New Strategy for the Optimization of Dispersion Paints Using Multifunctional Fillers

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1 Introduction

As products manufactured in many millions of tons, dispersion paints are subject to high pressure on prices. To survive under these highly competitive conditions, paint manufacturers are forced to continuously optimize their formulations in terms of performance and costs. For understandable reasons, up to now such efforts have largely focused on the expensive ingredients such as binders and pigments, presenting, as they do, the greatest leverage for savings in raw materials. This paper reveals how significant cost savings can be achieved by optimizing or revising the design of the filler package of the formulation.

What is a filler package?

Fillers are inorganic products in the form of insoluble fine particles, which are contained in varying proportions in all dispersion paints. Ground calcium carbonate (GCC) such as chalk, limestone or marble, are low-cost mass products and make up a large part of the filler package. They are used in large proportions in dispersion paints (Fig. 1, Table 1), accompanied by functional fillers, whose purpose is to perform a specific functional task (see Table 1). Functional fillers are more expensive than GCC and are used in smaller quantities. A third class of fillers, and one of increasing importance, is formed by the so-called multifunctional fillers. The main characteristics of these fillers is that they perform more than one function and have a positive impact on the properties and application of the paint as well as on the quality of the wall coating. This group includes for example refined kaolins, such as the calcined grades DORKAFILL® H and DORKAFILL® Pro_Void from the company Dorfner in Hirschau (Germany).

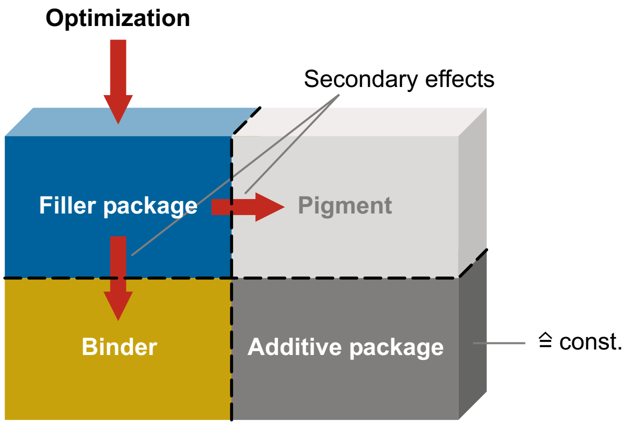

Fig. 1: The "package model" for dispersion paints (schematic presentation); Working strategy: Optimization of the filler package generates secondary effects for significant savings in expensive raw materials

Fillers	Type	Secondary effects
IMPORTANT FILLERS		
GCC	Calcium carbonate, ground calcium carbonate (GCC)	No
Marble dust	Calcium carbonate	No
FUNCTIONAL FILLERS		
Talc	Magnesium silicate	No
Diatomite	Silicon dioxide	No
Mica	Aluminum silicate	No
Aluminum silicate	Precipitated aluminum silicate	No
Precipitated calcium carbonate	Precipitated calcium carbonate (PCC)	No
MULTIFUNCTIONAL FILLERS		
DORKAFILL® H	Refined kaolin, calcined kaolin	Yes
DORKAFILL® Pro_Void	Refined kaolin, calcined kaolin	Yes

Table 1: Overview of commonly used fillers for dispersion paint

2 Terms of reference and objectives

Three dispersion paints – commercially available products of medium to premium quality – were selected for this new, unprecedented development strategy. All were considered to have fully developed formulations, i.e. there was no longer any appreciable potential for improving their quality and/or the cost of their raw materials. Any further optimization would result in only marginal success while incurring high costs. The benefits would not be worth the effort involved. With these formulations, trials were carried out to optimize the filler package in a way that makes sense technically and is worthwhile economically. Accordingly, for the optimization of the fully developed formulations, the following ambitious objectives were set:

- The raw material costs should be lowered significantly
- The properties of the dispersion paint or applied coating should remain unchanged or should become better than before
- After optimization, the dispersion paint should belong to the same quality class as before or to a better one
- If possible, the optimized paint should have fewer raw materials than its predecessor

