Influence of Different Binder Types on the Under Different Storage Time

By Simon Aben, Jörg Rüger, and Mark Coward, Clariant

Biocides, especially isothiazolinones, can often trigger allergic reactions, which, in recent years, has driven the demand for water-based, biocide-free paints for interior and exterior areas, as well as regulation. Silicate paints are an alternative, as they use liquid glass (i.e., liquid potassium silicate), rather than biocides, as a mineral/inorganic binder to adjust the paint pH so that bacteria growth is inhibited. To support paints and coatings formulators in their binder decision-making, we investigate the influence of binder choice on the wet scrub resistance of organosilicate paint (a silicate paint with a binder modification of more than 5%, which shows good adhesion to a variety of substrates) under various storage conditions, comparing four vinyl acetate ethylene (VAE) binders against each other and against the performance of several styrene acrylate binders.

Silicate Paints for Architecture

There are three categories of silicate paints. First, those that do not have an organic component and that typically contain 10–30% potassium silicate; these are historically used in buildings for beauty and protection. Second, standard silicate paints that have less than 5% organic content and a similar level of potassium silicate. These can be used in interior and exterior applications and adhere to a wider range of substrates. Finally, there are organosilicate paints with a binder modification of more than 5% and a lower level of potassium silicate. To enable the handling and suitability of these mineral paints for a wide variety of applications, organic binders are added to the paints as a complement to the liquid glass. These can also be used indoors and outdoors and show good adhesion to a variety of substrates.

Binders for High-pH Systems

A recognized disadvantage of biocide-free paints containing liquid glass is that, due to their rheological behavior, they can be difficult to formulate and apply using a paint roller or a brush application. Here, the choice of the binder is crucial. It should have a compatibility with liquid glass/resistance to high-pH conditions, otherwise stability issues and loss of performance such as a lower wet scrub resistance will most likely be observed.

While styrene acrylate binders are often used in organosilicate paints, the performance of other types of binders, such as vinyl acetate ethylene (VAE) binders, is often discussed in the industry since these tend to saponify due to the high-pH conditions.

To better understand this effect, in the following study, we investigate the performance of four VAE binders with different chemistries and physical properties. As well as comparing the performance between the four VAE binders, within this study the performance of styrene acrylate binders in a similar organosilicate paint system is presented as a comparison to VAE binders.

We chose wet scrub resistance as a parameter for the study because a significant increase in coating layer thickness loss after wet scrubbing is a clear indicator demonstrating that a binder has saponified. Wet scrub resistance is also a highly valued paint feature serving as a major selection criterion for interior paints for the DIY customer.

Results at a Glance

The use of VAE and styrene acrylate binders for silicate-based paint systems has been proven feasible. Both binder types show major differences in quality with regard to wet scrub resistance. Good performance can be achieved with selected raw materials in biocide-free organosilicate paint systems.

The following recipes were used to prepare the organosilicate paints containing the VAE binders **(Table 1)** and the styrene acrylate binders **(Table 2).** The paints were prepared using a Dispermat CN 10 dissolver from VMA Getzmann company.

Wet Scrub Resistance of Organosilicate Paints and Temperature Conditions

TABLE 1
Organosilicate VAE Recipe

VOC/SVOC < 1,0 g/L
WPS: 47,5 %
PVC: 25-30%

Ingredients	Dosage
Water	20.00%
Polyurethane thickener	0.30%
Cellulose thickener	0.08%
Dispersing agent and stabilizer Dispersogen SP Plus	**0.30%**
Defoamer	0.40%
Open time extender Emulsogen LCN 287	**2.00%**
TiO_2 Rutile titanium dioxide	17.50%
Talc d50 % = 10µm	5.00%
Calcium carbonate (GCC) d50 % = 1-5µm	27%
VAE binder	**16.70 – 17.00%**
Polyurethane thickener	0.50%
Alkali solution (10%)	100%
Potassium silicate solution (28%)	3.50%
Defoamer	0.15%
Water	5.57 – 5.27%*

