DELTA specialties

Issue 5, 2011

Additives Guide
DISPERSION CONTROL ADDITIVES

DISPERSION CONTROL ADDITIVES

When dispersing pigments, in particular organic pigments, one frequently encounters problems such as flocculation, insufficient color or transparency, poor rheological qualities or stability.
These issues arise along every step of the coatings life cycle from production and storage through to the end-use performance of the film.

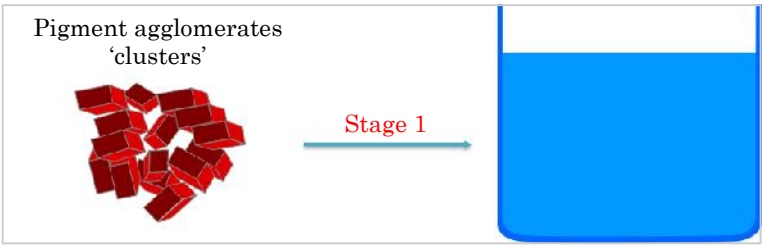
The dispersing of solid pigments or fillers into the liquid phase of binder solutions is an important step in paint and coatings production influencing optical properties like gloss and color strength.

Dispersion control additives are used to improve and accelerate the dispersion process and to stabilize the dispersion during storage. For the design and the use of these additives, it is essential to have knowledge about the dispersion process.

DISPERSION PROCESS

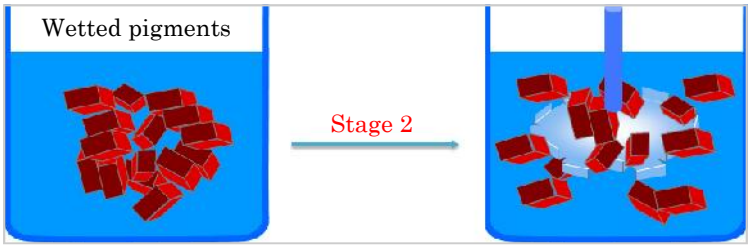
Pigment dispersing process can be subdivided in three stages:

- Wetting
- Dispersing
- Stabilizing



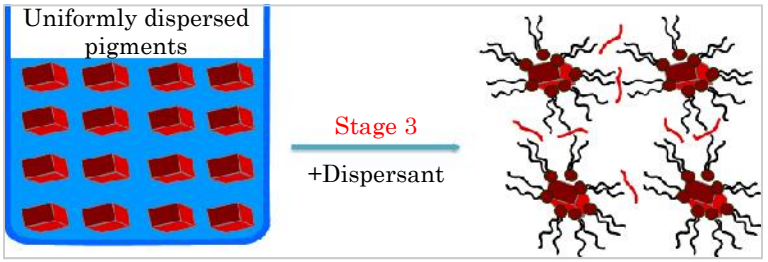
During the first step of pigment wetting, air and moisture are displaced from the pigment surface through the liquid of the grinding medium.

The interface, solid/gaseous (pigment/air), is changing into solid/liquid (pigment/grinding medium).



In the second step 'dispersing' the pigment agglomerates are fragmented by energy input. This mechanical separation can be achieved by dissolvers or different types of milling machines.

The amount and the duration of the energy input are the main factors for a complete separation of every primary pigment particle. The transmission of shear energy to the pigment particles is hardly influenced by the use of additives.



The third step is the stabilization of pigment dispersion. This stabilization indicates that the achieved separation of primary pigment particles has to be kept and controlled for a long period.

By adding a dispersant (dispersion control additive) on the pigment surface, attractive forces between the pigment surfaces can be neutralized.

PIGMENT STABILIZATION MECHANISMS

Once dispersed, the primary particles have a tendency to re-agglomerate. This process is called 'flocculation'. The grinding process can be regarded as a de-flocculation process.

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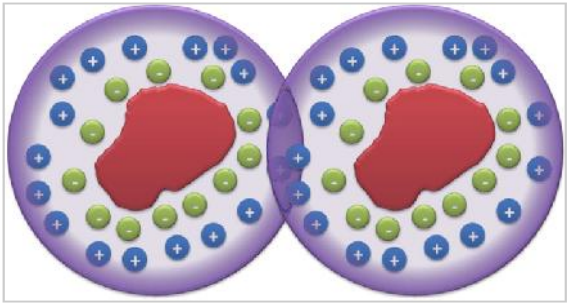
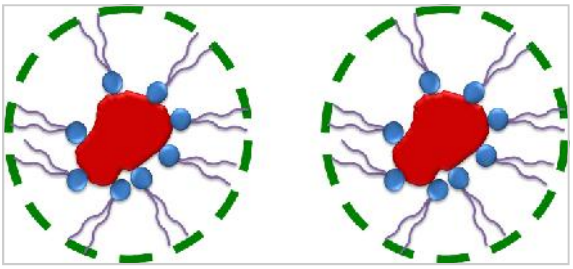
Since agglomerates or flocculates are reducing the color strength and brightness of finished coatings, the task for the coating/ink manufacturers is to stabilize the de-flocculated state of the pigment in the paint.

