Waterproof walls

Improved water management and better barriers for exterior wall and metal coatings

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Producers of building and corrosion protection coatings are faced with the challenge of developing and producing paint and coatings which are designed for more efficient control and better management of water on building materials and other substrates. Hydrophobically modified calcinated kaolins are looking increasingly attractive as innovative fillers for such applications.

Precipitation density is on the rise in the temperate zones as a result of climate change [1]. Heavy rain events are occuring more frequently. Driving rain puts buildings and construction elements under additional stress. At northern European latitudes the climate is getting wetter. This is likely to increase corrosion damage on construction elements made of steel. Companies which produce building and corrosion protection coatings are taking the situation very seriously. They are faced with the challenge of developing and producing paint and coatings which are designed for more efficient control and better management of water on building materials and other substrates.

Up to this point, water management has been almost exclusively a domain of binder chemistry or one of the functions of additives. Inorganic fillers are a major constituent of paint and coatings, but with few exceptions their potential to enhance water management does not hold much water with the industry. This view is well founded because nearly all standard fillers such as calcium carbonate (GCC, PCC), marble dust, magnesium silicate and others are crystalline inorganic solids which have an inherent affinity for water. They are highly hydrophilic, actually attract water and are hardly suitable for efficient water management in paint and coatings.

Addressing the issue

There is, however, one class of inorganic fillers which could make an essential contribution to water management in paint and coatings, namely new calcinated