* for binder active content compensation

TABLE 2
Organosilicate Styrene Acrylate Recipe

VOC/SVOC < 1,0 g/L
WPS: 61,0 %
PVC: 60-65%

Ingredients	Dosage
Water	15.00%
Polyurethane thickener	0.30%
Dispersing agent & stabilizer Dispersogen SP Plus	**0.50%**
Defoamer	0.40%
Open time extender Emulsogen LCN 287	1.00%
Rutile titanium dioxide	17.50%
Talc d50 % = 10µm	5.00%
Calcium carbonate (GCC) d50 % = 1-5µm	25.5%
Styrene acrylate binder	**12.00 – 12.20%**
Potassium silicate solution (28%)	8.00%
Defoamer	0.15%
Water	14.65 – 14.45%*

* for binder active content compensation

Wet Scrub Resistance of Organosilicate Paints

All the binders used in this study are commercial binders and their physical and chemical properties are listed in the following tables. To make **Table 3** easier to review, the VAE binders (Binders 1-4) are highlighted in yellow and the styrene acrylate binders (Binders 5-10) are highlighted in pink.

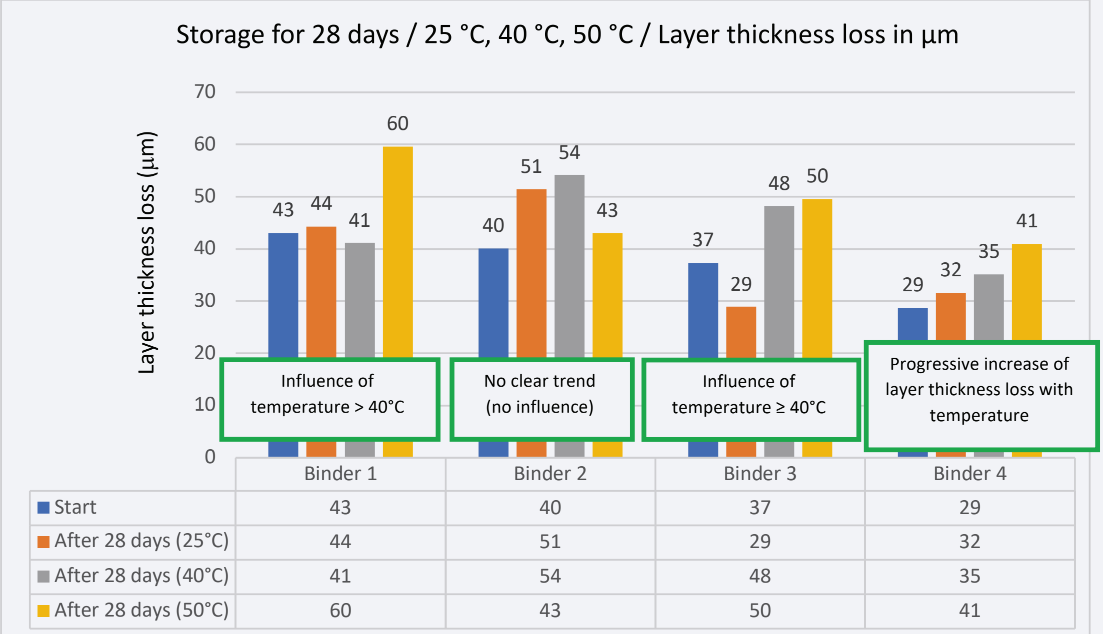
Testing at different conditions

All the formulations and tests described in the frame of this study were carried out by the same person on the same equipment, using raw materials and consumables, to limit the influence of external factors on the results. In order to study the effect of the storage condition on the performance of the binder, all the paints were split and stored at various temperatures: room temperature 25 °C, 40 °C, and 50 °C. Samples were then taken out of each of the stored paints at different storage times in order to perform wet scrub resistance

