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Unternehmensgruppe Hoffmann

Silfit Z 91

for TiO_2 extension in good hiding, solvent-free straight acrylic paint

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1 Introduction

Good optical properties and wear resistance as well as largely absence of emissions and solvents are essential characteristics of modern interior emulsion paints. As decorative coating systems, they contain a certain, sometimes higher portion of titanium dioxide, which as energy and cost intensive raw material suffers increasingly from variations in price and demand, and, therefore, decidedly determines the cost structure of the paint formulations.

As a result, at present a partial replacement of the white pigment with suitable mineral TiO_2 extenders frequently looks desirable. Representatives of this class often are light-colored fine precipitated calcium carbonates, silicates or also calcined clays.

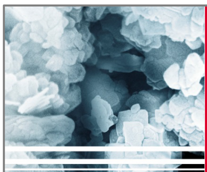
The objective of the present study is a basic evaluation of calcined Neuburg Siliceous Earth Silfit Z 91 as a TiO_2 extender in such an interior emulsion paint which is price and quality wise situated in the middle span.

The focus concerns primarily optical criteria such as brightness and color neutrality as well as hiding power and formulation costs as an index for the efficiency and economical viability. Further relevant aspects such as processing properties and wet-scrub resistance will be judged on the base of accompanying trials.

2 Experimental

2.1 Base formulation

The guide formulation listed in *Fig. 1* is based on a recommendation from BASF and contains a fairly high portion of titanium dioxide. There is a filler combination of primarily carbonate materials, and as reinforcing lamellar grades a talc and a mica. The PVC is situated on a rather low level compared with highly filled, lower cost interior emulsion paints (up to over 80 %).



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Base Formulation

		Parts by weight
Water deionized	-	300
Natrosol 250 HBR	Thickener	4
Sodium hydroxide, 20 % in water	Neutralising agent	2
Dispex AA 4135	Dispersing additive	3
Calgon N New, 25 % in water	Wetting / Disperging additive	2
Parmetol MBX	Can preservation	1
Foamaster MO 2134	Defoamer	2
Tronox CR-828	TiO_2 Pigment	**190**
Plustalc H15	Filler	20
Micro Mica W 1	Filler	50
Omyacarb 2 GU	Filler	65
Omyacarb 5 GU	Filler	165
Foamaster MO 2134	Defoamer	2
Acronal ECO 6270 (Straight acrylic)	Emulsion binder	180
Water deionized	-	14
Total		**1000**
Solids content w/w	[%]	59.0
PVC	[%]	65.7

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Fig. 1

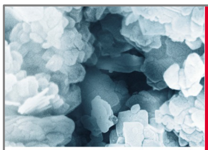
2.2 Formulation variations

As shown in *Fig. 2*, at first the white pigment loading in the control formulation is reduced by 20 % without replacement or other compensation. Then the calcined Neuburg Siliceous Earth will be added in increasing amounts at 1:1 to 1:2 in order to counteract the expected loss in hiding power.

In order to assess the performance of Silfit Z 91 as a TiO_2 extender, comparable variants with further reduced titanium dioxide content will be included.

In addition, the positive effect of fine light-colored cellulose fibers on the wet-scrub resistance of the coatings, as found in preliminary trials, will be considered.

The solids content and in particular the PVC of the formulations show a slight increase as a result of the Silfit additions.



Formulation Variations

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

		Control	TiO_2 Reduction								
TiO_2		190	150				135				
TiO_2 Extender Silfit Z 91		---	---	40	60	80	60	80	100	80	100
Arbocel B 600*		---	---				---			20	
Solids content w/w	[%]	59.0	57.3	59.0	59.8	60.6	59.2	60.0	60.8	60.8	61.5
PVC	[%]	65.7	64.3	66.5	67.6	68.5	67.1	68.1	69.0	69.7	70.5

* Natural cellulose fibre for optimization of wet-scrub resistance / hiding power

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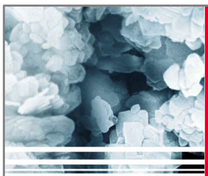
Fig. 2

2.3 Characteristics of Silfit Z 91

Neuburg Siliceous Earth as mined near Neuburg-on-the-Danube is a naturally formed mixture of corpuscular Neuburg silica with lamellar kaolinite: a loose mixture impossible to separate by physical methods. As a result of natural aging, the silica portion exhibits a round 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 portion under the applied temperatures remains unchanged. An integrated air classifier process eliminates grain sizes > 15 µm.

