Pigment Concentrates with Extremely low Viscosity[1)]

1) Extract of a paper in Farbe und Lack, February 2010

Introduction

The necessity to reduce VOC content poses a particular challenge to formulators of coatings. The coatings must satisfy environmental guidelines but also meet performance criteria.

Besides waterborne formulations, high-solids systems are an important alternative to conventional solventborne coatings. In such systems, the low organic solvent content is achieved with binders of low molecular weight and thus low viscosity. But how can the VOC content of solventborne coatings be lowered further?

This article shows possibilities using modern wetting and dispersing additives with outstanding viscosity-lowering characteristics and compares binder-containing with binder-free pigment concentrates.

Pigment concentrates for solventborne coatings

Large volume products are usually manufactured by direct grind in which various pigments are dispersed in one step in a main binder. In the case of small batches, pigment concentrates permit cost-effective, flexible production. The base paints are colored by mixing.

Traditionally, pigment concentrates containing binders are used in solventborne industrial coatings. Grinding resins such as ketone or urea-aldehyde resins ensure a relatively broad, though limited compatibility of the concentrates. The lowest possible amount of dispersing additive is used to lower viscosity and increase color intensity.

Because of more stringent environmental legislation, the VOC content of pigment concentrates must be reduced. Since the ketone or urea-aldehyde resins used are already of low molecular weight, it is almost impossible to lower the viscosity of the solution by further decreasing the molecular weight of such resins. Dispersing additives with extreme viscosity-lowering action are thus becoming increasingly important.

Novel additives reduce viscosity

Researchers at Evonik Tego Chemie GmbH have developed particularly powerful wetting and dispersing additives with a star-shaped structure. Many functional groups with affinity for pigments are concentrated at the center. Precise modification with stabilizing side chains is easy to achieve. The compact polymers effectively reduce interactions between the pigments.

Binder-free: an alternative?

Binder-containing and binder-free pigment concentrates based on a new, star-shaped wetting and dispersing additive, TEGO® Dispers 670, were produced and investigated. Priority was given to optimizing the VOC content. By definition, binder-free formulations do not contain any grinding resin. In the following discussion, pigment concentrates based on iron oxide red (PR 101) and titanium dioxide (PW 6) are used as examples (Table 1). A urea-aldehyde resin was used as the grinding resin. The dispersing additive TEGO® Dispers 670 was compared with commercial benchmarks with known viscosity-lowering characteristics. According to the manufacturers, the statistically branched polyurethane is recommended for binder-containing systems, the block polymer polyacrylate particularly for binder-free systems. The additives chosen for comparison represent the established chemical classes.

Fundamentally, the binder-containing concentrates contain less pigment than the binder-free variants.

Rheological properties

A high pigment loading is desirable on economic grounds in order to disperse as much pigment as possible in a single grinding operation. The more pronounced the lowering of viscosity by a dispersing additive, the higher the pigment loading can be and the less organic solvent is required.

It is clear from Figure 1, in which PR 101 is used as an example, that the comparison additives do not lead to extremely low viscosities. In contrast, both the binder-containing and the binder-free concentrates with TEGO® Dispers 670 have a low viscosity.

In all cases, stability is sufficient although the stability of the formulations based on the comparison additives is borderline.

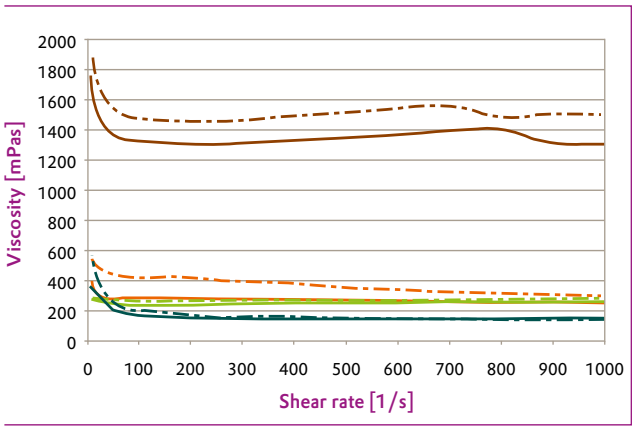
With inorganic pigments, the binder-free technology leads to lower viscosities despite unusually high pigment loadings. In the case of PW 6, the formulation of a free-flowing, binder-free concentrate containing 80 % pigment was only possible using TEGO® Dispers 670. The comparison additives resulted in paste-like products.

