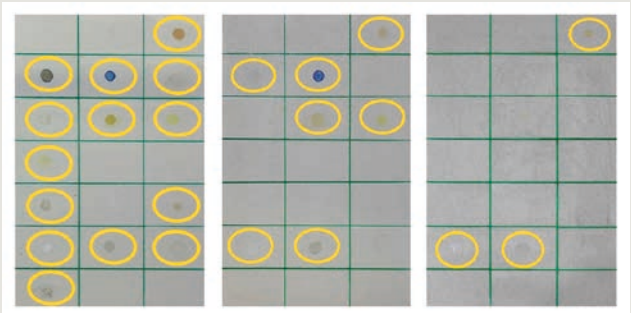
Figure 1: Structure of an α-dimethoxysilane-terminated polyether. The two silane termini are each bound to a polyether backbone via a methylene group (red) and a urethane unit.



crosslinkable alkoxy groups which are released during curing in the form of a short-chain alcohol.
The new product can be handled safely as it contains no solvents or plasticisers, has no odour, is not considered a hazardous substance and has a flash point of over 100 °C.
Even the most basic stirrers can be used for processing this binder into one-component formulations for treating cementitious floors. The addition of UV stabilisers is recommended as a way of achieving the proper degree of light stability for the thin coating and/or for the impregnation application at hand.
The next step is then to stir in the final component: the catalytically active aminosilane. Generally speaking, the product is sensitive to moisture once the catalyst has been added. If the formulator makes certain that no moisture enters the system during production, ready-to-use, one-component products can be stored in closed containers for one year.
The new polymer can be formulated in a number of different ways: while the product can be processed without the use of solvent, the viscosity of the end product can also be reduced by adding a suitable reactive diluent, which will keep the ready-to-use end product free of solvents and odours. One example of a suitable reactive diluent is iso-octyltriethoxysilane. Formulators can also blend in ground quartz, pigments and other solids for the purpose of broadly influencing the mechanical and optical properties of the cured end product.
If no solids are added, the formulated products are transparent and lend the cement-bound flooring a glossy surface suitable for polishing. *Table 1* shows a solvent-free reference formulation that, depending on the coating weight, yields a transparent impregnation or a thin transparent coating.
The open time for this kind of formulation is roughly 20 minutes and the skin-over time is 30 minutes. Addition of a reactive diluent can expand the window available for processing by up to two hours.

Figure 2: Stain test: twenty substances were tested, including salt water, red wine, cola, mustard, ketchup and used oil.

Figure 3: Results of the comparison test on cementitious test plates (stains caused by test substances circled in yellow). Only three stains cannot be removed from the plate impregnated with the alpha-silane system (right).



APPLICATION AND CURING PARAMETERS

End products made from the new binder can be applied onto a clean, polished floor using a mop, a short-haired roller or an airless spray gun. Curing is largely completed after twenty-four hours, at which point the floor can be walked on or processed further.
Applying two coats generally yields the best results, especially over highly absorbent surfaces. With this kind of substrate, the first application mostly fills the pores and strengthens the floor. Because the majority of the material soaks into the substrate, the treated surface looks inhomogeneous and spotty. The second coat then produces a uniform surface, along with a thin glossy film suitable for polishing.
As regards application, it is worth noting that the binder was designed for impregnation. According to DIN EN 1504-2, the film that forms on the surface of the substrate during impregnation can be up to 100 µm thick. However, studies have shown that, depending on how absorbent the flooring is, the total coating weight of the new binder (the sum of both coats) should not exceed 100 to 150 g/m². Its low coating weight makes the new technology of interest from an economic perspective as well.
Because they incorporate an aminosilane, products made from the new binder adhere very well to cement-bound surfaces, even if the substrate has not been previously primed. This has been verified in tensile adhesive strength tests performed by applying two thin coats of the reference formulation onto concrete slabs. The resulting average value of the tensile adhesive strength was 5.79 N/mm², at which point the concrete substrate underwent cohesive failure.
Adhesion is also good on glass and many metals. In the event that a surface treated with the new α-silane-terminated polyether is damaged during use, the product can also be used for repairing and potentially polishing the site.

STAIN RESISTANCE IS EXCELLENT

Impregnation with this binder system has a threefold effect: it protects cementitious floors from lasting stains, intensifies colour and strengthens the surface. These effects have been confirmed by using cement-bound test plates and small sections of cementitious flooring treated with the reference formulation (*Table 1*) for testing purposes.
Anti-staining properties were tested by comparing products on test plates and on test samples of flooring. In this study, the ability of the reference formulation to prevent staining was compared to that of

Figure 4: The impregnation noticeably intensifies colour.

Figure 5: The material removed by abrasion from concrete test plates fell from 40 grams (left-hand column, untreated concrete) to 3 grams (right, impregnated with a formulation based on the alpha- silane).

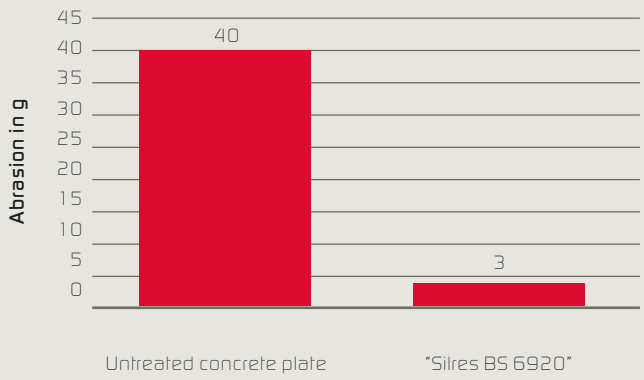


Figure 6: The diluted impregnation agent was applied to the sanded-down concrete floor of a production hall at the Agricolae Kft. fruit preserves plant in Jánkmajtis, Hungary.