Last not least because of its unique morphology (*Fig. 3*), the high degree of fineness, the very good color neutrality and high brightness Silfit Z 91 offers ideal conditions for its use as a TiO_2 extender in interior emulsion paints.



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Characteristics
Silfit Z 91

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	Particle size d_{50} [µm]	Particle size d_{97} [µm]	Oil absorption [g/100g]	Density [g/cm³]	Specific Surface BET [m²/g]	Color L*	Color a *	Color b*
Silfit Z 91	2.0	10	55	2.6	8	95.5	- 0.1	0.7

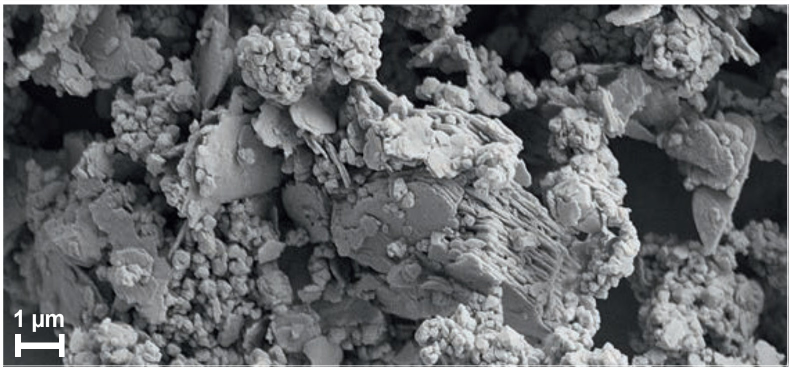

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Fig. 3

2.4 Preparation of batches, application and testing

The preparation of the batches was done following the sequence of the raw materials in the formulation in a laboratory dissolver under cooling with water.

Pigment, Silfit Z 91 and fillers were pre-mixed and after adding to the mixer dispersed for 20 min with a peripheral speed of the toothed disc 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 with a doctor blade with an automated applicator. The drying and conditioning of the paint films as well as the testing were done after 7 days of storage (28 days for wet-scrub resistance) in an air-conditioned laboratory at 23 °C and 50 % relative humidity. Detailed indications are given in *Figs. 4* and *5*.

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Properties
Without Significant Difference

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Incorporation Pigment / Filler	very good to good
Dispersing process 20 min 15 m/s	no agglomerates, no foam formation
Fineness of grind	15 µm, with cellulose fibres 40 µm
Storage stability 6 months at 23°C	low phase separation; settling of sediment easy to re-stir and to homogenize
Viscosity 23°C	Shear rate at $0.1\ s^{-1}$: 35 - 48 [Pa*s]; $1000\ s^{-1}$: 0.12 - 0.16 [Pa*s]
Gloss	dull matt, DIN EN 13000 85° < 5

Preparation and Testing

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Fig. 4

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Testing

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Paint Preparation	
Incorporation, Foam formation	Subjective assessment
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, DFT* ~ 120 µm	
Wet-scrub resistance	200 Cycles on automated wet-scrub resistance tester according to ISO 11998. Classification along with DIN EN 13300
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.

* Dry film thickness

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Fig. 5

3 Results

3.1 Processing properties and storage stability

Because of the generally very good dispersion properties of Neuburg Siliceous Earth in aqueous systems, Silfit Z 91 offers correspondingly rapid and foam-free incorporation for the production of the formulations. The grain size of the complete interior emulsion paints after grindometer tests is situated around 15 µm, with added cellulose fibers around 40 µm.