TABLE 3
List of VAE and Styrene Acrylate Binders

Binder Name	Chemical structure	MFT	Particle size distribution	T_g	Solid content	pH	Viscosity (Brookfield)	Density
Binder 1	Copolymer dispersion based on vinyl acetate, vinyl esters, and ethylene	0 °C	100 – 550 nm	-3 °C	50%	6.0 – 8.0	100 – 1500 mPa.s	1.03 g/cm³
Binder 2	Polymer dispersion based on vinyl ester, ethylene, and acrylic acid ester	3 °C	200 nm	3 °C	52 – 54%	7.5 – 85	1000 – 6000 mPa.s	1.07 g/cm³
Binder 3	Dispersion of a vinyl acetate, ethylene, and vinyl ester terpolymer	2 °C	300 nm	n.a.	49 – 51%	4.5 – 5.5	2100 – 3900 mPa.s	1.05 g/cm³
Binder 4	Dispersion of a terpolymer of vinyl acetate, ethylene, and vinyl chloride	2 °C	700 nm	n.a.	49 – 51%	4 – 5	6000 – 12000 mPa.s	1.09 g/cm³
Binder 5	Aqueous dispersion of a styrene acrylic copolymer	3 °C	0.15 µm	n.a.	50%	6 – 7.5	70 – 400 mPa.s	1.03 g/cm³
Binder 6	Aqueous polymer dispersion based on styrene and an acrylic acid ester	1 °C	0.13 µm	3 °C	50%	8	1000 – 4000 mPa.s	1.03 g/cm³
Binder 7	Copolymer dispersion of styrene and acrylic acid esters	0 °C	0.10 µm	1 °C	49 – 51%	9 – 9.5	1500 – 2500 mPa.s	1.06 g/cm³
Binder 8	Acrylate-styrol-copolymer dispersion	0 °C	013 µm	6 °C	47 – 49%	8 – 9	500 – 2000 mPa.s	1.05 g/cm³
Binder 9	Aqueous dispersion of a styrene acrylic copolymer	5 °C	0.17 µm	n.a.	49 – 51%	6.5 – 7.5	20 – 100 mPa.s	1.03 g/cm³
Binder 10	Styrene acrylate dispersion	4 °C	0.1 µm	6 °C	50%	8.5	100 mPa.s	1.04 g/cm³

FIGURE 1
Scrub resistance after 28 days.



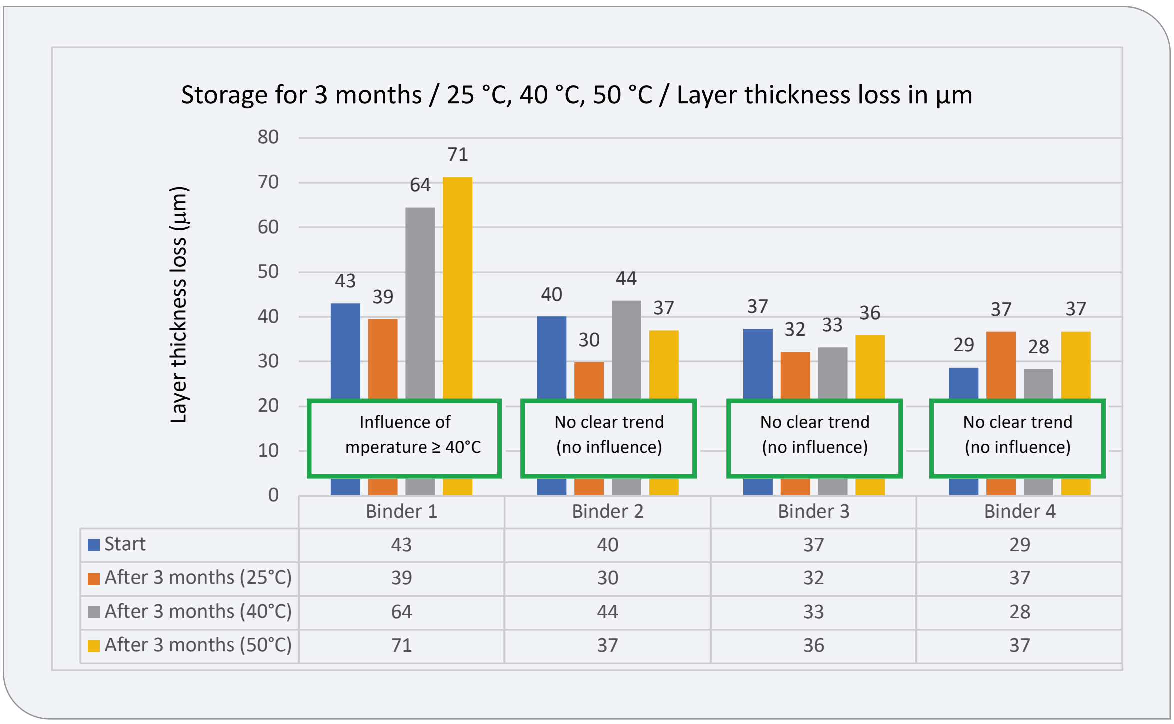
	Binder 1	Binder 2	Binder 3	Binder 4
Start	43	40	37	29
After 28 days (25°C)	44	51	29	32
After 28 days (40°C)	41	54	48	35
After 28 days (50°C)	60	43	50	41

