Facade emulsion paints:

Silfit Z 91

vs. precipitated Na/Al silicate

Author: Bodo Essen
Hubert Oggermüller

VM-1/0715/09.2019

HOFFMANN MINERAL GmbH • Muenchener Strasse 75 • D-86633 Neuburg (Donau) • Phone +49 (0) 8431 53-0
www.hoffmann-mineral.com • e-mail: info@hoffmann-mineral.com

Contents

1 Introduction

An outstanding performance profile as well as high resistance properties and functionality are essential characteristics of modern dispersion-based facade paints. As decorative coating systems, they contain mostly a relatively high portion of titanium dioxide which, however, as energy and cost intensive filler suffers from increasingly strong variations concerning price and demand, and, therefore, decidedly determines the cost structure of a given façade paint.

As a consequence, recently more often a partial replacement of the white pigment by a suitable mineral TiO_2 extender is desired. Representatives for this class frequently are light-colored fine precipitated calcium carbonates, silicates or also calcined clays.
The basic requirement refers to at least comparable performance properties of the coatings, in order to offer an attractive combination of price related and technical advantages.

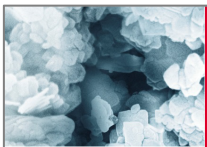
The objective of the present study is an evaluation of the performance profile of calcined Neuburg Siliceous Earth Silfit Z 91 as a TiO_2 extender in comparison with precipitated sodium aluminum silicate in a facade emulsion paint.

The main properties looked at concerned optical criteria such as color neutrality and brightness as well as hiding power and formulation costs as an index for efficiency and cost effectiveness. Other relevant aspects such as processing properties, wet-scrub resistance and effects involving the humidity balance will be taken into account by accompanying tests.

2 Experimental

2.1 Base formulation

The base of the evaluations is a European market approved formulation for a matted facade paint based on a styrene-acrylate dispersion from BASF (*Fig. 1*). Aside from a classical filler combination of predominantly carbonate materials and a smaller part of lamellar talc, pigmentation relies on 190 pbw of a surface treated rutil-type titanium dioxide. The TiO_2 extender is added in various concentrations.



Base Formulation

HOFFMANN MINERAL

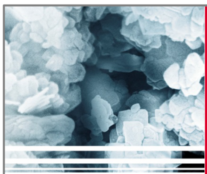
		Parts by weight
Water deionized	-	180
Natrosol 250 HR	Thickener	2
Ammonia, conc. 25 %	Neutralising agent	2
Dispex AA 4030	Dispersing additive	2
Calgon N New, 10 % in water	Wetting- / Dispersing	3
Parmetol MBX	Can preservation	2
Foamaster MO 2134	Defoamer	2
Propylene glycol : Butyl diglycol : Texanol = 1 : 1 : 1	Cosolvent	30
Kronos 2190	TiO_2 Pigment	**190**
TiO_2-Extender		**varied X**
Omyacarb 5 GU	Filler	220
Finntalc M 15	Filler	50
Acronal S 790 (Styrene acrylic)	Emulsion Binder	320
Foamaster MO 2134	Defoamer	3
Acticide MKB 3	Film preservation	10
Rheovis PE 1330	Thickener	12
Water deionized	-	12
Total		**1040 + X**

VM-1/0215/09.2019

Fig. 1

2.2 Formulation variations

Fig. 2 offers a summary of the added concentrations of the TiO_2 extenders concerned, at first with the regular content of white pigment. In the further variants, the portion of titanium dioxide is reduced by 10 to 20 %. Following the recommendations of the producer, the sodium aluminum silicate was introduced into the control formulation at the usual loading of up to 40 pbw. Silfit Z 91 was used in comparable or also higher amounts, in order to take into account the differences in the typical particulate properties. In relation with higher additions the solids content and the PVC go up to increased levels.