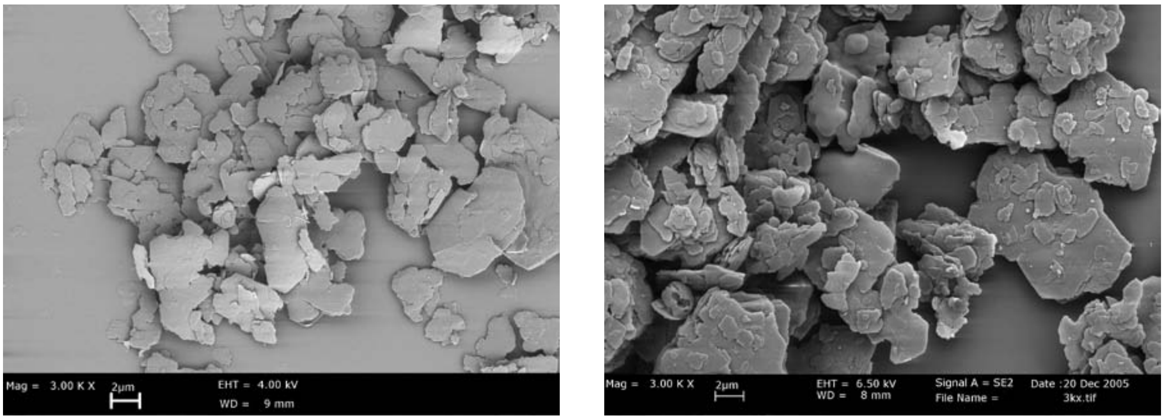

Figure 1: SEM images of plate-like kaolin grains, (a) native and (b) calcinated

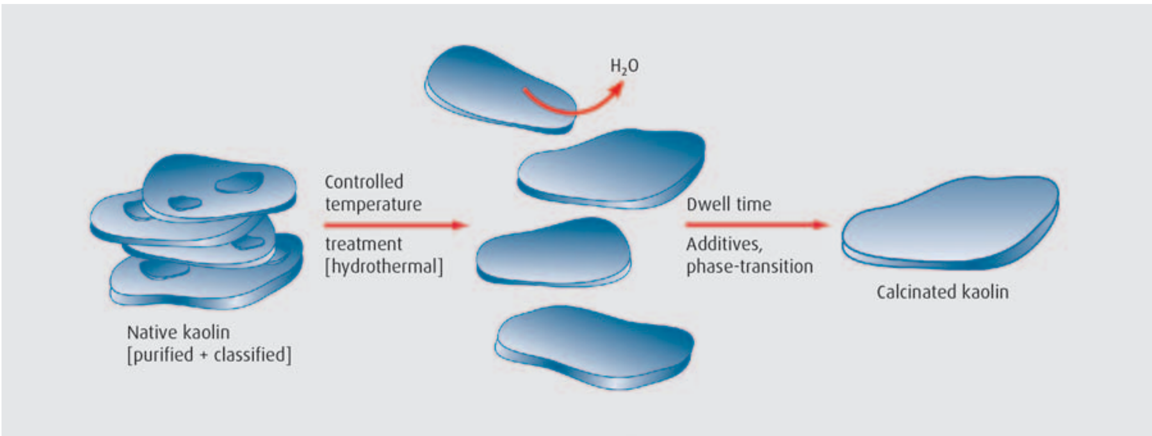

Figure 2: Kaolins that have been calcinated have a homogeneous chemical surface

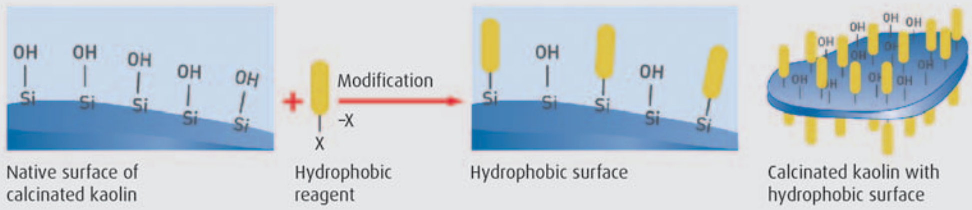

Figure 3: Chemical surface modification of calcinated kaolins with hydrophobic groups

kaolins which have hydrophobic organic groups firmly attached to the surface. They have recently become commercially available. These hydrophobic calcinated kaolins were packed as functional fillers into the filler packages used in standard paint and coatings. The influence they had on the resulting coating and the extent to which they alter the properties of the coating were then observed.

Kaolin and calcinated kaolin - what are they?

Kaolin is a mineral which is extracted from deposits in places like the open-pit mines in the Hirschau Basin of Southern Germany. In chemical terms, pure kaolin (the common name for kaolinite) is an aluminum silicate (*Figure 1a*) with a plate-like structure. Before kaolin can be used as a filler in the paint industry, it has to pass through an elaborate treatment, cleaning and drying process and then has to be fractionated into different grain sizes. In a subsequent refining stage, the native kaolins are calcinated in a kiln at temperatures exceeding 1000 °C and screened again (*Figure 1b* and *2*). The resulting calcinated kaolins are familiar functional fillers and are widely used in filler packages for many top-class dispersion paints to improve the quality of th formulation and help reduce cost [2].

Results at a glance

- ››› Styrene acrylic paints can be upgraded to the level of paints containing silicon resin
- ››› Low-cost alternative to silicon resin and silicon oil additives
- ››› Easy dry effect
- ››› Dirt-repellant exterior wall coating with good anti-fouling protection
- ››› Upgrade of corrosion protection paint
- ››› Reduction of corrosion protection pigment

How are kaolins modified?

Calcinated kaolins have a special property which can be cleverly exploited. They have groups (-Si-OH) on the surface to which organic groups can be coupled using a modification reaction (*Figure 3*). The resulting chemical compounds are covalent and extremely resistant to hydrolytic attack. If the functional groups which are “grafted on” are hydrophobic in nature, the previously polar hydrophilic kaolin grains change polarity during modification and develop water repellant properties. However the surface properties of the hydrophobic kaolins are so equalised that they can easily be blended into any formulation, regardless of whether they are water or solvent borne.

Water management on building exteriors

A common technique for providing rain protection on building exteriors is to blend highly hydrophobic “reinforcement” additives such as silicon resins and silicon oils

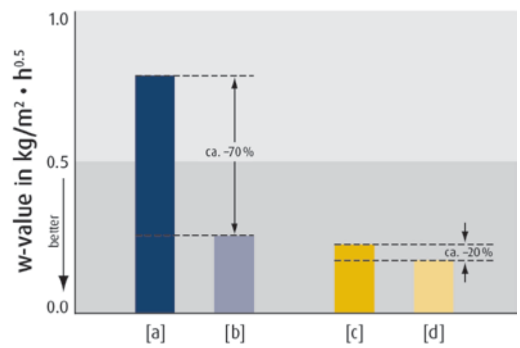

Figure 4: Water absorption by a construction element coated with an acrylate exterior wall paint
(a) without additional additives (benchmark).
(b) reinforced with hydrophobically modified calcinated kaolin.
(c) reinforced with silicone resin.
(d) reinforced with silicon resin and hydrophobically modified calcinated kaolin.

