Organic Pigments – Perfectly Distributed!

Color Masterbatches. The trend in production of color masterbatches is moving toward ever-higher fill levels. By adding specially developed dispersing additives, it is now possible to achieve this with high quality in the final product. These processing aids also help, in particular, to incorporate organic pigments into nonpolar polyolefins.

Addition of dispersing agents facilitates the incorporation of expensive and difficult-to-process pigments considerably

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Processors and compounders are making increasing use of color masterbatches when coloring plastics today (Title photo). This allows them to control the costs of coloring better. At the same time, it is possible to achieve a specific set of properties in the finished part by using this approach. In spite of continually improved compounding techniques for producing color masterbatches, dispersion of organic pigments still presents difficulties.

When challenging, highly filled color masterbatches are involved in particular, the manufacturer is required to use additives such as waxes or fatty acid derivatives to achieve good distribution of the pigments in the carrier resin. Depending on the pigment used, however, satisfactory dispersion results are not always attained. Moreover, it is often necessary to employ additional processing aids (e.g. stearates) that simplify processing. Unfortunately, though, these may produce undesirable effects such as migration, plate-out in the mold or reduced printability at the same time.

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Dispersing

Achieving a fine, uniform distribution of the solid pigment in what is usually a relatively nonpolar polymer melt is one of the most important steps in production of color masterbatches. If this process step does not proceed in an optimal manner when incorporating the pigment, a variety of undesirable effects (Fig. 1) such as those listed below can result:

- Mechanical compacting of pigments during extrusion,
- changes in the color tone,
- flocculation and
- loss of gloss.

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Dispersion involves reducing the size of pigment agglomerates – ideally, down to primary particle size. Agglomerates are collections of several pigment particles with air and moisture trapped in between; the individual pigment particles are in contact with one another only at corners and edges. The forces acting between the particles are relatively low, so that they can be overcome through use of the usual dispersion equipment. Aggregates, on the other hand, are more compact in structure, exhibit surface-to-surface contact and are considerably more difficult to break down into primary particles.

In the course of dispersion (Fig. 2), energy is introduced to the system consisting of pigments and polymers, producing smaller particles that have a larger interface with the carrier polymer. The system wants to revert to a low-energy state from its high-energy state: these flocculates are very similar in structure to the agglomerates, the difference being that the interstices between the pigment particles are now filled with the carrier polymer instead of air. ▶

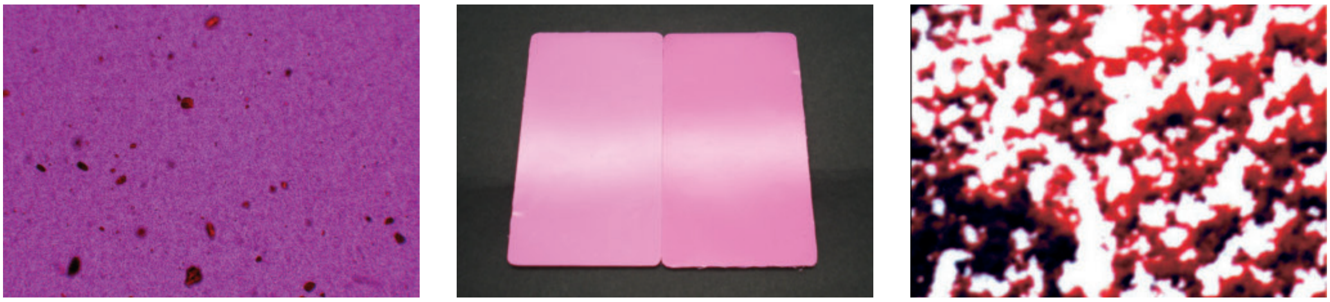

Fig. 1. Undesirable effects during dispersion: mechanical compaction of pigments in an PE-LD film (left), changes in color tone as the result of inadequate dispersion of pigments (center) and flocculation (right)

The Dispersion Process

Pigment dispersion can be broken down into three phases (Fig. 3): In the 1st step, the air and moisture on the surface of the pigment are displaced and replaced by the carrier polymer. The solid/gas interface (pigment/air) is converted into a solid/liquid interface (pigment/carrier polymer). For this to happen, the carrier polymer must penetrate into the interstices of the agglomerate. When producing color masterbatches, an additional problem occurs: feeding the dry pigment/polymer premix often results in mechanical compaction of pigments in the feed zone, since the carrier polymer has not melted quickly enough from heat and shear to prevent this effect.