Figure 7: Production hall at the Agricolae Kft plant following a second coat of the impregnation agent. The surface is now uniformly glossy.

commercially available silicate- and silane-based impregnation agents. Twenty test substances were used in the study, including salt water, red wine, cola, mustard, ketchup and used oil (*Figure 2*). After allowing them to soak in for twenty-four hours, the test substances were wiped off first with a dry and then with a damp paper towel.
In the case of silicate impregnation, fourteen of the twenty test substances left stains. Solvent-based silane impregnation reduced that number to seven, and only three substances left stains on substrates impregnated with the new binder (*Figure 3*). A video on YouTube shows how the tests were performed and describes the results [4].
The new binder, in other words, offers far more extensive protection against staining than traditional products, with virtually any kind of common spill leaving no trace at all when removed within one day. Highly acidic and highly alkaline media are the only substances that push the new technology to its limits.

SURFACE COLOUR IS ENHANCED BY CLEAR COATS

The alpha silane also greatly intensifies colours (*Figure 4*). Impregnating a cement-bound floor with a transparent product formulation makes the aggregate material in the floor stand out visually.
Once treated with the new silane-terminated binder, surfaces are better able to resist abrasion and scratching. When subjected to the rolling-wheel test described in EN 13892-5, for example, concrete test plates treated with a thin coat of the alpha-sllane formulation produced only 3 g of material due to abrasion – by contrast, 40 g of material were collected from untreated plates (*Figure 5*). These results demonstrate how well the new binder strengthens cementitious surfaces.

PRACTICAL VALUE CONFIRMED IN AN INDUSTRIAL PLANT

Initial projects have now been carried out in which cement-bound flooring has been impregnated with products containing the new binder. One of the first cases for which empirical data are now available is the Agricolae Kft. fruit preserve production plant in Jánkmajtis, a town in north-eastern Hungary. The aim of the project was to renovate and protect the floor of a 390 m² production hall primarily used for filling and labelling glass jars containing marmalade and other fruit preserves.
The contract was awarded to Durostone Kft., an industrial flooring restoration specialist of Sóskút, Hungary. The hall floor consisted of an epoxy resin wearing surface that had been applied to a concrete substrate. Durostone recommended removing the highly damaged

Table 1: Solvent-free reference formulation for transparent concrete impregnation.

Component	Function	Concentration in %
"Silres BS 6920"	Binder	94
"Tinuvin B75"	UV stabiliser	1
"Geniosil GF 9"	Catalyst and adhesion promoter	5

"Two applications always yield the best results."

3 questions to Udo Anders

For which types of cement do you recommend the impregnating agent; how open-pored should they be at most? *Because of the incorporated aminosilane, the new binder adheres very well to all cement-bound surfaces. Two applications always yield the best results. But the coats should not be thicker than 0.1 mm. This also applies to open-pored, highly absorbent surfaces. The first coat fills the pores and consolidates the base while the second yields a glossy, polishable surface.*
How do you test the tack after the first coat and is there a guideline for when to start applying the second? *It's best to do a manual check for absence of tack. It takes about two hours for the diluted product to form a skin at room temperature. The impregnating agent is tack-free after six to eight hours*
Which challenges still have to be overcome before the product can be used outdoors without reservation? *Light radiation poses the greatest challenge. Too much sunlight can impair the product's stability. For this reason, we are testing various photo-stabilisers at the moment. Our goal is to formulate the product such that it can be used outdoors in the future as well.*

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epoxy resin layer and treating the concrete floor with the α-silane-terminated polyether impregnation system instead.

PROJECT PREPARATION AND IMPLEMENTATION

The old epoxy resin layer was completely sanded off to expose an untreated concrete floor that was flat and in good condition. Impregnation was carried out on two consecutive days in early June using a blend of 95% "Silres BS 6920" and 5% "Geniosil GF 9". UV protection was not included, as the hall does not have any windows.
For the first coat, the product was thinned on site through the addition of 10% reactive diluent. The applicators used about 50 g of the diluted formulation per square metre, after which they could immediately see that the colour had been intensified (*Figure 6*).
While the diluted impregnation agent readily permeated the absorbent floor, the surface looked spotty. It took around two hours for a skin to form, while the initial coat as a whole took a solid seven hours to cure.
The applicators returned the next day after an 18-hour break to see whether the surface was still sticky. It was not, so they began the second application, for which they used the undiluted formulation – again at a concentration of 50 g/m². The second coat was complete after six hours to yield a uniform, glossy surface with no spotting (*Figure 7*). The applicators reported that the impregnation agent was easy to apply, whether in diluted or undiluted form. The neutral odour of the product earned their praise as well.

EFFICIENT FLOOR PROTECTION, WITH WIDE APPLICATION

A highly effective alternative to waterglass or silanes is now available for impregnating cement-bound substrates: a new, α-silane crosslinking polyether binder that contains no solvent, does not need to be classified as a hazardous substance and can be processed without any difficulty.
It shows excellent stain resistance and is easily applied. Floors treated with formulations based on the new binder can be cleaned and maintained easily and affordably. Typical applications include cement-bound flooring in showrooms and sales areas, restaurants, railway station buildings, event and exhibition halls, museums, private homes, underground parking lots, logistics centres and production halls. Until now, its use has been limited to building interiors, but outdoor applications are currently also being tested.

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