2 main stabilization mechanisms can be distinguished:

- Electrostatic stabilization: This kind of stabilization takes place when particles bear the same electrical surface charges and as a result, repulsion occurs. The charge around the particle is arranged into a double layer in which each layer possesses an equal charge. When two particles approach one another, their charged double layers overlap and repulsion takes place. At the same time, London-van der Waals forces cause the particles to attract



- Steric stabilization: This stabilization, brought about by adsorbed polymers is dependant upon the structure and dimensions of the adsorbed polymer layer. The polymer can adsorb onto the particle through so-called 'anchoring groups', which have strong affinity toward the particle surface. The remainder of the polymer can be seen as dissolved and can extend into the resin medium. These extended parts of the stabilizing polymer are the first point of contact between two approaching particles.



TYPES OF DISPERSION CONTROL ADDITIVES

DELTA specialties manufactures 2 types of dispersion control additives:

1. Low molecular weight wetting and dispersing agents (DELTA-DC® 4000-series)

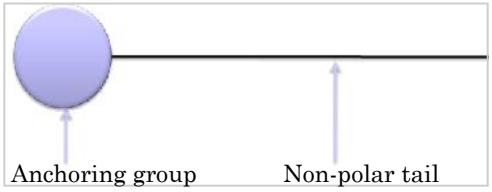
Properties:

- 800 g/mol < Molecular weight < 2,000 g/mol
- Categorized according to their chemical structure and the nature of their hydrophilic groups (amphoteric, cationic, … etc)
- The interaction of their polar groups with the pigment surface and the behavior of the non-polar chains in the medium determine their effectiveness
- Only used for stabilizing inorganic pigments and extenders

Mode of action:

- The polar heads will form hydrogen bonding interactions between different pigment units resulting in a network that enhances the separation of the particles (controlled flocculation)

DELTA-DC® 4000-series



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- This interaction is of great importance in this class of dispersion control additives since the relatively low molecular weight will not give sufficient steric hindrance
- Inorganic pigments are usually metal oxides which contain positive metal ions and negative oxide ions. These ions are good anchoring points that the anchoring groups that build-up the polar head of the dispersion control additive can attach to (polar interactions)
- Unfortunately this type of charge interaction is not possible with organic or black pigments

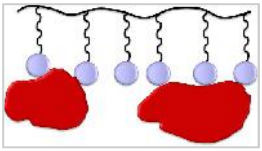
2. High molecular weight wetting and dispersing agents (DELTA-DC® 3000-series)

Properties:

- 5,000 g/mol < Molecular weight < 30,000 g/mol
- They are built of branched or long linear molecules, which in general have a polyurethane or polyacrylate structure
- Designed to adsorb via special groups with high affinity towards specific sites on the pigment surface. These are called anchoring groups, and are built in at strategic points on the polymer backbone
- Suited for inorganic and organic pigments, in addition to carbon black pigments

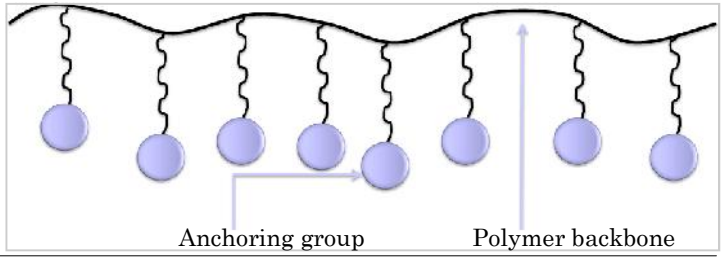
Mode of action:

- Anchoring groups enable strong interaction between the dispersion control additive and the pigment surface
- This interaction is much stronger than in the case of the low molecular weight types as the dispersion control additive is bound to numerous sites on the surface via the anchoring groups (mono-adsorption in the case of DELTA-DC® 4000 series) assuring an efficient steric hindrance between the solid particles by keeping them apart



- The remaining parts of the dispersion control additive act as a steric barrier to the surroundings by stretching into the liquid phase preventing flocculation
- These parts have a good affinity with the solvent and the resin system, so the compatibility with the liquid phase is increased and the viscosity of the paint system is reduced as a desired side-effect
- Organic pigments molecules consist mainly of the elements C, H, O and N. These atoms are not charged and are connected to each other through covalent bonds. Despite the fact that the main interaction between the anchoring groups and pigment surface is hydrogen bonding, this mechanism applies for both organic and inorganic pigments. Inorganic pigments are usually treated with different types of polar organic compounds which enable this interaction to take place as it does by the organic pigments

DELTA-DC® 3000-series



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The compatibility of the dispersion control additive chain in various vehicles is determined by its chemical nature. Therefore different chemistries were developed by DELTA specialties, which are divided according to their chemical composition into two groups:

- Polyurethane-based: They have a branched backbone, with a 3 dimensional network structure. On various places of this network structure, different anchoring groups are introduced. They are compatible with systems from medium to high polarity. They reduce the viscosity of the mill-base greatly and therefore promote the use of higher pigment loading during grinding (pigment concentrate applications). However, since viscosity and tendency for settling may increase in the case of high density pigments (inorganic pigments), it is essential to use a rheological modifier or an anti-settling agent next to the polyurethane-based dispersion control additives

