Modified Alpha-Silane-Terminated Polyether – A New Hybrid Binder for Innovative Surface Protection

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Introduction

Architects, planners and property developers are increasingly choosing 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.

Coatings based on epoxy or polyurethane resins, for example, are among the other conventional products widely used for protecting cementitious floors.

New hybrid binder offers fast, effective thin-layer floor coating

A new hybrid binder has been developed that belongs to a class of materials known as alpha-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 alpha position to the urethane-nitrogen atom. Their structure allows these polymers to crosslink very quickly, even when little catalyst is present [1-3].

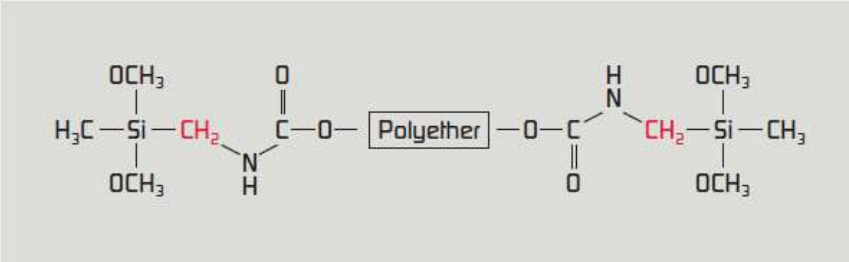

Figure 1. Structure of an alpha-dimethoxysilane-terminated polyether.
The two silane termini are each bound to a polyether.
backbone via a methylene group (red) and a urethane unit [4]

Wacker calls its alpha-silane technology hybrid polymers because in these molecules an organic polymer is linked to an organofunctional silane, thereby enabling targeted control of the system's properties. Hence the name hybrid binder: hybrids are things or living things of mixed origin that arise through mixing or crossing two different components or beings.
As soon as atmospheric moisture acts on the polymers, catalyzed formulations of alpha-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 is an amino-functional silane that has been shown to be an excellent choice. The compound also functions as an adhesion promoter.
The new alpha-silane-terminated polyether has been optimized for use in thin-layer coatings 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 optimization work resulted in a new, low-viscosity binder that penetrates deep into the pores of the cementitious substrate, fills these pores and crosslinks to form a hard material.
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 forklifts, cars and trucks.

Safe and simple to formulate and process – exceptional performance for preparation and application

The viscosity of the new alpha-silane binder – 130 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 crosslinkable alkoxy groups which are released during curing in the form of a short-chain alcohol.

1K formulation – easy preparation and application (rolling/spraying/brushing/wiping)

The hybrid binder can be handled safely as it contains no solvents or plasticizers, has no odor, 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 optional addition of UV stabilizers is recommended as a way of achieving the proper degree of light stability for the thin-layer coating.
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.

Free of solvents and hazardous ingredients – no mandatory training required

Formulations based on our hybrid binder are also more conducive to ensuring occupational health and safety than binders based on epoxy or polyurethane resins. In fact, craftsmen who work with polyurethane-based synthetic resins will have to provide proof of safe use and handling training in the European Union from August 2023. In our system, neither solvents nor isocyanates or any heavy metals are present. Therefore, our hybrid binders do not require a mandatory training.

Comprehensive variety in formulation

The new polymer can be formulated in a number of different ways: while the product can be processed without the use of solvents, 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 odors. One example of a suitable reactive diluent is iso-octyltrimethoxy-silane. 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.

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.

Color-enhancing thin and glossy transparent film

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 most of the material soaks into the substrate, the treated surface looks uneven and spotty. The second coat then produces a uniform surface, along with a thin glossy film suitable for polishing (Figure 2).

Figure 2. The diluted thin-layer coating agent was applied to the sanded-down concrete floor [4]

Possible to apply close to freezing point without change of viscosity

This new binder presents innovative as well as very attractive properties and advantages in contrast to conventional materials. The viscosity of the formulations does not change significantly at temperatures close to freezing point so that processing is easy even at lower temperatures.