INTRODUCTION

EXPERIMENTAL

RESULTS

SUMMARY

HOFFMANN MINERAL

Formulation Variations

Variation of the Pigment / TiO_2-Extender package
All other formulation ingredients remain unchanged

	Control, without TiO_2-Extender	with TiO_2-Extender										
		Full TiO_2					- 10 % TiO_2				- 20 % TiO_2
TiO_2	190	190					171				152
Na/Al Silicate	---	20	40	---	---	---	20	40	---	---	---
Silfit Z 91	---	---	---	20	40	60	---	---	60	98	98
Solids content w/w [%]	61.0	61.8	62.5	61.8	62.5	63.1	61.1	61.8	62.5	63.8	63.2
PVC [%]	49.6	51.2	52.7	50.9	52.1	53.3	50.5	52.0	52.6	54.8	54.2

VM-1/0215/09.2019

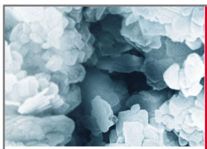
Fig. 2

2.3 Characteristics of TiO_2 Extenders

The Neuburg Siliceous Earth, as exploited close to Neuburg-on-the-Danube, is a naturally formed mixture of corpuscular Neuburg silica with lamellar kaolinite: a loose conglomerate which cannot be separated by physical means. The silica portion because of its natural formation shows a rounded grain shape and consists of aggregated cryptocrystalline primary particles about 200 nm diameter.

The calcination of the Neuburg Siliceous Earth into Silfit Z 91 splits off the crystal water of the kaolinite portion under formation of new, largely amorphous mineral phases. The silica part under the temperatures applied remains unchanged. Via an integrated air classifier process, grain sizes > 15 µm are eliminated.

In comparison with Silfit Z 91, the precipitated sodium aluminum silicate, as shown in *Fig. 3*, offers a coarser grain size distribution along with a markedly higher specific surface area and oil absorption. The density is lower than with the calcined Neuburg Siliceous Earth. Both TiO_2 extenders in powder form along with very good color neutrality are characterized by high brightness values, while Silfit Z 91 does not attain the particularly high L* level of the precipitated silicate.



INTRODUCTION

EXPERIMENTAL

RESULTS

SUMMARY

TiO2-Extender

HOFFMANN MINERAL

	Particle size		Oil absorption	Density	Specific Surface BET	Color		
	d_{50} [µm]	d_{97} [µm]	[g/100g]	[g/cm³]	[m²/g]	L*	a *	b*
Precipitated Na/Al Silicate	5.0	18	140	2.1	95	98.9	- 0.1	0.6
Silfit Z 91	2.0	10	55	2.6	8	95.5	- 0.1	0.7
Other Fillers in Formulation (for comparison only)								
Omyacarb 5 GU	5.5	26	16	2.7	2	96.0	- 0.2	0.7
Finntalc M 15	4.5	17	41	2.8	6	92.8	- 0.5	1.1

VM-1/0215/09.2019

Fig. 3

2.4 Preparation of batches, application and testing

The preparation of the batches followed the sequence of the raw materials indicated in the pertinent formulation and was carried out in a laboratory dissolver equipped with a toothed disc under cooling with water. Pigment, TiO_2 extender and fillers were pre-mixed and, after adding to the mixer, dispersed for 20 min with a peripheral speed of 15 m/s. After adding the binder and the other additives, a maturing time of 12 h was observed. The coatings were applied undiluted and usually per doctor blade with an automated applicator. The drying and conditioning of the paint films as well as the tests after 28 days of storage were done in an air-conditioned laboratory at 23 °C and 50 % relative humidity. Detailed information is given in *Figs. 4* and *5*.

INTRODUCTION
EXPERIMENTAL
RESULTS
SUMMARY

Testing

HOFFMANN MINERAL

Paint Preparation	
Filler incorporation Foam formation	Subjective assessment during preparation
Wet Paint	
Fineness of grind	Grindometer 0 – 50 µm
Viscosity	1d after preparation, Rheometer 23°C, Searle system
Storage stability	Undiluted in 1l-metal can, 6 months 23°C
Application with doctor blade gap 300 µm on Leneta film Dry film thickness (DFT) ~ 70 µm	
Wet-scrub resistance	200 Cycles on automated wet-scrub resistance tester according to ISO 11998. Classification along with DIN EN 13300