tests, according to ISO DIN EN 13300. Wet scrub resistance tests were performed with PVC cards (following DIN 53778) and an abrasion and scrub resistance tester (Erichsen washability and scrub tester model 494) while using 2,5g/L Hostapur SAS 60 (Clariant) as a washing solution.

Interpretation of results

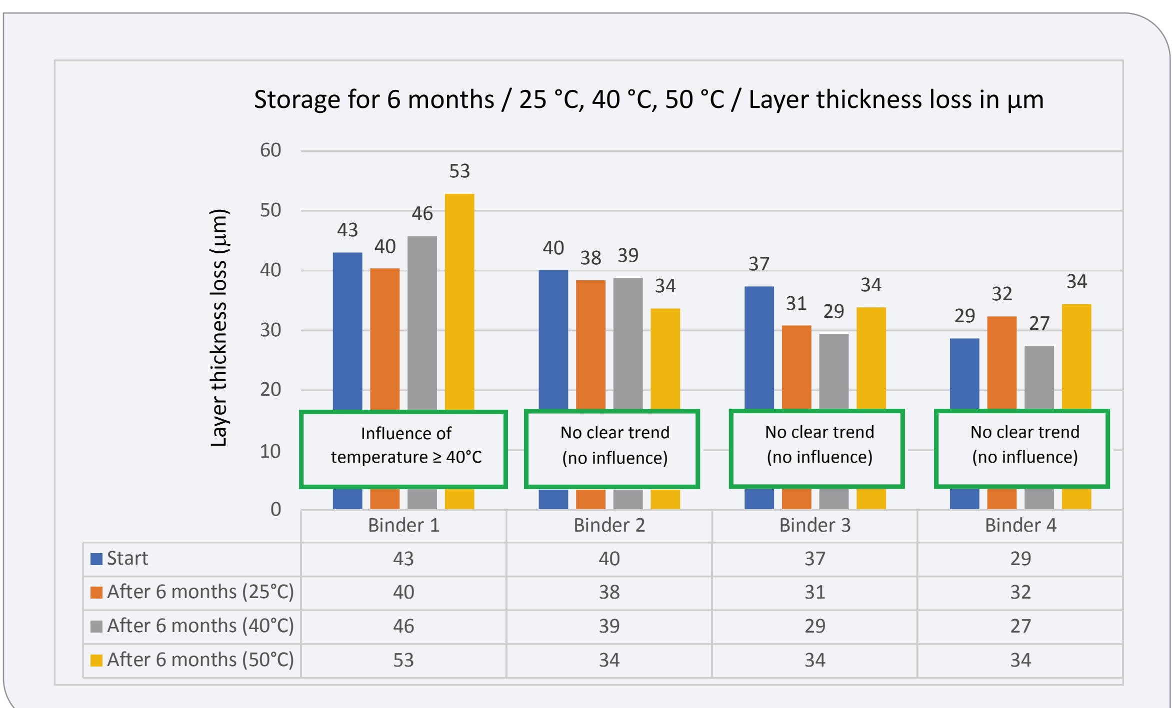
The results of the wet scrub resistance (WSR) of the paints associated with the four VAE binders are presented at different storage times: 28 days **(Figure 1)**, 3 months **(Figure 2)**, and 6 months **(Figure 3)**, whereby the loss in layer thickness after wet scrubbing is presented for 3 different temperatures being 25 °C, 40 °C, and 50 °C. In addition, the result of the WSR after sample preparation and 3 days' storage at room temperature, is depicted as "Start" in each graph.