Table 1
Formulations of binder-containing and binder-free pigment concentrates

	Iron oxide red (PR 101)		Titanium dioxide (PW 6)	
Raw materials	BF*	BC*	BF*	BC*
Grinding resin (60 % in MPA)	–	19.0	–	20.6
Methoxypropylacetate (MPA)	9	7.8	7.7	11.1
Bentone paste	–	–	0.3	–
Dispersing additive	21	8.2	12.0	3.3
Pigment	70.0	65.0	80.0	65.0
Total	**100.0**	**100.0**	**100.0**	**100.0**
Dispersing additive relative to pigment [%w/w]	12	5	6	2
Grinding resin relative to pigment [%w/w]	–	17.5	–	19
Density [kg/L]	2.6	2.4	2.5	2.0
VOC content [g/L] when using TEGO® Dispers 670	398	430	283	407
Non-volatiles [%]	84.7	82.1	88.5	79.7

*) BC: binder-containing, BF: binder-free

Figure 1
Comparison of the viscosities of the PR 101 concentrates before and after storage



BC: binder-containing, BF: binder-free

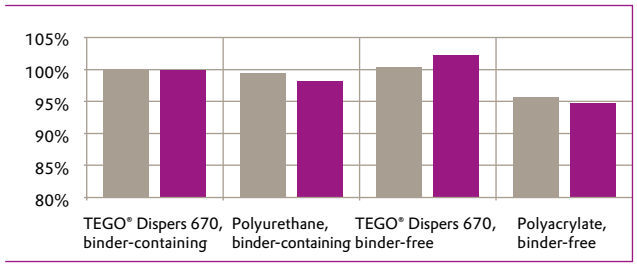
- TEGO® Dispers 670 BF, initially
- TEGO® Dispers 670 BF, 7d@50 °C
- TEGO® Dispers 670 BC, initially
- TEGO® Dispers 670 BC, 7d@50 °C
- Acrylate BF, initially
- Acrylate BF, 7d@50 °C
- Polyurethane BC, initially
- Polyurethane BC, 7d@50 °C

Color intensity

For better comparison, the unpigmented test coatings were treated with the same amount of PR 101, so that the amount each concentrate used in the coating varied. Figure 2 shows the color intensity of the concentrates in the various paints relative to the color intensity of the binder-containing concentrates with TEGO® Dispers 670. TEGO® Dispers 670 increases the color strength compared to the benchmarks.

The color intensity of the binder-free concentrate with TEGO® Dispers 670 is slightly (about 2 %) greater than that of the binder-containing variant. The pigment loading is also higher so that the same color intensity can be achieved using 10 % less pigment concentrate.

Figure 2
Relative color intensity of the PR 101 concentrates after let-down (TEGO® Dispers 670, binder-containing = 100 %)



VOC content

Despite the inorganic pigments' high density, the VOC content of the binder-free pigment dispersions based on TEGO® Dispers 670 is significantly lower than that of the binder-containing variants because of the greater pigment concentration (Table 1). The formulation of binder-free pigment concentrates with a VOC content below the limiting value of 400 g/L was therefore successful.

Cost calculation

In the case of PW 6, the raw material costs of the binder-containing and binder-free variants were comparable. Taking into account the production costs (time/kg of dispersed pigment), the binder-free technology has advantages because of the higher pigment loading.

With PR 101, the raw material costs of the binder-free concentrate are greater than those of the binder-containing variant. However, the emphasis during development of the concentrates was on achieving the lowest possible VOC content.

Binder-free PR 101 concentrates with raw materials costs considerably lower than those of the binder-containing variants can be easily formulated with TEGO® Dispers 670. The pigment concentration is then at 75 % w/w. However, because of the high density of PR 101, the VOC content is above 400 g/L.

Summary

The viscosity-lowering effect of TEGO® Dispers 670 enables the VOC content of pigment concentrates, mixing systems and direct grinds to be reduced. The use of TEGO® Dispers 670 enables binder-free pigment dispersions, particularly of inorganic pigments, to be formulated with lower VOC content than that of their binder-containing counterparts.

Contact
patrick.gloeckner@evonik.com