3 Materials and methods

The filler packages of the three dispersion paints which were investigated contained GCC in varying proportions as well as up to three functional fillers. In order to maintain a good overview of the variables in the optimization trials, the type of binder and pigment as well as the additive system was left unchanged in all formulations. Similarly, the concentration of GCC, as part of the filler package, was retained. Only the functional fillers were replaced by multifunctional fillers. The multifunctional fillers used were the calcined kaolins DORKAFILL® H and DORKAFILL® Pro_Void which have been exceptionally successful as calcined kaolins in the re-formulation of dispersion paints. Therefore, the chances were high that these two multifunctional fillers would achieve good results and optimize “fully developed” paints by increasing the pigment volume concentration (PVC). The classical criteria and measurement methods customary for assessing dispersion paints were used for the analysis of the formulations (Table 2).

Criterion	Description, measurement device
Pigment volume concentration [%]	$PVK = \frac{(Pigment+Filler)}{(Pigment+Filler+Binder)} \times 100$
Filler content [%]	Sum of all fillers
Solid particles [%]	Solid material
Shear stress at 1,200 s^{-1} [Pa]	Dimension for viscosity and application characteristics, Brookfield R/S plus rheometer
Wet scrub [µm]	According to ISO 11998, division into classes 1–5 *(1 = very good, 5 = poor)*
Yield [m²/l]	According to VdL-RL 09, division into classes 1–5 *(1 = very good, 5 = poor)*
Standard color value Y4	Degree of whiteness, measuring device: Datacolor 110
Gloss 60°/85°	Dimension for matting, measuring device: Byk micro-TRI-gloss
Density [g/cm³]	Measuring device: DMA 38 Anton Paar

Table 2: Criteria and measurement methods/devices for assessing dispersion paints

4 Results – replacing the functional fillers

Replacing the functional fillers completely with a combination of DORKAFILL® H and DORKAFILL® Pro_Void resulted in significant improvements in nearly every case investigated to date (!) (Fig. 2). The improvements were particularly striking when both multifunctional fillers were skillfully combined in one formulation rather than using only one of the substances. This synergy between DORKAFILL® H and DORKAFILL® Pro_Void was verified in more than 95 % of the formulations for which the filler package was optimized.

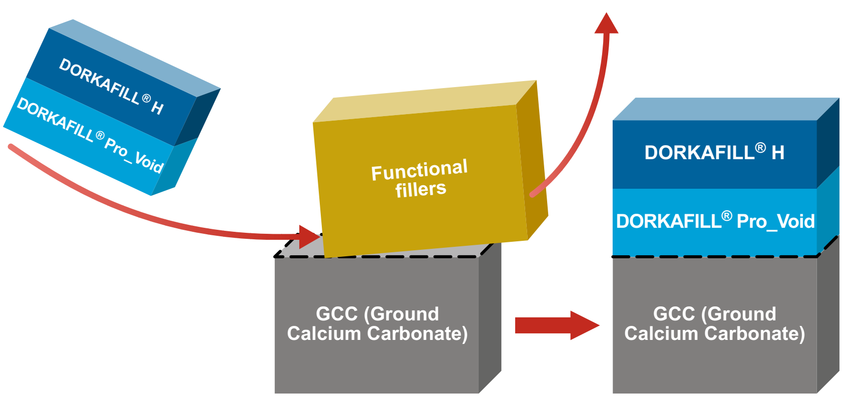

Fig. 2: Complete substitution of functional fillers by the multifunctional fillers DORKAFILL® H and DORKAFILL® Pro_Void

5 Case studies

In order to illustrate the effect of the filler package optimization on existing formulations, three cases are presented below.

5.1 Example 1

The dispersion paint investigated in this case is a standard commercial product of medium quality, commonly used in DIY or professional segments for designing interior walls. The main ingredients of this filler package are GCC and functional fillers such as precipitated aluminum silicate and talc. In a first step, the functional fillers in this formulation were substituted by DORKAFILL® H and DORKAFILL® Pro_Void and the properties of the paint and its coating analyzed (Fig. 3).