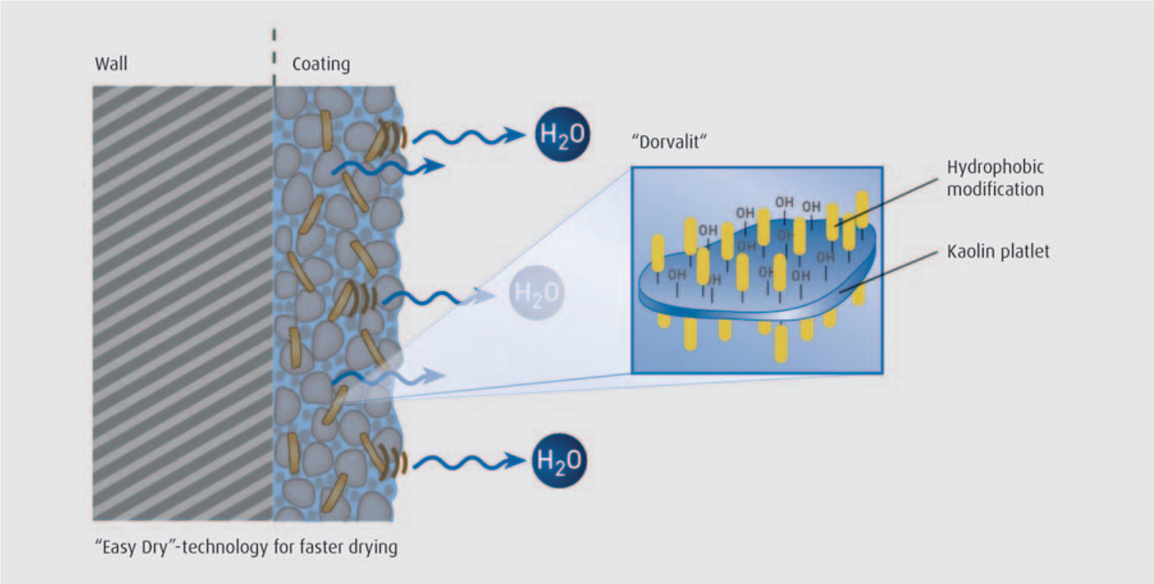

Figure 5: Integration of hydrophobically modified calcinated kaolin in exteriors wall coating and "Easy Dry Technology"

into the exterior wall paint. The objective is to prevent rain water from penetrating into the paint film and the underlying substrate or masonry. However large amounts of silicon resin and oil are needed to achieve the desired effect. There are also the following issues to consider:

» How will the water exit again if the construction element becomes soaked despite the water repellent coating?
» Is it really possible to make wall paint that contains hydrophobic additives so permeable to diffusion that moisture does not accumulate inside the construction element?
» It is a well-known fact that dirt readily accumulates on exterior wall paint which contains silicon resin and silicon oil. How can that be avoided?

To make a comparison with commonly used systems, hydrophobically modified calcinated kaolins were added as fillers to commonly used silicon-free exterior wall paint formulations.

Two metrics were used as indicators of successful water management: dynamic water absorption [2] and mould resistance [3]. A series of trials carried out in collaboration with EPH (Entwicklungs- und Prüflabor Holztechnologie Dresden, a wood technology development and test lab based in Dresden, Germany) produced the following surprising results: all exterior wall paints benefited from the addition of hydrophobically coated calcinated kaolins. At 10 % content in the exterior wall paint, the dynamic water adsorption metric showed approximately 70 %