VM-1/0215/09.2019

Fig. 4

INTRODUCTION
EXPERIMENTAL
RESULTS
SUMMARY

Testing

HOFFMANN MINERAL

Application 400 ml in total equal to 2 coats with 5 m²/l each, DFT ~ 180 µm	
Liquid Water Permeability W	Priming + 2 coats brush-applied on sand lime bricks Testing according to DIN EN 1062-3 Classification along with DIN EN 1062-1
Water-Vapor Transmission Rate V	2 coats brush-applied on filter paper grade 1575 Testing according DIN EN ISO 7783, wet-cup method; classification along with DIN EN 1062-1
Application: gap 100 - 400 µm gradually with doctor blade on Cardboard	
Color / Gloss	L*, a*, b* over white, 85°-Gloss (Sheen) at full hiding film with DFT 120 µm
Hiding Power	Contrast ratio over black/white depending on dry film thickness. Calculation of minimum dry film thickness to comply with DIN EN 13300 classifications and resulting spreading rates, contrast ratio at given spreading rate respectively

back

VM-1/0215/09.2019

Fig. 5

3 Results

3.1 Processing properties and storage stability

In the aqueous medium with its good dispersion characteristics for Neuburg Siliceous Earth, Silfit Z 91 enjoys an equally rapid and good incorporation in comparison with the other variants with precipitated Na/Al silicate. According to grindometer tests, the grain size of the complete facade paints is in the region of 25 µm.

The resulting rheology profile is characterized by the strong shear thinning typical for facade paints. The markedly reduced viscosity of 0.3 to 0.4 Pas under high shear load (1000 s-1) reflects the easy processing and spreadability. High viscosity levels of 40 to 60 Pas at low shear (0.1 s-1) indicate low run-off tendency after application and allow to apply the high film layer thicknesses required for good hiding power and sufficient weather resistance.

All formulations after 6 months give evidence of excellent storage stability without signs of phase separation or sedimentation.

3.2 Wet-scrub resistance

The very good properties with respect to mechanical resistance put all formulations into the region of the best class for wet-scrub resistance.

With precipitated Na/Al silicate, a slight tendency towards lower resistance levels can be observed, in particular with higher loadings (*Fig. 6*). By contrast, when working with Silfit Z 91 the high level of the control formulation is maintained even with reduced TiO_2 additions and high loadings.