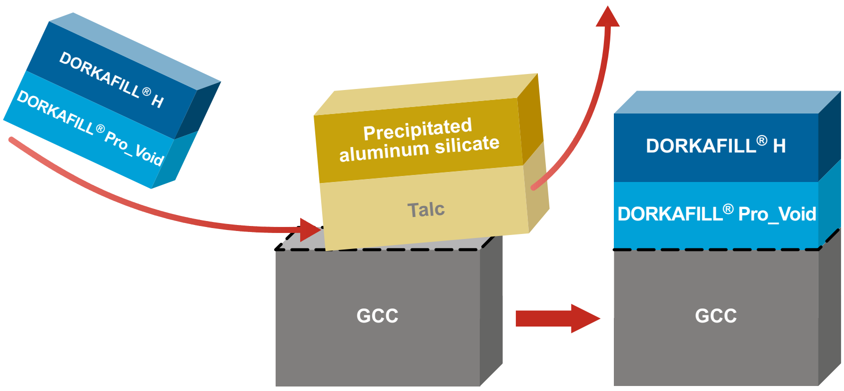

Fig 3: Substitution of functional fillers by DORKAFILL® H and DORKAFILL® Pro_Void (Example 1)

	Initial formulation (was)	Optimized formulation (is now)
CLASSIFICATION ACC. TO EN 13300		
Wet scrub class	3	3
Class for hiding power	2	2
Degree of gloss	Flat matt	Flat matt
MEASURED VALUES		
PVC [%]	**82.0**	**85.4**
Filler content [%]	51	52.9
Solid particles [%]	62.2	61.8
Shear stress at 1,200 s^{-1} [Pa]	745	735
Wet scrub [µm]	48	50
Yield [m^2/l]	8	8
Standard color value Y	88.2	89.3
Gloss 60°/85°	2.4/3.7	2.3/2.6
Density [g/cm^3]	**1.573**	**1.564**

Table 3: Comparison of the characteristic data of a dispersion paint's formulation before and after optimization of the filler package with DORKAFILL® H and DORKAFILL® Pro_Void (Example 1)

Discussion of the results from Example 1

Table 3 shows that the dispersion paint with the revised filler package has the same quality level as the original paint (classification according to EN 13300). Accordingly, the optimized dispersion paint is equivalent to the original formulation in all essential requirements. The measurement data show one decisive difference: after optimization of the filler package with DORKAFILL® H and DORKAFILL® Pro_Void, the pigment volume concentration (PVC) is far higher. Compared to the original formulation, this corresponds to binder savings of as much as 20 %: one important development objectiveis achieved. But that's not all. It was also possible to save 20 % of titanium dioxide compared to the "fully developed" formulation. Plus: the final cost was further improved by a reduction in density.

In conclusion it can be said that significant savings in the most expensive ingredients of a formulation, namely binder and titanium dioxide, were achieved through optimization of the filler package. Applying the achieved savings to the complete formulation and taking the current raw material prices as basis, this results in cash savings of approximately 4 to 5 Euro cents per liter of dispersion paint. For a high-volume dispersion paint it certainly pays therefore to optimize the filler package using multifunctional fillers of the DORKAFILL® range.

5.2 Example 2

The dispersion paint in this example is a product of upper-medium quality. It is a typical product for specialist dealers and is used predominantly by professionals. In this case the filler package was comprised of GCC and two functional fillers (Fig. 4): precipitated calcium carbonate (PCC) and diatomite. Drawing on the experience gathered from numerous optimization trials, it was possible to completely replace the PCC and diatomite of the old formulation with a combination of DORKAFILL® H and DORKAFILL® Pro_Void.