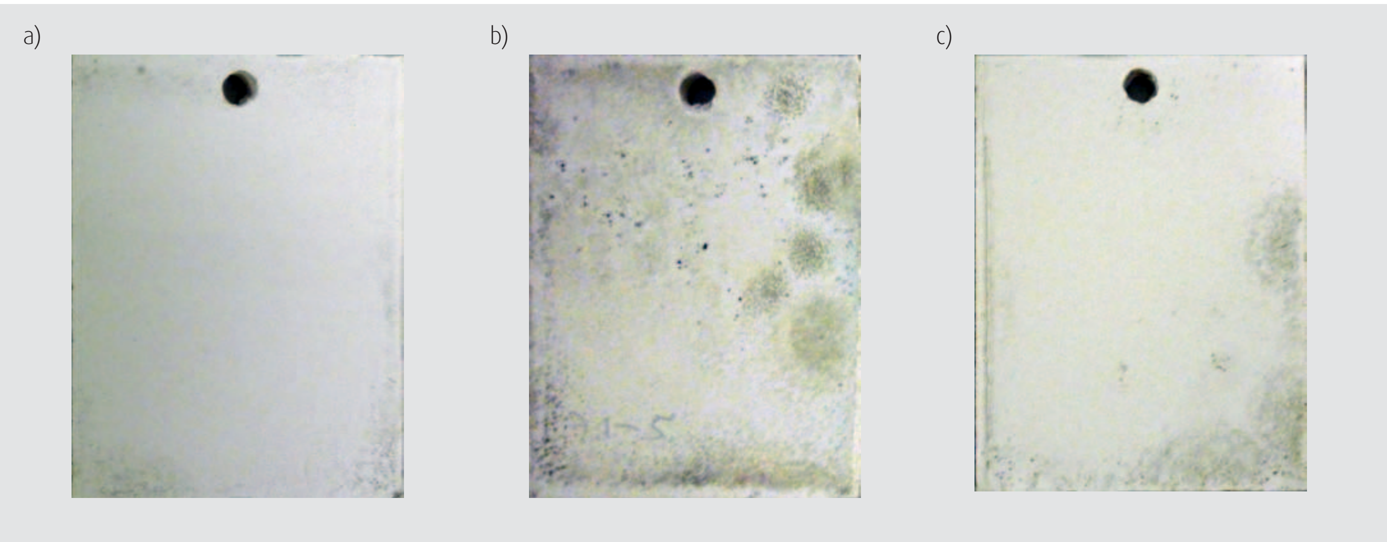

Figure 6: Fouling test with mold (Aspergillus niger) acrylate exterior wall paint with the following additives: (a) 10 % hydrophobically modified calcinated kaolin, infestation mark: 7.5 - slight fouling; (b) 10 % talcum; infestation mark: 2.5 - heavy fouling; (c) silicon resin and 10 % talcum, infestation mark: 7.5 - slight fouling

improvement (*Figure 4*). This demonstrates that hydrophobically coated calcinated kaolins promote drying of exterior walls and effectively counteract the accumulation of water in the interior of a construction element.
It would appear that the statically distributed hydrophobic calcinated kaolin grains in the paint film largely prevent the ingress of water into the film but do not create an impenetrable barrier which could prevent water vapour from escaping (*Figure 5*). Paint coatings containing hydrophobically modified calcinated kaolins are open-pored to a large extent and have a certain similarity with membranes used in outdoor clothing which keep out rain but are permeable to water vapour.
Mould resistance trials provide definite confirmation of these positive findings (*Figure 6*). Exterior wall paint formulated using hydrophobically coated calcinated kaolins shows low susceptibility to mould colonisation. The paint dries quickly and removes the water from the mould spores needed for germination and growth.
It also explains the low fouling rates of 7.5 for exterior wall paint containing hydrophobically coated calcinated kaolins. This is a good result for the first attempt, and further improvement is undoubtedly possible with additional optimisations.
An alternative approach is to upgrade basic dispersion paint to high-grade exterior wall paint by adding hydrophobically modified calcinated kaolins. The hydrophobic filler (10 %) was blended into standard styrene acrylic wall paint and the water absorption was assessed. The results showed very low water absorption, roughly at the same level as exterior wall paint containing silicon resin and silicon oil additives (*Figure 4*). This value-add has attractive qualitative and economic potential. Hydrophobically modified calcinated kaolins give paint manufacturers an economical alternative for enhancing water management in exterior wall paint and increasing performance without significant cost. The paint coatings are well protected against moisture and keep their appearance intact over long periods of time.

Water management for corrosion protection coatings

Products which provide corrosion protection on substrates are applied to high-volume goods, and they are also used in house paint. Besides the decorative aspect, they must prevent corrosion of the substrates on metal surfaces. Pigments which suppress corrosion are often used in corrosion protection coatings in combination with special additives or inhibitors [3]. The list of pigments includes conventional zinc, zinc oxide, zinc phosphate and to an increasing extent zinc-free pigments such as aluminum phosphate and calcium phosphate. The idea is to prevent water from penetrating through the various layers to the iron surface. Plate-like inorganic compounds are blended into the formulations. These compounds stack up in the coating, creating an effective barrier against the flow of water. Talcum and various types of mica are used as “barrier builders” in many corrosion protection coatings.
Modified calcinated kaolins are a new development, and they have been blended into corrosion protection coatings for the first time. A standard acrylate system containing 7 % zinc phosphate as corrosion protection pigment and 11 % “barrier builder” was chosen as the model formulation. These formulations are intended for applications with low to medium corrosion attack and are typical for house paint. The model formulation remained the same throughout the trials. Only the "barrier builders" were changed. Conventional “barrier builders” such as talcum and mica were compared with hydrophobically modified calcinated kaolins. In addition, a commercially available professional corrosion protection coating was