FIGURE 2
Scrub resistance after 3 months.



	Binder 1	Binder 2	Binder 3	Binder 4
Start	43	40	37	29
After 3 months (25°C)	39	30	32	37
After 3 months (40°C)	64	44	33	28
After 3 months (50°C)	71	37	36	37

FIGURE 3
Scrub resistance after 6 months.



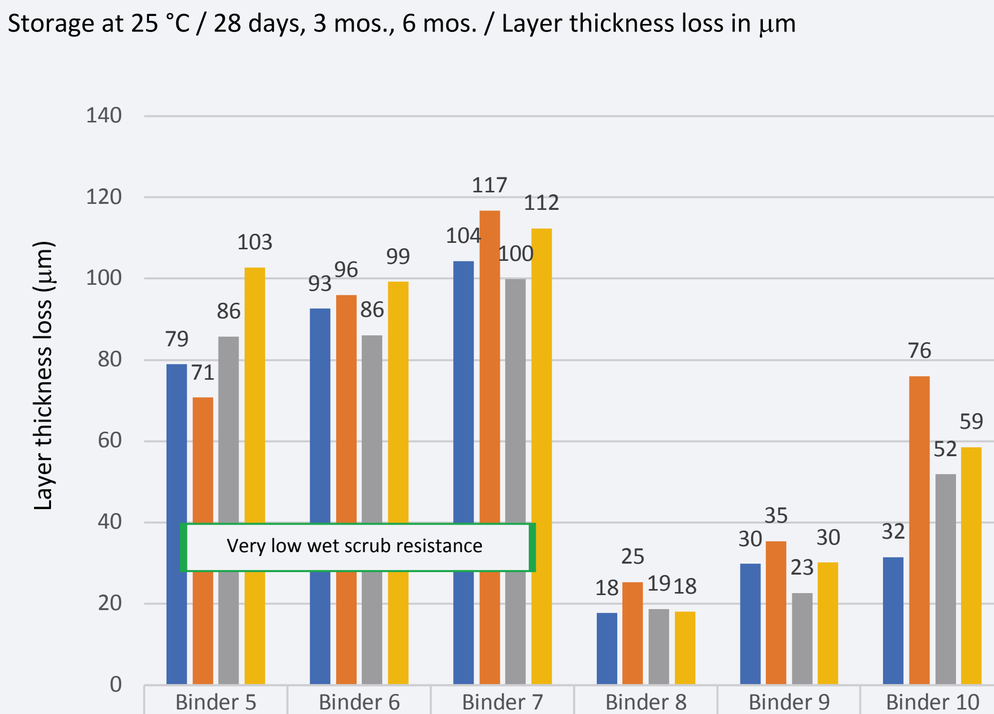
	Binder 1	Binder 2	Binder 3	Binder 4
Start	43	40	37	29
After 6 months (25°C)	40	38	31	32
After 6 months (40°C)	46	39	29	27
After 6 months (50°C)	53	34	34	34

As illustrated in **Figure 1**, which shows the results after 28 days of storage, we observed no clear rule in the loss of layer thickness with temperature. For the paint with Binder 1, it seems that the layer thickness loss is constant at 25 °C and 40 °C and strongly increased at 50 °C, while the same effect is seen for Binder 3 starting already at 40 °C instead of 50 °C. Interestingly, we see a progressive increase of the layer thickness loss with temperature for Binder 4 while no clear trend can be seen for Binder 2.

After 3 months **(Figure 2)** and 6 months **(Figure 3)** of storage, it is observed that the loss of layer thickness is quite constant and shows no influence of the temperature for the paints containing Binders 2, 3, and 4. It is difficult to see trends here and to differentiate which binder performs the best; generally speaking, Binder 4 appears to have the lowest thickness-loss values with less variation over time.