- Polyacrylate-based: They have linear structures with a carbone-carbone backbone, which bears various functional side groups and short chains. They bear groups, which participate in the anchoring of the pigment. Others play a role in the solvation of the acrylate in the liquid medium, or induce a sterical hindrance, that thwarts the re-agglomeration, after the adsorption of the polymer onto the pigment surface. They are compatible with systems from non-polar to very high polar systems and do not reduce the viscosity as much as in the first class. This allows the polyacrylate-based dispersion control additives to promote anti-settling behaviour as well

CHOOSING A DISPERSION CONTROL ADDITIVE

To achieve the best de-flocculation/stability effect of pigment dispersions, one must consider three main points:

- Compatibility of the dispersion control additive with the vehicle
- Quantity of the dispersion control additive in relation to pigment
- Proper application procedure

A quick preliminary test can be carried out to ensure that no major errors are made in the initial choice of the dispersion control additive. The test is done by mixing the dispersant with the main let-down vehicle in the ratio 90:10. The mixture should be clear. It might be necessary in some cases to shake the mixture with glass beads (1:1 by weight) using a shaker like Skandex® for 1 hour. The mixture must then be clear. The extra mixing is needed to find out whether the dispersant is difficult to incorporate or is completely incompatible.

This test, however, is not indicative of the effectiveness of the dispersing agent. It can only predict possible deficiencies in de-flocculation performances (loss of gloss) and, in the case of mixed pigments, the risk for floatation.

Addition levels used in the case of low molecular weight dispersion control additives are generally low and thus can easily be determined. In the case of high molecular weight dispersion control additives, it is of prime importance to use the right addition level in order to achieve an optimum pigment dispersion.

From past experience, a handy calculation method has been developed that will minimize initial testing trials.

For inorganic pigments, the percentage of high molecular weight dispersant (as active material) used on pigment is usually 10% of the oil absorption value*.

For carbon black pigments, the minimum percentage (as active material) used on pigment is 20% of the DBP-value**.

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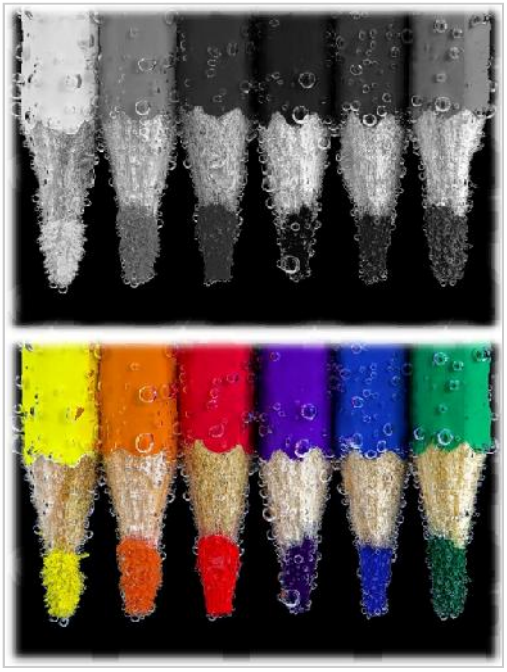
The required percentage for organic pigments is more difficult to determine. The BET-value*** is a good starting point.
For yellow, orange and red pigments, the percentage (as active material) used on pigment is 50% of the BET-value. For phthalo-cyanine blue, phthalo-cyanine green, maroon and violet pigments, with BET-values lower than 50 m^2/g, the percentages (as active material) used on pigment are 50% of the BET-value.

The general guideline for calculating the amount of high molecular weight dispersion control additive required to stabilize a certain type and quantity of pigment will be correct in most cases. However, organic pigments might require amounts of dispersants beyond or below the calculated ones. Such unexpected required amounts are dependant on the way the pigment is pre-treated. Many pigments are pre-treated nowadays, in such a way that they can be dispersed easier than the untreated ones.



Please take a look at our website www.deltaspwll.com (select 'Technical Info' and then 'Pigments list and characteristics') where you can have access to a list (sorted by pigment color) containing a large number of commercially known pigments with their respective technical information (Color index, supplier name, BET-value,...etc).

In case a pigment is not listed in, please contact your pigment supplier to get the required value (OA, BET or DBP) for your calculation of dispersant dosage.

We will be delighted to establish a tailored formulation for you should you find difficulties collecting the technical information from your supplier. All you have to do is to send our Technical Service team a small sample of your pigment.

(*) Oil absorption (OA) value of a pigment is defined as the number of grams of linseed oil absorbed by 100 g of the pigment.
(**) DBP (Dibutylphtalate)-value is defined as being the volume of Dibutylphtalate absorbed by 100 g of carbon black pigment.
(***) BET-value is defined as being the surface area of a pigment per its weight; and is determined by N_2-adsorption method according to Brunauer, Emmet and Teller.

Some think business opportunities, we think business partnerships

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