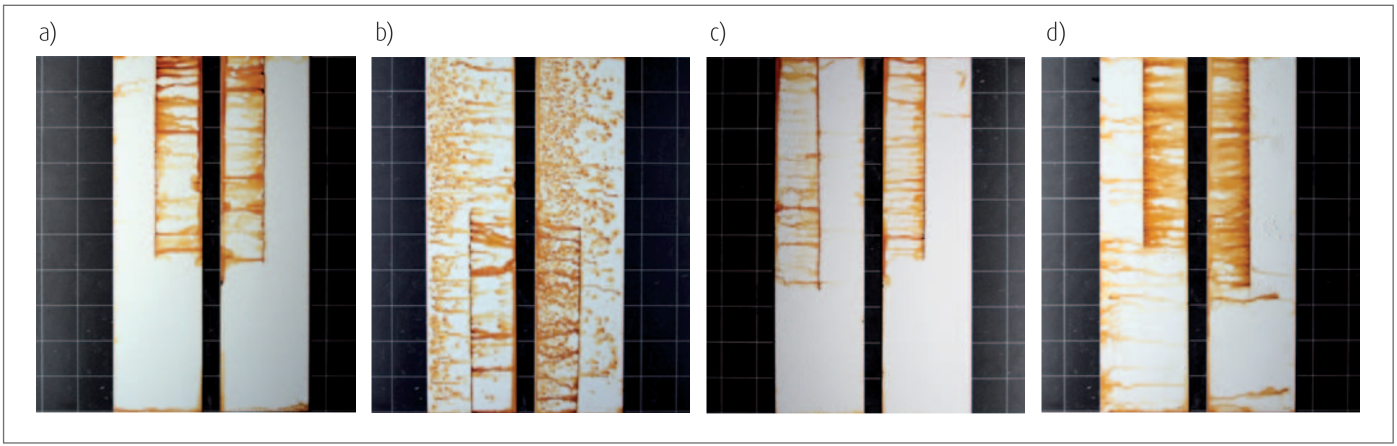

Figure 7: Results of the corrosion tests (salt spray test) of corrosion protection coating containing various "barrier builder:
(a) hydrophobically modified kaolin: no rust or blistering on the surface, slight infiltration at the scribe;
(b) mica: significantly more rust and blistering on the surface, slight infiltration at the scribe;
(c) talcum: heavy blistering on the surface, slight infiltration at the scribe;
(d) commercially available product (benchmark): significant more rust and blistering on the surface, slight infiltration at the scribe

included in the test as a benchmark. In corrosion testing, the model coating samples were applied to standardised pre-treated steel plates and rigorously evaluated criteria in multiple test series conducted by "Technikerschule für Farbe und Gestaltung", Munich [4]. The salt spray test used to evaluate the corrosion resistance of coatings intended for steelwork applications ran for 240 hours. The results were surprising. The coating containing hydrophobically modified calcinated kaolin showed by far the best corrosion protection performance compared to coatings containing talcum and mica as "barrier builders" (*Figure 7a-d*). Even established commercially available corrosion protection coatings showed inferior corrosion protection performance.

Better water management and barriers for stopping corrosion

The results are very encouraging and show the potential benefits of using hydrophobically calcinated kaolins as functional fillers in exterior wall paint. They enhance water management in exterior wall coatings and counteract soaking and waterlogging in construction elements. As a result, they reduce the risk of mould and mildew formation in the interior and especially on the building's exterior surface. They also suppress the growth of algae and moss on the exterior wall, preventing unsightly discolouring. In addition compared to silicon-reinforced formulations, the exteriors are less susceptible to dirt accumulation.

The modified calcinated kaolins which were used appear to have genuine potential to provide efficient water management in formulations for exterior wall paint without the need for silicon resin or silicon oil. The new functional fillers make a significant contribution to reducing the cost of the formulations.

In addition, exterior wall paint containing modified calcinated kaolins as fillers is sustainable and eco-friendly. The hydrophobic grains are immobilised and firmly bound in the paint film. In contrast to additives with hydrophobic action, they cannot migrate in the film nor can they be exuded or washed out, and they help minimise the use of biocides to provide film protection.

The value which hydrophobically modified calcinated kaolin adds to corrosion protection is essentially the result of two functions. The plate-like solids in the coating form the necessary stacks and create a mechanical barrier to keep out the flow of water. In addition, the hydrophobic functions on the surface create an additional physicochemical barrier which repels water. Together, the two effects are very useful because they prevent water which strikes the surface from penetrating into the substrate. As a result, hydrophobically modified calcinated kaolins are a new and attractive alternative which can elegantly and efficiently enhance the anti-corrosion effect in house paint.

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