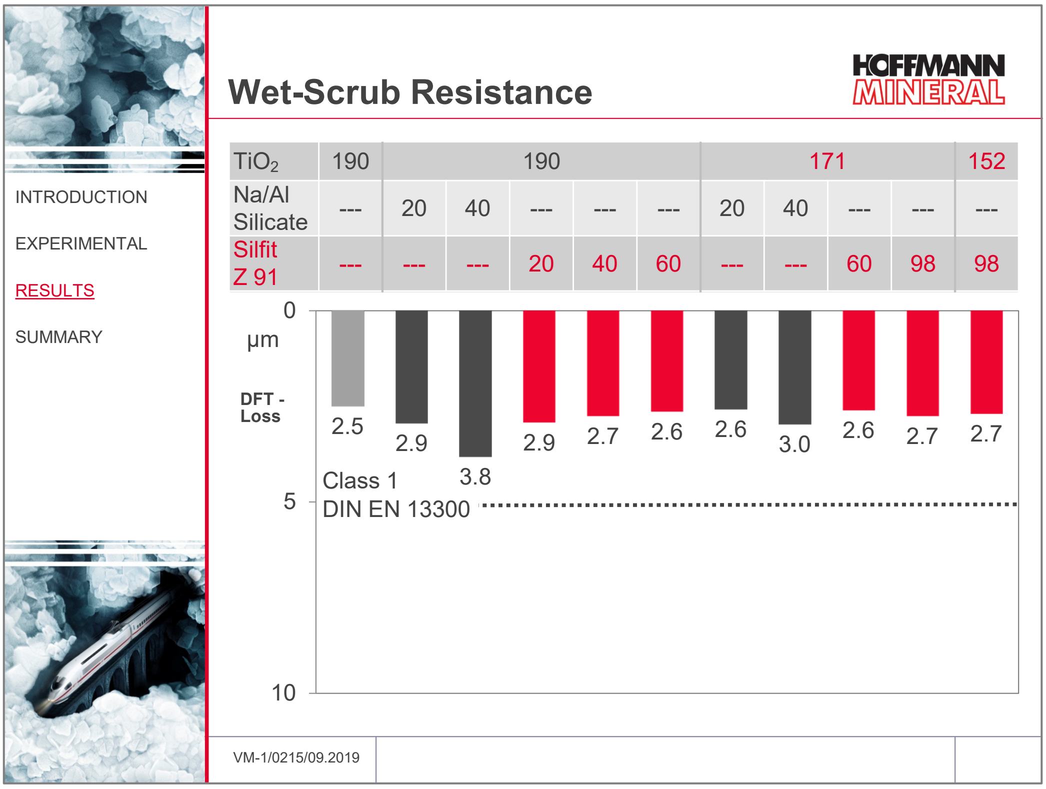


Fig. 6

3.3 Liquid water permeability

For the evaluation of the water permeability of the facade paints, the capillary water uptake of a lime-sand brick coated with the formulation variant to be tested was determined gravimetrically after 24 h of immersion. This internationally standardized test method close to reality gives concern to the normally suction determined properties of the underground, which further tend to increase the water uptake. The transport of the water here is realized from the outside across the facade paint coating which in the quality of an intermediate layer should offer the best barrier effect possible.

All formulation variants with a very low water permeability of 0.020 to 0.026 $kg/(m^2 * h^{0.5})$ lead to comparable results within the best class W3 (low) of DIN EN 1062-1, which means they are to be classified as highly water repellent.

3.4 Water vapor permeability

After applying the formulation to be tested in two layers onto filter paper, drying and conditioning, the coated paper is bonded to a dish with saturated aqueous ammonium dihydrogen phosphate solution. The defined high humidity generated in the test chamber causes a diffusion of water vapor across the coating into the surrounding air (23 °C, 50 % relative humidity), and the total weight of the dish goes down with time correspondingly. The results are expressed as “water vapor transmission rate V”, i.e. as weight loss in grams per m^2 per day.

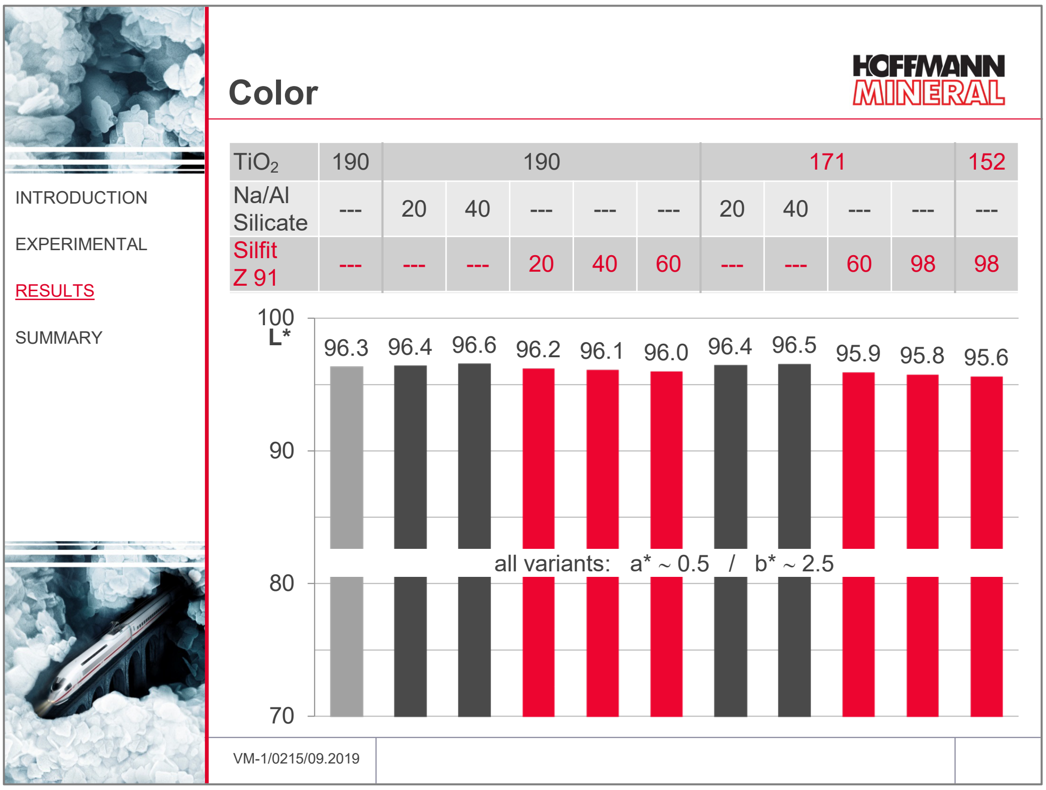
The present study for the formulations tested gave very similar results in the area of 20.0 to 23.5 $g/(m^2 * d)$. Following DIN EN 1062, therefore, all have found their way into Class V_2 with medium water vapor permeability.