In order to observe if these trends and differences are also seen for another binder, e.g., styrene acrylate, we performed the same experiment with six

FIGURE 4
Wet scrub effect after defined time intervals.



	Binder 5	Binder 6	Binder 7	Binder 8	Binder 9	Binder 10
Start	79	93	104	18	30	32
After 28 days (25°C)	71	96	117	25	35	76
After 3 months (25°C)	86	86	100	19	23	52
After 6 months (25°C)	103	99	112	18	30	59

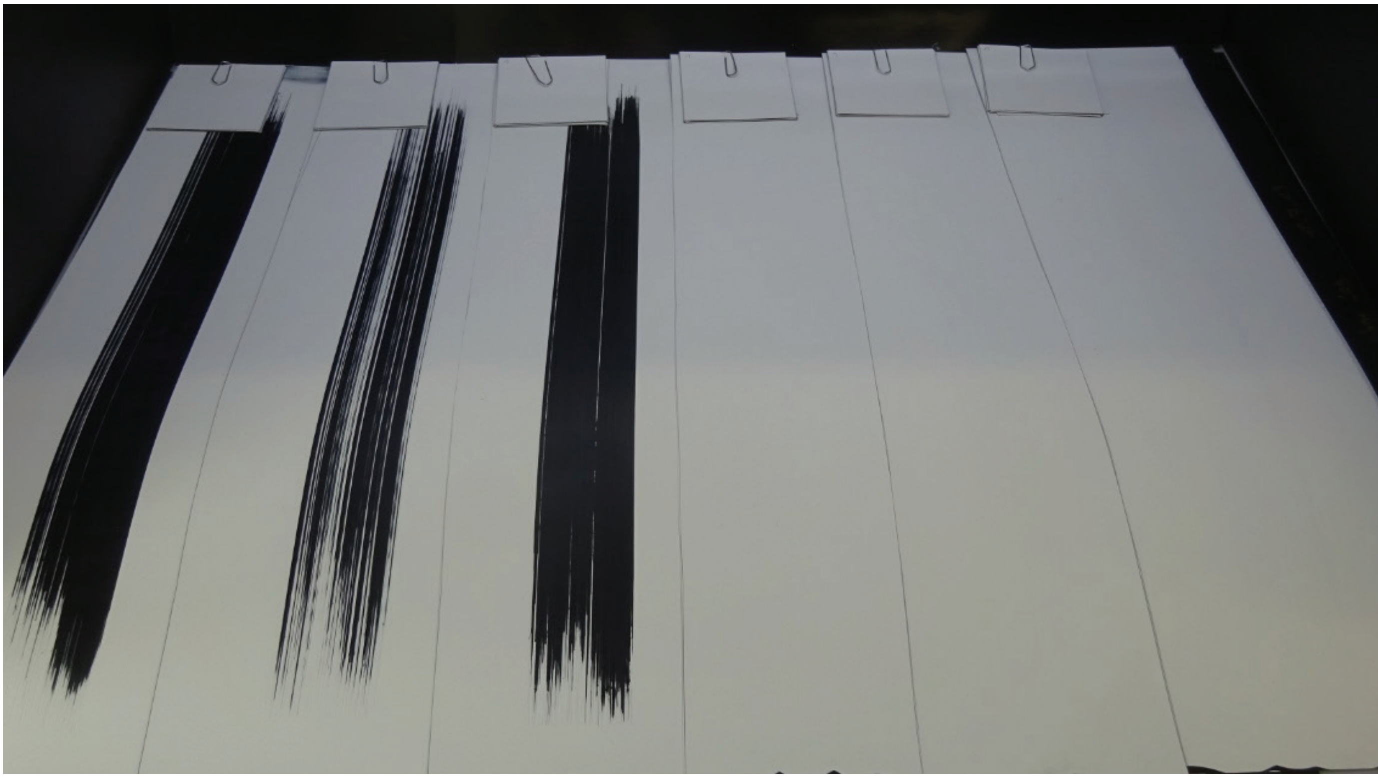
further styrene acrylate binders in another organosilicate paint system with reduced binder content. See **Figure 4.**

Interestingly, strong differences in the performances are recorded. It is clear to see that Binders 5, 6, 7, and 10 are not so well suited for the paint formulations, whereas Binders 8 and 9 are much more resistant and show limited layer thickness loss.