Greater tolerance of substrate moisture compared with other systems

Another advantage of our hybrid binders is their greater tolerance of substrate moisture compared with other systems. The thin-layer coating acts as a vapor-permeable membrane. Mineral floors can thus be treated much earlier after installation compared with most conventional coating materials. No blistering is caused as a uniform level of humidity is achieved over time.

Nothing goes to waste – packaging protects contents and allows full use
Once opened, the packaging protects the contents and ensures future use of the material. This prevents waste, as all the material is used up.
Just close and open the packaging for future work and, in case a thin film is formed on the surface of the material, just remove it and work with the protected material underneath.

Thin-layer technology
As regards application, it is worth noting that the binder was designed for impregnation and thin-layer coating. 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 attractive from an economic perspective as well.
Good adhesion is generally given on all polar substrates, including glass, wood and many metals, and thus presents a wide range of applications of this hybrid binder.

Benefits of final floor coating – excellent stain resistance
Impregnation with this binder system has a threefold effect: it protects cementitious floors from lasting stains, intensifies color and strengthens the surface. A video on YouTube shows how the tests were performed and describes the results [5].

Figure 3. Easy removal of chewing gum

Heat-resistant and fire-retardant
Areas of special load like welding zones in our machinery shop have demonstrated the heat resistance of this coating for more than 6 years now.

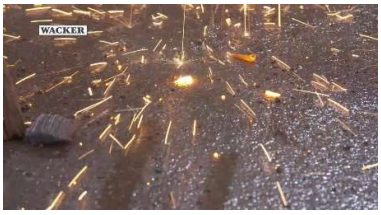

Figure 4. Heat-resistant and fire-retardant

Easy to repair and refurbish
In the event that a surface treated with the new alpha-silane-terminated polyether is damaged during use, the product can also be used for repairing the site.
This is a huge plus compared with other conventional materials whereby the complete surface has to be removed by grinding and recoated again. These features are also demonstrated in a video on YouTube [6].

Figure 5. Easy to repair/refurbish

Numerous reference projects stand testimony to this innovative, tried-and-tested flooring technology

Over the years, we have applied this material for several reference projects worldwide.
Different transparent and pigmented floor coatings were applied in our warehouse, for example where there is regular forklift traffic. After more than 6 years of real-time, long-term exposure, these coats fulfill their function and are still in good condition.
Public areas like a terrazzo floor at Nyugati Railway Station in Budapest was one of the first projects which was completed 7 years ago. Thanks to our floor coating, this terrazzo floor stands out with an elegant gloss and is easy to clean [7].
Silage clamps and chicken farms provide examples of surfaces in the agricultural sector which have been prepared and are successful in use. The most important benefit here is that the surfaces are much easier to clean compared with other conventional coating materials.
Outdoor areas too have been treated successfully. A paved driveway including a private garage were treated with our transparent coating 6 years ago.
These reference projects accompanied the successful introduction of this new technology into the market.

From floor coating to stone carpet applications

Besides thin-layer coatings for mineral substrates, this innovative binder system is also used for stone carpets. Floor coverings made of stone granules and synthetic resins can be laid without joints, are resilient and easy to process and clean. They are increasingly being installed not only in commercial premises but also residential spaces. With its new hybrid binder, Wacker offers a well-adhering and solvent-free binder for such floors.
Stone carpets were first developed for commercial properties in the 1970s, but they remained a niche application in residential settings until recently. For several years, they have enjoyed increasing popularity. Robust and non-slip, they are popular in entrances, homes and residential spaces and retail areas with heavy foot traffic, such as car or furniture stores. Unlike tiles, they can also be laid without joints, which makes them ideal for use in swimming pools, saunas or wellness areas. Depending on the binder used, stone carpets are UV-stable and can also be laid outdoors, on balconies or terraces.