The rheology profile gives evidence of the strong shear thinning typical for interior emulsion paints, with the distinctly low viscosity of 0.12 to 0.16 Pas under higher shear load (1000 s^{-1}) reflecting the easy processing and spreadability. High viscosity results of 35 to 48 Pas at low shear (0.1 s^{-1}) indicate a low run-off tendency after application and allow to apply the film layer thicknesses required for good hiding power.

All formulations after 6 months offer good storage stability. The batches show only little tendency towards phase separation and are easy to stir up and homogenize.

3.2 Wet-scrub resistance

Abrasion under wet conditions of the original formulations without TiO_2 extender will increase just marginally with the use of Silfit Z 91. The scrub resistant coatings, as shown in *Fig. 6*, with results between 5 and 20 µm dry film thickness loss remain at least within Class 2 of DIN EN 13300.

Only with a lower loading of white pigment and higher extender additions a classification in the still acceptable region of Class 3 is possible. For a visible optimization of the mechanical resistance these formulations benefit from the additional use of fine cellulose fibers, which also affect positively the matting effect and the hiding power (*Fig. 8*).

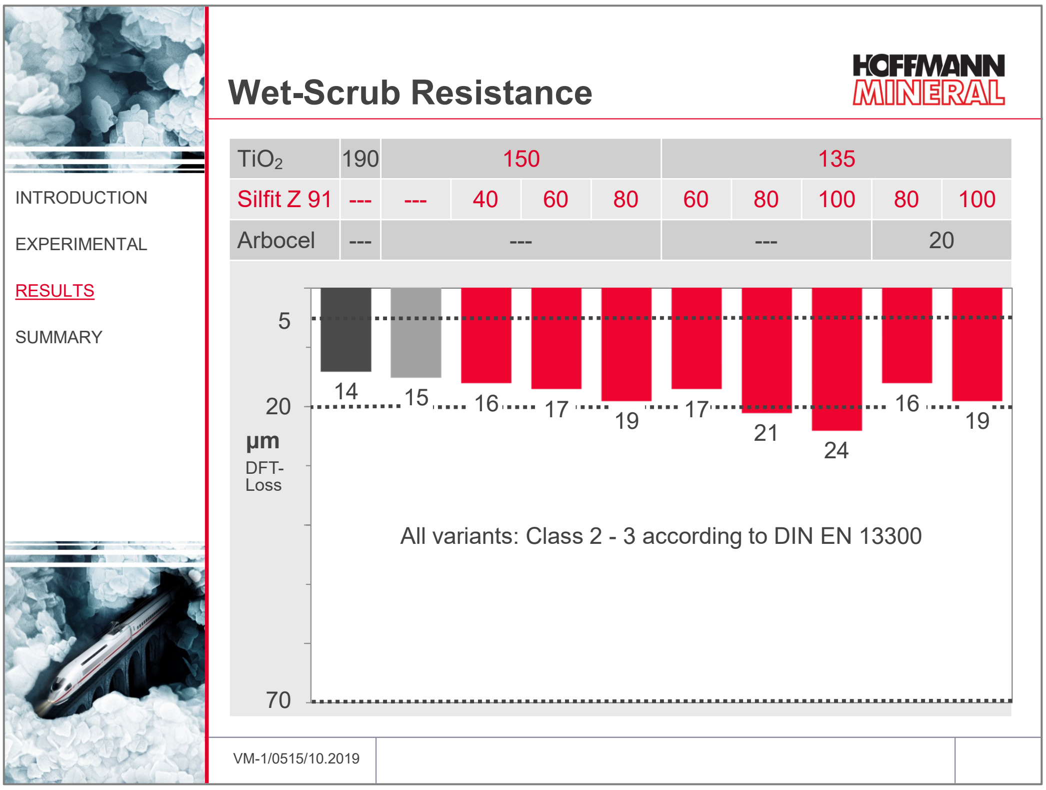


Fig. 6

3.3 Gloss

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

3.4 Color

The very good optical properties of Silfit Z 91 in total result in highly positive effects. The titanium dioxide content under substitution with Silfit Z 91 can be significantly reduced without losses in brightness or color neutrality (*Fig. 7*).