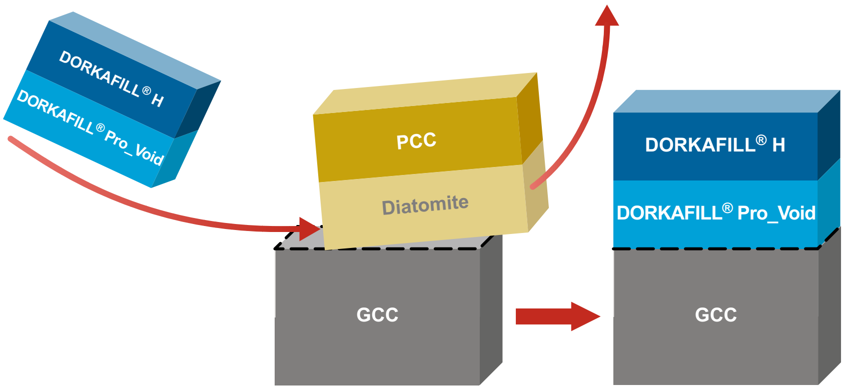

Fig. 4: Substitution of functional fillers by the multifunctional fillers DORKAFILL® H and DORKAFILL® Pro_Void (Example 2)

	Initial formulation (was)		Optimized formulation (is now)
CLASSIFICATION ACC. TO EN 13300			
Wet scrub class	**3**	→	**2**
Class for hiding power	2		2
Degree of gloss	Flat matt		Flat matt
MEASURED VALUES			
PVC [%]	**71.9**	→	**77.1**
Filler content [%]	34,1		34,1
Solid particles [%]	56.6		54.6
Shear stress at 1,200 s^{-1} [Pa]	**800**	→	**590**
Wet scrub [µm]	**21**	→	**10**
Yield [m^2/l]	7		7
Standard color value Y	93.7		93.1
Gloss 60°/85°	2.4/3.6		2.3/2.3
Density [g/cm^3]	1.447		1.430

Table 4: Comparison of the characteristic data of a dispersion paint's formulation before and after optimization of the filler package with DORKAFILL® H and DORKAFILL® Pro_Void (Example 2)

Discussion of the results from Example 2

In spite of the already very good properties of this formulation, mainly due to the high binder content, the use of DORKAFILL® H and DORKAFILL® Pro_Void led also in this case to a significant improvement of the price/performance ratio (Table 4). Compared to the original formulation it was again possible to combat the cost drivers by cutting consumption: 21 % less binder and 8 % less titanium dioxide were the results. This corresponds to a cost saving of approx. 4 to 5 Euro cents per liter in real terms, a figure impressive enough to satisfy any raw material purchaser. Plus: the wet scrub resistance could be improved from class 3 to class 2, which would even justify a higher selling price for this paint. It was also surprising to discover that the viscosity of the paint is far lower after optimization of the filler package. Taking into account the fact that a low viscosity formulation can be rendered “thicker” by using thickeners but that a paint cannot be made “thinner” without losing its hiding power, this development opens up the possibility of adjusting a paint’s viscosity over a wide spectrum to suit the particular application, thus improving its workability on the job.

5.3 Example 3

This dispersion paint is a product from the premium market segment. It impressed with a high binder content (low PVC), but it still failed to convince with its wet scrub. The chances for improving the formulation through optimization of the filler package were therefore good. The original formulation was found to contain a complicated filler package: marble-based GCC, PCC, talc and mica for additional functionalities (Fig. 5). In the optimization trials, the three existing functional fillers were replaced iteratively by DORKAFILL® H and DORKAFILL® Pro_Void.

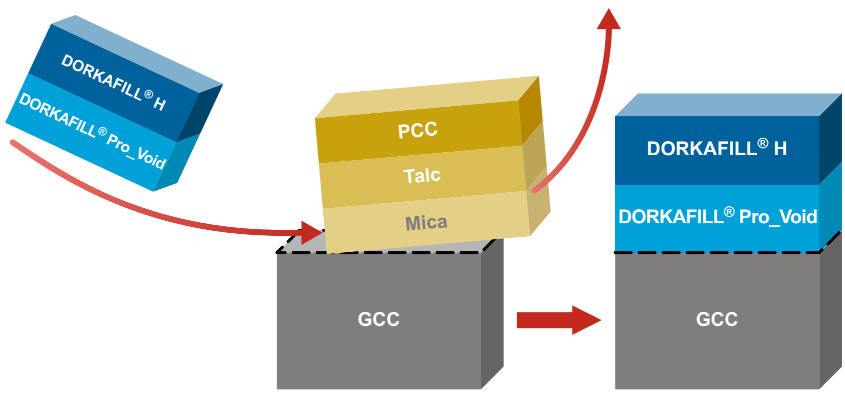

Fig. 5: Substitution of functional fillers by the multifunctional fillers DORKAFILL® H and DORKAFILL® Pro_Void (Example 3))