3.5 Gloss

All formulations with a degree of gloss at 85° of < 5 units according to DIN EN 13300 show a “dull-mat” appearance.

3.6 Color

Despite the brightness differences between the TiO_2 extenders and the lower white pigment content the color properties of the facade coatings are affected just marginally (*Fig. 7*). Compared with Na/Al silicate, Silfit Z 91 gives rise to a fairly good brightness level, but for very demanding requirements the loading should be reduced in an appropriate way. The color neutrality of the control formulation with its regular TiO_2 concentration remains unchanged with both TiO_2 extenders.



TiO_2	190	190					171				152
Na/Al Silicate	---	20	40	---	---	---	20	40	---	---	---
Silfit Z 91	---	---	---	20	40	60	---	---	60	98	98

Fig. 7

3.7 Hiding power

For the definition of the hiding power, the EU Ecolabel offers a good starting point. As a help for the user, it distinguishes and honors products which aim at serving the high quality requirements of the market and in particular offer as high as possible an environment and health preserving contribution during production and application. The objective of the recognized voluntary environment sign is to sensibilize for an improved environment protection by working with correspondingly labeled products.

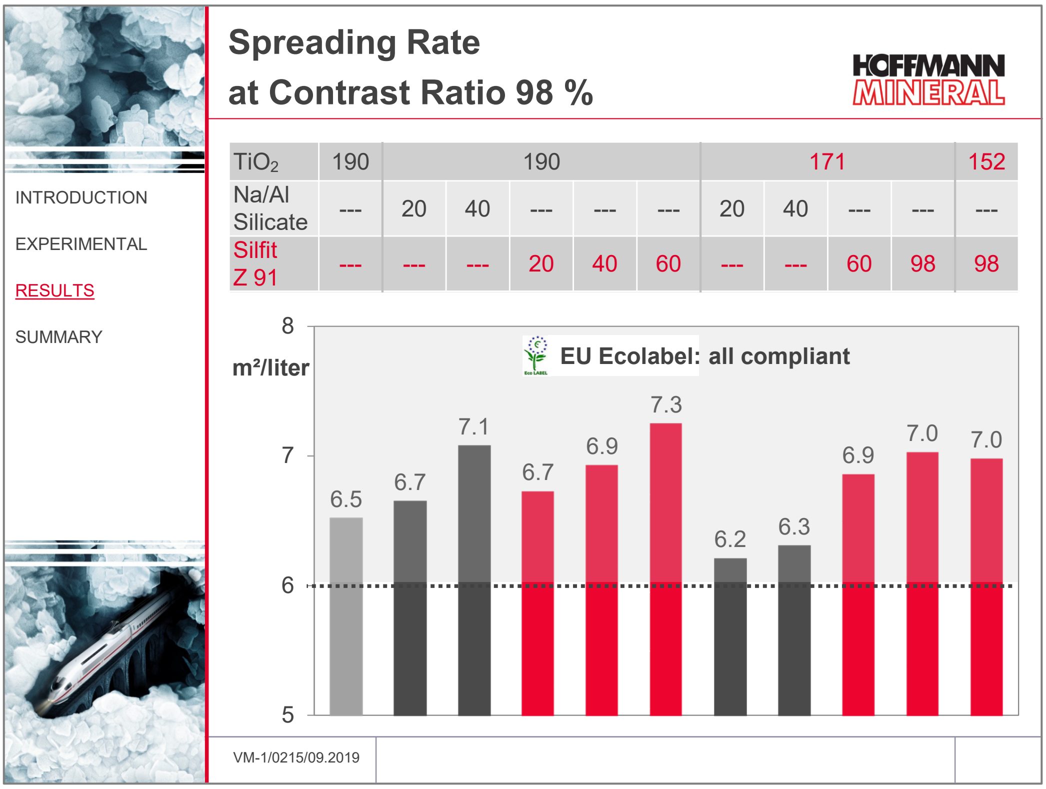
The reduction of the white pigment titanium dioxide which is ecologically precarious during production represents a step in this direction, and is already considered and quantified by the requirements of the Ecolabel for facade paints:

- Spreading rate ≥ **6 m² / liter** at a hiding power with contrast ratio of 98 %

- Content of white pigments (refractive index ≥ 1.8) ≤ **38 g / m²** of dried film at a hiding power with contrast ratio of 98 %

Considering these requirements, according to the comparison in *Fig. 8* without exception the results for spreading rates agree with each other. By further addition of extenders the performance will be enhanced more and more.

If the loading of white pigment is reduced, the resulting loss of hiding power cannot be compensated by using Na/Al silicate. Even with twice the added quantity the hiding power will practically not come out improved, and the level of the control formulation is not met.



TiO_2	190	190					171				152
Na/Al Silicate	---	20	40	---	---	---	20	40	---	---	---
Silfit Z 91	---	---	---	20	40	60	---	---	60	98	98

Fig. 8

Silfit Z 91 under these critical conditions offers evident advantages, as shown by the high spreading rate results markedly above the original level of the control.
The further reduction of the white pigment portion under maintaining the performance points to the high efficiency of Silfit Z 91 as TiO_2 extender.

The titanium dioxide concentrations per square meter of coated surface calculated from the spreading rate are going down from 40 pbw of additive TiO_2 extender towards the accepted region below 38 g/m² (*Fig. 9*).

With Na/Al silicate, a continued optimization under reduction of the TiO_2 content cannot be realized, as the limiting threshold (20 pbw) is not reached, or at higher levels (40 pbw) the loss of covering power requires an application of higher layer thicknesses and thus leads again to an increase of the surface related pigment content.