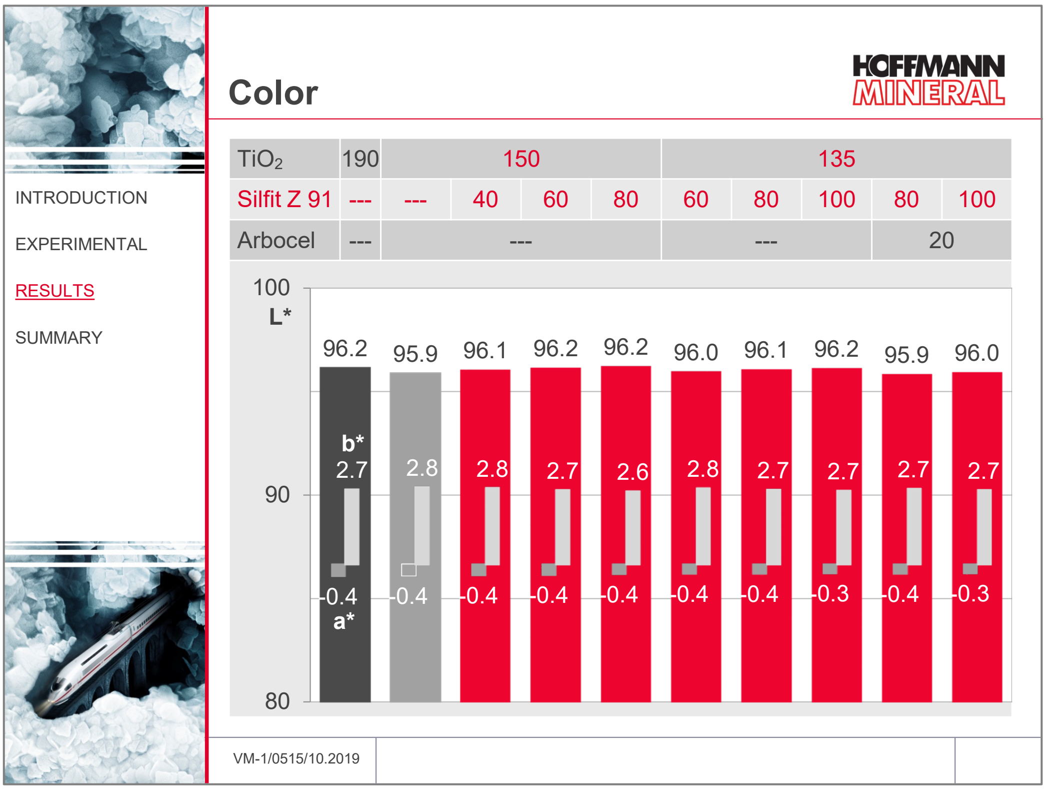


Fig. 7

3.5 Hiding power

The reduction of the white pigment portion according to *Fig. 8* (second bar) leads to an evident diminution of the performance with respect to the hiding power. The resulting spreading rate during the application of a good hiding paint with a contrast ratio of at least 98 %, therefore, goes down correspondingly strong in comparison with the control formulation.

The visible loss in hiding power can be avoided by compensating the white pigment reduction with Silfit Z 91 as TiO_2 extender. With increasing additions, the performance will improve markedly in a way that above a 1.5-fold loading (60 pbw) the titanium dioxide portion can be decreased still further without sacrifices vs. the control formulation.

As evident, the combination of Silfit Z 91 with Arbocel shows additional positive effects regarding the hiding power.