	Initial formulation (was)	Optimized formulation (is now)
CLASSIFICATION ACC. TO EN 13300		
Wet scrub class	**2**	**1**
Class for hiding power	1	1
Degree of gloss	Flat matt	Flat matt
MEASURED VALUES		
PVC [%]	**67**	**69.5**
Filler content [%]	25.1	24.8
Solid particles [%]	57.3	57.2
Shear stress at 1,200 s^{-1} [Pa]	1,580	1,660
Wet scrub [µm]	**11**	**4**
Yield [m^2/l]	8	8
Standard color value Y	91.7	93.7
Gloss 60°/85°	2.4/2.8	2.2/1.4
Density [g/cm^3]	1.461	1.433

Table 5: Comparison of the characteristic data of a dispersion paint's formulation before and after optimization of the filler package with DORKAFILL® H and DORKAFILL® Pro_Void (Example 3)

Discussion of the results from Example 3

Optimization of this filler package produced the usual picture. It was possible to reduce the binder content of the original formulation while retaining the quality level of the paint (Table 5). At the same time the wet scrub resistance was improved, resulting in a higher wet scrub class (class 1 instead of class 2) and enabling the formulation to enter the top-end segment for dispersion paints. Thanks to this quality enhancement, the formulation can strengthen its position among its rivals. At the same time the number of ingredients in the formulation could be reduced. This is yet another important argument for paint manufacturers looking to simplify their formulations, reduce their logistics, storage and purchasing costs, and cut their capital expenditure.

6 Conclusion

The results of the investigations indicate that it pays in every respect to optimize the filler package for dispersion paints. However, the purpose of this project was not simply to use different fillers with apparent numerical advantages in terms of matting, hiding power, oil number or other parameters. Nor was it intended to make savings in the fillers themselves, or for existing individual fillers simply to be replaced one to one. With such an approach, the benefits of re-formulation would never be worth the effort. The investigations into the optimization of the filler package proved that the formulation can be substantially improved by using a combination of multifunctional fillers such as DORKAFILL® H and DORKAFILL® Pro_Void, e.g. through savings in the price drivers (binder and titanium dioxide pigment). Although these two ingredients are essential for a dispersion paint and even define its quality, the optimization trials prove that enhanced filler packages can achieve secondary effects and can certainly reduce the consumption of binder and pigment without any sacrifices in quality, application characteristics or appearance. What is more, in most cases the quality of the dispersion paint was even improved, e.g. in terms of better wet scrub properties. And because the additive system was not changed, there is still potential for additional optimization.

7 Summary and outlook

In the case studies described above, revision of the dispersion paint filler packages achieved the following results:

- DORKAFILL® H and DORKAFILL® Pro_Void successfully replaced numerous fillers in a formulated dispersion system.
- Paint properties were selectively set and adjusted by varying the ratio of DORKAFILL® H to DORKAFILL® Pro_Void.
- The PVC was increased in nearly all cases.
- The raw material costs were significantly lowered in most cases.
- The properties of the paint remained unchanged or were better than before.
- After optimization, the paint belongs to the same quality class as before or to a better one.
- The quality of the coating after optimization was the same as before or better
- The application characteristics of the paint did not change compared to the original formulation.
- The number of raw materials was reduced in many cases.

Optimization of the filler package with the help of DORKAFILL® H and DORKAFILL® Pro_Void brings significant technical benefits which results in cost advantages and quality improvements. Together, the benefits and cost advantages are so valuable as to outweigh the expense of optimization and reformulation in many cases. It can be assumed that a large number of existing products can be optimized by revising the filler package and by using DORKAFILL® H and DORKAFILL® Pro_Void in the way described.

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