As seen in **Figure 5,** the PVC cards of the applied “Start paints” contain styrene acrylate binders, respectively, from left to right, Binders 5, 6, 7, 8, 9, and 10. The black background is visible when a bad wet scrub resistance is observed.

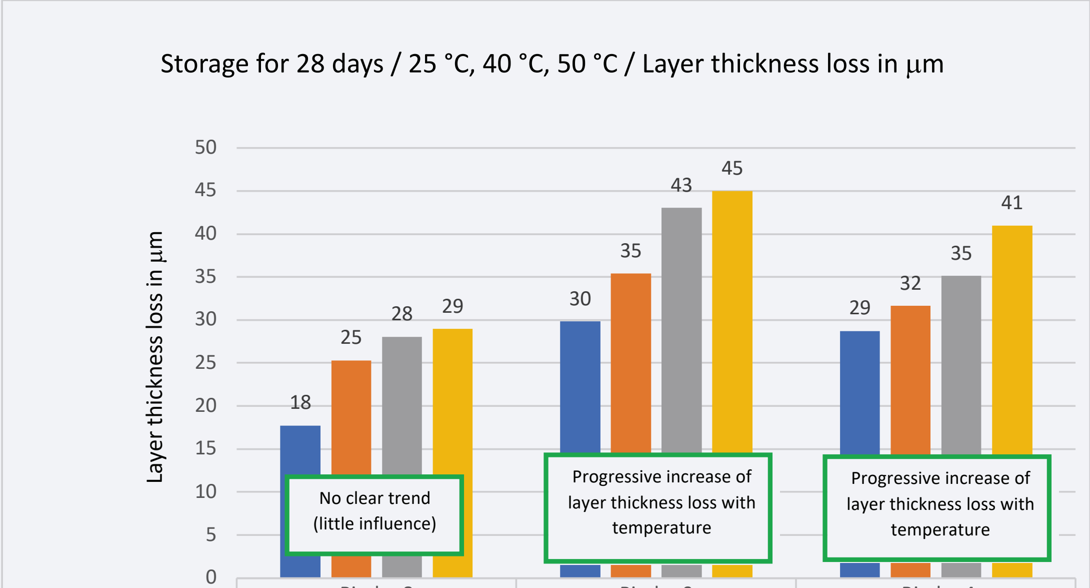
To better see differences in storage stability and the influence of the temperature on the loss in layer thickness, we will focus only on Binder 8 and Binder 9 in the next graphics, compared with the VAE Binder 4. The results of the wet scrub resistance of the paints associated with Binders 4, 8, and 9 are then presented at different storage times, being 28 days **(Figure 6),** 3 months **(Figure 7)**, and 6 months **(Figure 8),** whereby the loss in layer thickness after wet scrubbing is presented for

FIGURE 5
Start paints after 200 scrub cycles.



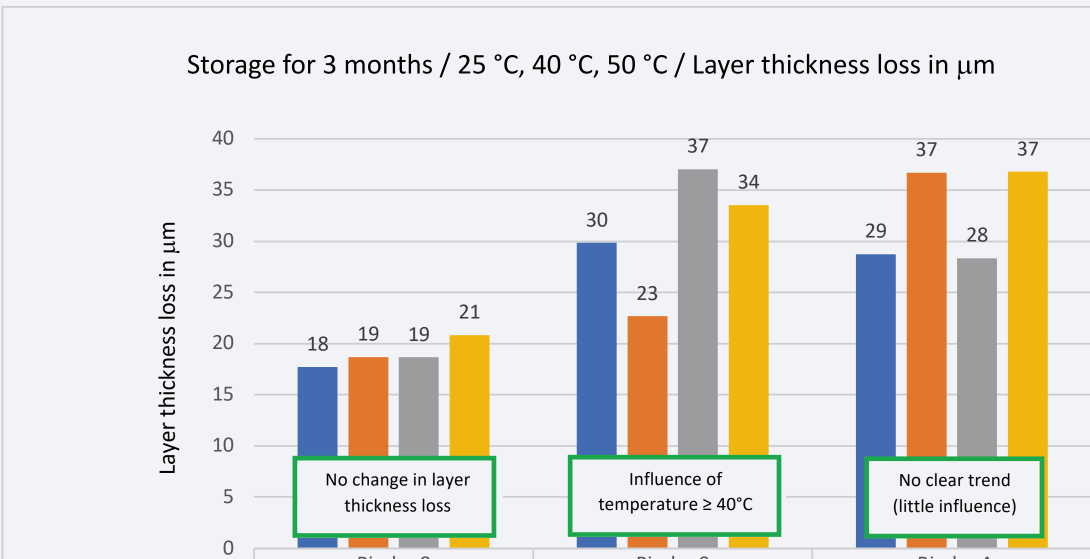
Good performance can be achieved with selected raw materials in biocide-free organosilicate paint systems.