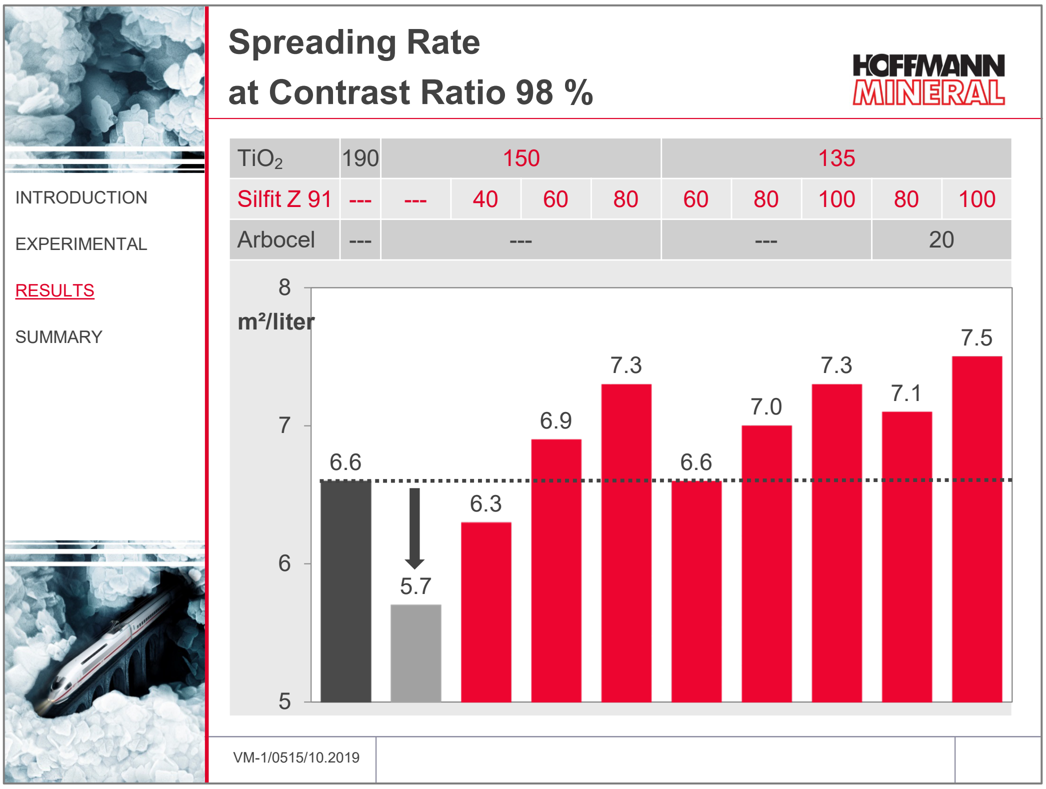


Fig. 8

The benefits in hiding power and spreading rate determine directly the overall performance of the paint (see following paragraph).

3.6 Cost / Performance calculations

The calculations are based on the volume related raw material costs in Germany 2019 (*Fig. 9*, upper graph, left-hand column) as well as on the volume related spreading rate resulting from the hiding power (upper graph, right-hand column). The figures indicate the relative change (in %) from the control formulation with an index of 100. The lower graph summarizes the changes of cost and spreading rate as an index for the effective performance.

All formulation variants impress by advantageous favorable formulation costs as a result of the reduction of the white pigment portion. In the formulation without TiO_2 extender, however, the over-proportionally strong decrease of the hiding power more than compensates the better costs which lastly lead to a negative overall balance.

In the Silfit Z 91 containing formulations favorable raw material costs almost without exception (40 pbw) are combined with higher hiding power and spreading rate in the direction of an effective increase of the overall performance. The advantages in the hiding power improve the usage properties of the emulsion paint or can be used to further optimize the cost structure.