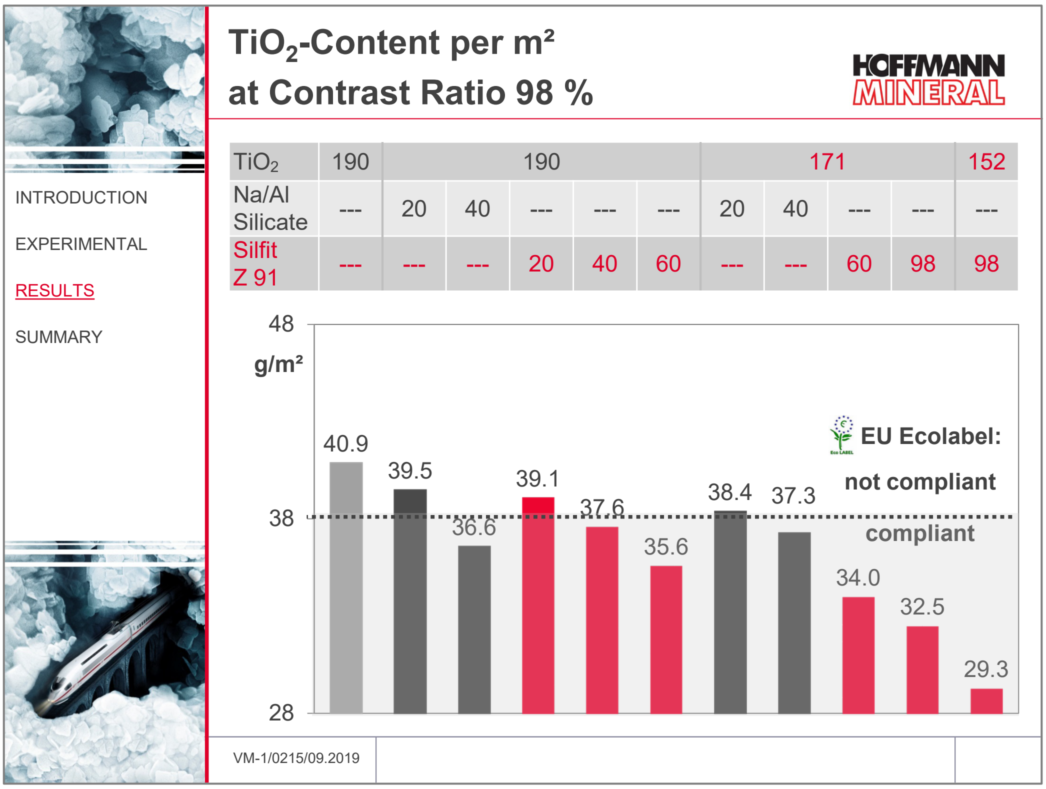


Fig. 9

The higher spreading rates of the formulations with Silfit Z 91 compared to the control give rise to an effectively reduced paint consumption with material savings, which last not least is reflected in a diminished TiO_2 content.

If the white pigment content of a formulation is already reduced by 20 %, this will cause additionally particularly beneficial effects as shown in *Fig. 9* on the right-hand side.

Compared with precipitated sodium aluminum silicate, Silfit Z 91, therefore, offers a distinct contribution towards reducing the white pigment content and to better preserve the environment. At the same time, Silfit Z 91 makes further cost savings possible, as discussed in the following paragraph.

3.8 Cost / Performance calculations

The base of the relations illustrated in *Fig. 10* are the volume related raw material costs in Germany 2019 (upper graph, left-hand column), as well as the volume-related spreading rate resulting from the hiding power (upper graph, right-hand column). The results are expressed as the relative change (in %) versus the control formulation with an index of 100. The lower graph reflects the pertinent additive summary of the changes in costs and spreading rate as an index for the effective performance.