FIGURE 6
Wet scrub resistance after 28 days.



	Binder 8	Binder 9	Binder 4
Start	18	30	29
After 28 days (25°C)	25	35	32
After 28 days (40°C)	28	43	35
After 28 days (50°C)	29	45	41

FIGURE 7
Wet scrub resistance after 3 months.



	Binder 8	Binder 9	Binder 4
Start	18	30	29
After 3 months (25°C)	19	23	37
After 3 months (40°C)	19	37	28
After 3 months (50°C)	21	34	37

3 different temperatures being 25 °C, 40 °C, and 50 °C. In addition, the result of the wet scrub resistance after paint preparation is also added to each graph.

It is noticeable from **Figure 6** that Binder 8 has the lowest loss of layer thickness while showing very little dependency on the temperature, contrary to the paints with Binders 9 and 4, where we observe a progressive increase of the layer thickness loss with increasing temperature.

In **Figure 7**, we observe an increase of the layer thickness loss for the paint with Binder 9 above 40 °C, while no clear correlation between temperature and layer thickness loss after 3 months of storage was observed for the paint containing Binder 4. On the contrary, it seems that after 3 months' storage the layer thickness loss for the paint with Binder 8 is constant and independent of the storage temperature.

In **Figure 8,** it is now the paints containing Binders 9 and 4 that show no dependence between temperature and layer thickness loss after 6 months of storage, while a progressive increase of the loss in layer thickness with temperature can be seen for the paint containing Binder 8.

For the series of styrene acrylate binders, we clearly see differences in the performance of the different binders but, as for the series with the VAE binders, it is difficult to see any trends in the influence of temperature and storage condition. Interestingly and using a similar organosilicate paint system, we observe that the VAE Binder 4 has very similar performance and wet scrub resistance to binders from styrene acrylate types. It is also difficult from the chemical and physical data of the binders given in **Tables 1** and **2** to find a link with the performance, especially because the full chemical structure is not given.

VAE and Styrene Acrylate Binder Suitability

In this work, we have evaluated the loss in wet scrub resistance over various storage temperatures and storage time for binders made of VAE and styrene acrylate. It is very difficult to see a clear trend in the loss of layer thickness with increased temperature and storage time for both kinds of binders. Nevertheless, it was possible to show that VAE binders, which are advertised on the market as high-pH-stable types, display excellent wet scrub resistance, including after 6 months of storage at 50 °C.

This work aims to demonstrate that VAE binders could also be suitable for high-pH paints, delivering the same performance as with styrene acrylate binders. For modern paints to meet formulation, regulatory, and consumer requirements and expectations, consideration must be given to compliance with environmental labels, for example, as well as price competitiveness, ingredient-interaction control, and performance properties. Particularly for decorative interior wall and ceiling paints, the key domain of organosilicate paints, the emphasis toward improving indoor air quality and environmental protection is increasing demand for low-odor, low-VOC, durable products without compromising quality. ❊

Simon Aben, Ph.D., is a global launch manager, Global Marketing Industrial Applications, Business Unit Care Chemicals, at Clariant. Email: simon.aben@clariant.com.

FIGURE 8
West scrub resistance after 6 months.