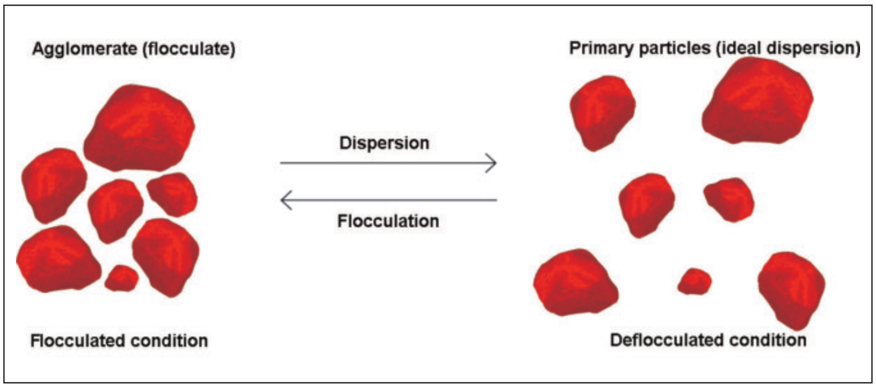

Fig. 2. Ideal underlying pigment dispersion

The 2nd step involves the actual incorporation of the pigment. By introducing mechanical energy (impact and shear forces), the agglomerates are broken up and reduced to the size of their particles.

In the 3rd step, pigment dispersion must be stabilized in order to prevent the uncontrolled and undesirable flocculation. By adding suitable dispersing additives, it is possible to keep the individual pigment particles apart, so that they cannot join together again. Step 1 (wetting) and step 3 (stabilizing) can be influenced by additives.

Polymer Dispersion Additives

In contrast to waxes and stearates, polymeric dispersion additives adsorb to the pigment surface, keep the pigment particles apart through steric stabilization and in this way reduce the tendency toward uncontrolled flocculation. Furthermore, they melt considerably faster during extrusion and wet the pigments before the polymer melts. This prevents the undesirable compaction of unwetted pigments. It is important that the additives are distributed optimally in order to wet the pigment as uniformly as possible during extrusion.

The polymeric dispersion additives Disperplast-1018 and Byk-P 4102 developed by BYK-Chemie GmbH, Wesel, Germany, are based on the effect of steric stabilization. They are characterized by two distinct structural features: First of all, they contain so-called "pigment-affine groups" – anchor groups that are responsible for firm and long-lasting adsorption to the pigment surface. The second characteristic feature involves the carrier polymer-compatible chains that extend as far as possible away from the surface of the pigment after adsorption of the additive and extend into the surrounding polymer carrier of the masterbatch. Flocculation can no longer occur, since the pigment particles are shielded by the additive molecules (Fig. 4).

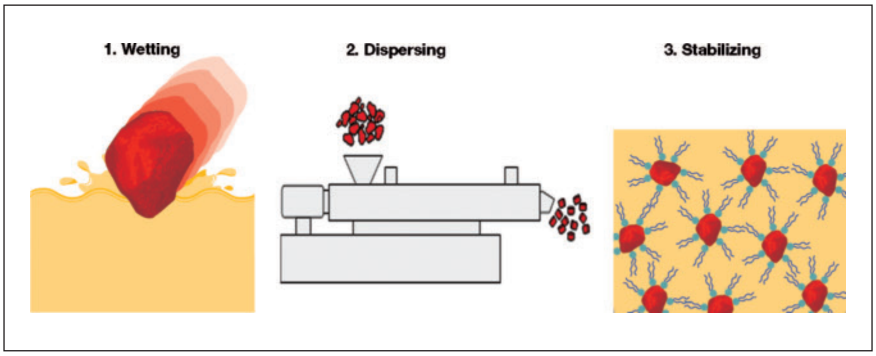

Fig. 3. Schematic illustration of the wetting and dispersion processes

Field of Use

When producing color masterbatches, the trend is toward ever-higher fill levels. These can now be attained through addition of the additives Disperplast-1018 and Byk-P 4102.

The previously mentioned benefits of these two additives also become evident when the organic pigments copper phthalocyanine and chinacridone red are involved. Dispersion is improved even with diketopyrrolopyrrol pigments.

From the multitude of application-related results, only the most common organic pigments are presented here: copper phthalocyanine (P.B. 15:1), chinacridone red (P.R. 122) and azopigments

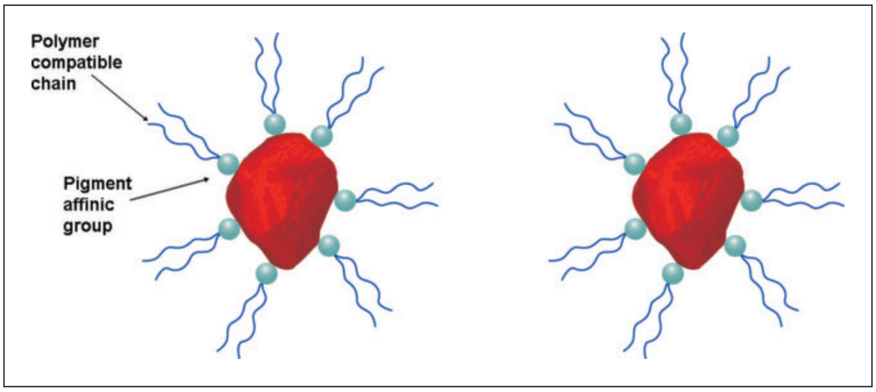

Fig. 4. The dispersing additives are based on the effect of steric stabilization

(P.R. 53:1), each dispersed in a PE and PP carrier polymer. The dispersing additives Disperplast-1018 and Byk-P 4102 were added to these basic formulations in different concentrations to determine the effect of the amount added. Only the optimized result is sometimes presented.