Free of solvents and hazardous ingredients (e.g. no harmful isocyanates, tin catalyst)

Wacker's hybrid systems combine the typical properties of silicones (for example, high elasticity) and polyurethanes (such as mechanical strength), but, unlike the latter, they are free of potentially harmful isocyanates, tin catalysts and solvents.

Fast-curing and more tolerant to substrate moisture than other systems

The higher tolerance to moisture is also beneficial for stone carpet applications. Floors exposed to relatively high humidity can be treated earlier compared with other conventional coating systems. The primer consists of a thin layer of the pure binder formulation based on a hybrid binder. The binder is applied to the clean substrate with a paint roller and ensures good adhesion of the stone carpet. The mixture of silicone resin and stone granules is then applied to the

substrate. The layer that forms is breathable and permeable to water vapor, allowing the residual moisture of the substrate to escape. Another advantage the new binder offers is rapid curing. The stone carpet is open to foot traffic just three to four hours after application.

Guide formulations for horizontal and vertical surfaces

Provided that the mixing ratio and application are correct, water can flow freely through or out of the open-pored stone carpet.

Just as there are both wall carpets and normal carpets, stone carpets made of silane-modified hybrid polymers can also be used as wall coatings. In this case, the formulation of the resin must be adapted to the application. Such wall formulations are adjusted by adding appropriate auxiliaries to prevent run-off from a wall when the material is applied to it. We therefore developed guide formulations for horizontal and vertical surfaces.

Good stain resistance

Because of the way stone carpets are structured, they don't reveal stains as readily as concrete or other floors. Nevertheless, the good stain resistance of our hybrid binder for coatings also has a positive effect on stone carpets. Hybrid resin stone carpets are easier to clean than those with polyurethane or epoxy resins. The surface structure depends strongly on the size and texture of the stones used [8].

Reference objects for stone carpets

Test surfaces for indoor and outdoor application have been installed and are under inspection to test the concept of our technology. A representative area of around 150 m^2 that is well integrated in the rustic atmosphere of the surroundings has been completed at Franz Xaver Gruber Memorial House in Hochburg-Ach.

Conclusion

Wacker's hybrid binders offer new flooring technologies with advantages in the field of preparation and application as well as for the final floor coat or stone carpet.

Some of the exceptional performance criteria for preparation and application are presented below:

- 1K formulation (avoid mixing failure at construction site)
- Easy preparation and application (rolling/spraying/brushing/wiping)
- Free of solvents and hazardous ingredients (e.g. no harmful isocyanates, tin catalyst)
- More tolerant to substrate moisture than other systems
- Curing speed adjustable depending on environmental conditions or operations
- No mandatory training required
- Possible to apply close to freezing point without change of viscosity
- Fast-curing (walkable after 24 hours for floor coatings and 3-4 hours for stone carpets)
- Material-saving – future use possible despite opened packaging
- Thin-layer technology (max. 100 g/m^2) for floor coating
- Environmentally sound and user-friendly

Benefits of the final floor coating or stone carpet:

- Extremely versatile – for indoor and outdoor applications, even as a wall covering
- Easy to process – can be laid on all substrates
- Time-saving process by priming and laying the stone carpet consecutively
- Robust, durable and non-slip – perfect for high-traffic areas
- Seamless and water-permeable – ideal for swimming pools and spas (stone carpets)
- Easy to clean – conveniently with a vacuum or steam cleaner (stone carpets)

- Good scratch resistance, high hardness and abrasion resistance
- Excellent stain protection/easy to clean
- Heat-resistant and fire-retardant
- Cured material is permeable to water vapor (no blistering)
- Surface is water-repellent and stain-resistant
- Anti-slip
- Slip-resistance classes R9, R10 and R11 for floor coatings
- No yellowing
- Easy to repair/refurbish

This new technology offers formulators, craftsmen and end users a powerful system with multiple advantages compared with well-established conventional binder systems.

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