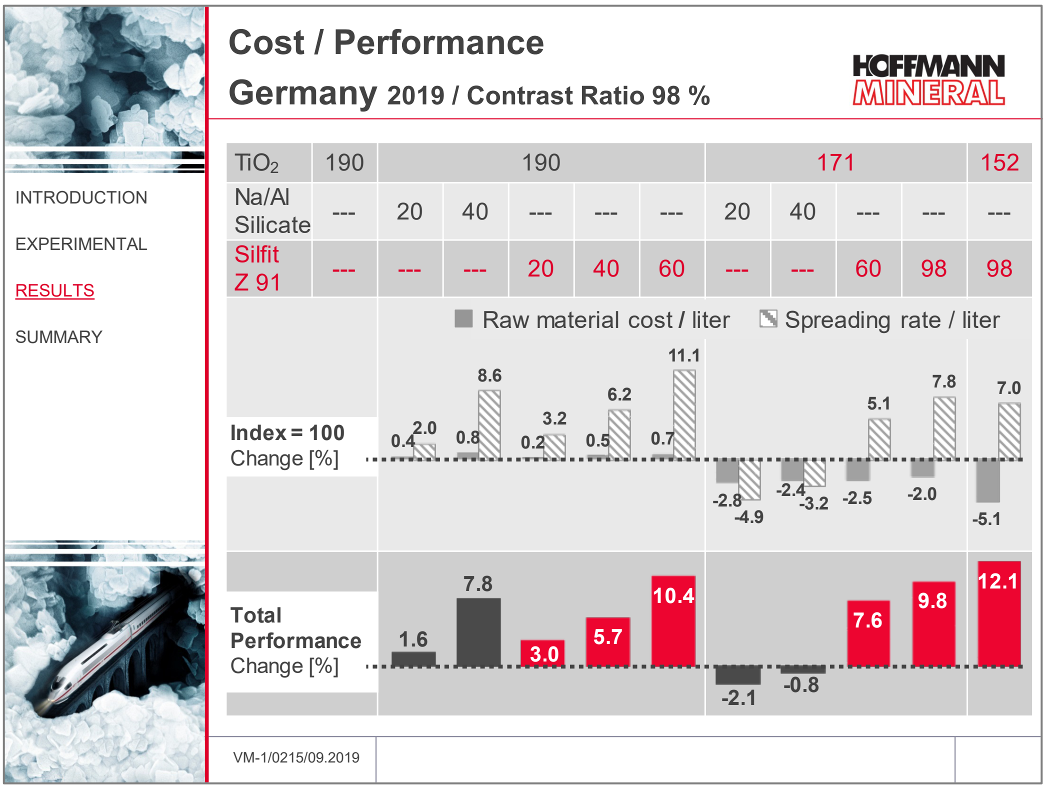


Fig. 10

The additional use of Na/Al silicate as extender leads to an increase of the raw material costs. Counteracting by TiO_2 reduction is possible, but negatively affects the performance in an over-proportional way down to below the level of the control formulation even when doubling the concentration. As a result, it is not possible to effectively improve the overall performance.

Only with Silfit Z 91 the desired cost savings can be reached along with a moderate to marked optimization of the performance beyond the control level:
With regular TiO_2 loading in particular there are benefits in the spreading rate without a negative effect on the cost structure. TiO_2 reduction primarily saves white pigment and raw material costs, while also obtaining a high performance advantage.

4 Summary

The additive use of both tested TiO_2 extenders leads to the following effects:

- Practically comparable properties with respect to storage stability, water permeability, water vapor permeability, gloss and color properties
- Wet-scrub resistance reduced by precipitated Na/Al silicate; with Silfit Z 91 the very good level is largely maintained
- Optimized hiding power; with Silfit Z 91 in addition raw material cost savings
- With 10 % less TiO_2 loss of hiding power by Na/Al silicate not correctable; with Silfit Z 91 and even 20 % less TiO_2 high gain in hiding power beyond the level of the control formulation along with additionally reduced formulation costs

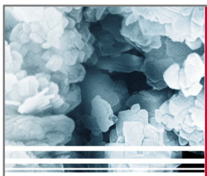
As a result, Silfit Z 91 in facade paints offers the following combined benefits vs. precipitated Na/Al silicate:

- Maintained mechanical toughness of the coating
- Distinct improvement of hiding power and spreading rate along with simultaneous reduction of formulating costs
- TiO_2 reduction with realistic possibility of saving white pigment, i.e. further potential for lower costs without sacrifices in performance

The optimized spreading rate further makes it possible to reduce the surface related material consumption, which in turn reduces costs and decreases the TiO_2 consumption.

With distinctly remaining below the EU Ecolabel white pigment limits Silfit Z 91 offers a contribution to develop environmentally more friendly coating systems, and underlines in a marked way its suitability as an effective TiO_2 extender for modern facade paints.

Recommended formulations with Silfit Z 91 can be found in *Fig. 11* on the following page.



Starting Formulations

HOFFMANN MINERAL

[1] highest brightness [2] best hiding power + high brightness [3] high cost savings + high hiding power		[1]	[2]	[3]
Water deionized			180	
Natrosol 250 HR			2	
Ammonia, conc. 25 %			2	
Dispex AA 4030			2	
Calgon N New, 10 % in water			3	
Parmetol MBX			2	
Foamaster MO 2134			2	
Propylene glycol : Butyl diglycol : Texanol = 1 : 1 : 1			30	
Kronos 2190		190	190	171 to 152
Silfit Z 91		20 to 40	40 to 60	60 to 98
Omyacarb 5 GU			220	
Finntalc M 15			50	
Acronal S 790			320	
Foamaster MO 2134			3	
Acticide MKB 3			10	
Rheovis PE 1330			12	
Water deionized			12	
Solids content w/w	[%]	61.8	63.1	63.2
PVC	[%]	50.9	53.3	54.2

VM-1/0215/09.2019

Fig. 11

Our technical service suggestions and the information contained in this report are based on experience and are made to the best of our knowledge and belief, but must nevertheless be regarded as non-binding advice subject to no guarantee. Working and employment conditions over which we have no control exclude any damage claims arising from the use of our data and recommendations. Furthermore, we cannot assume any responsibility for any patent infringements which might result from the use of our information.