A color-guide spectrophotometer from BYK-Gardner was used to evaluate the color strength. An extruder from Labtech Engineering Company Ltd. provided the filter pressure values in accordance with DIN ISO 13900-5.

All masterbatches were produced on a Berstorff ZE 25 UT extruder (25 mm screw; L/D 40; screw speed: 1,200 rpm). The premixes for the masterbatches came from a 10-l high-speed mixer from Labtech Engineering Company Ltd. The test specimens were molded on an ES 200/75 HL-V injection molding machine from Engel Austria.

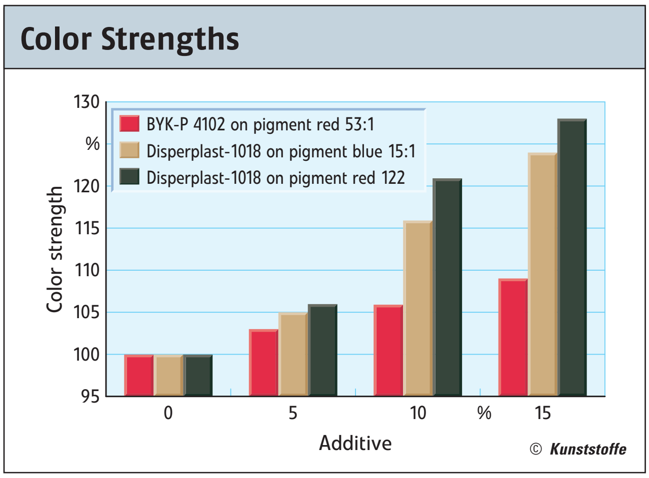

Fig. 5. Increase in color strength of PP masterbatches with 40 % pigment load at increasing additive dosing

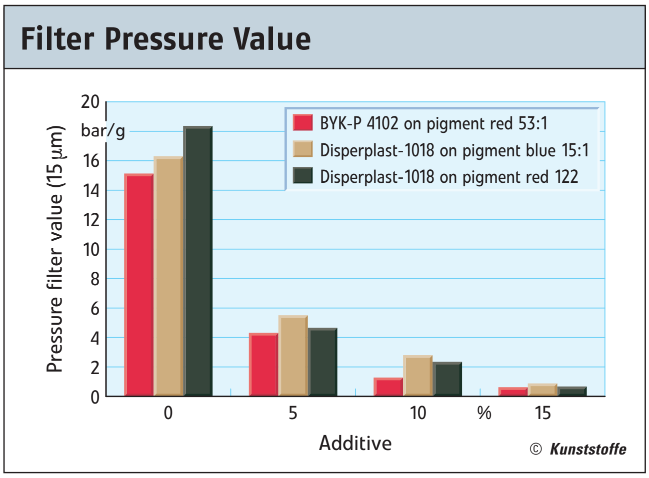

Fig. 6. Decrease in filter pressure value of PP masterbatches with 40 % pigment load at increasing additive dosing

Case Study of Dispersion Quality

For the organic pigments copper phthalocyanine (P.B. 15:1) and chinacridone red (P.R. 122), the dispersion additive Disperplast-1018 achieved greater color strength than that measured for the control without additive. Figure 5 shows the different color strengths. To produce the masterbatches, the powdered polymer, with additive and pigment, was mixed in the high-speed mixer for 5 min at 900 rpm. Following this, the premixes were processed in the twin-screw extruder at 800 rpm and a throughput of 20 kg/h. The color strength was then measured on the injection molded test plaques.

For the organic pigments copper phthalocyanine (P.B. 15:1), chinacridone red (P.R. 122) and the azopigment (P.R. 53:1), Byk-P 4102 achieved lower filter pressure values than those obtained for the control without additive. Figure 6 shows a comparison of the filter pressure values. To produce the masterbatches, the powdered polymer, with additive and pigment, was mixed in a high-speed mixer for 5 min at 900 rpm. Following this, the premixes were processed in the twin-screw extruder at 800 rpm and a throughput of 20 kg/h. The color strength was then determined in accordance with DIN EN13900-5.

Conclusions

The dispersing additives Byk-P 4102 and Disperplast-1018 make it possible to incorporate organic pigments into polyolefins much more easily. This simplifies the use of expensive and difficult-to-disperse pigments, giving processors a higher-value end product with enhanced properties from their process. ■

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