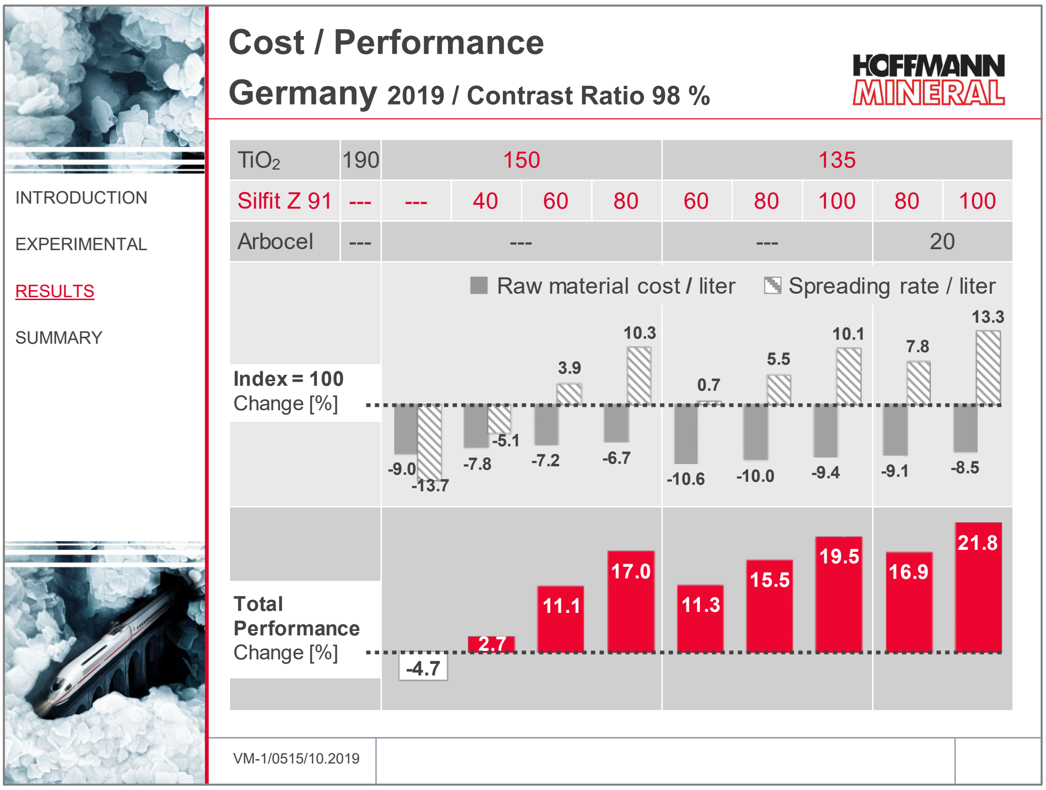


Fig. 9

4 Summary

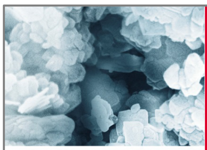
In the interior emulsion paint studied, Silfit Z 91 offers the following performance picture:

- Maintained processing properties, storage stability, color characteristics and degree of gloss
- Slightly increased wet-scrub loss, with optimization possible through addition of up to 2 % fine cellulose fibers
- Markedly improved hiding power and higher spreading rate
- Along with a white pigment reduction, compensation of the loss in hiding power by replacing the eliminated TiO_2 with 1 to 1.5 times the amount of Silfit Z 91, which in addition leads to a distinct cost saving

The calcined Neuburg Siliceous Earth Silfit Z 91 with this property profile is able to improve the performance of existing interior emulsion paints.

In addition, Silfit Z 91 via the high savings potential in costs and white pigment usage offers a distinct contribution towards formulating more environmentally friendly coating systems and underlines in an outspoken way its suitability as an effective TiO_2 extender for modern dispersion-based interior paint systems.

Recommended formulations with Silfit Z 91 can be found in *Fig. 10*.



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Starting Formulations

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[1] High hiding power [2] High cost savings [3] Cost savings, Wet-scrub resistance		[1]	[2]	[3]
Water deionized			300	
Natrosol 250 HBR			4	
Sodium hydroxide, 20 % in water			2	
Dispex AA 4135			3	
Calgon N New, 25 % in water			2	
Parmetol MBX			1	
Foamaster MO 2134			2	
Tronox CR-828		150	135	135
Silfit Z 91		80	60 (bis 100)	80 (bis 100)
Arbocel B 600		---	---	20
Plustalc H15			20	
Micro Mica W 1			50	
Omyacarb 2 GU			65	
Omyacarb 5 GU			165	
Foamaster MO 2134			2	
Acronal ECO 6270 (Straight acrylic)			180	
Water deionized			14	
Solids content w/w	[%]	60.6	59.2	60.8
PVC	[%]	68.5	67.1	69.7

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Fig. 10

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