The Smaller – The Better? Influence of Dispersion Quality on the Performance of Toner Ingredients

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Abstract

In general an electrophotographic toner consists of pigment, charge control agent (CCA) and wax which are homogeneously dispersed into a resin and, if necessary, contains external additives. For dispersing the toner ingredients into solid matrices in conventional toner processes, two roll mills, extruders or kneaders can be used. Liquid dispersions that are used in chemical toner processes or as a liquid toner are usually dispersed using bead mills. The dispersion quality of the toner ingredients has significant impact on charging properties, color strength, transparency etc. This presentation will discuss some selected examples relating to the dispersion quality of pigments and CCAs and the resulting effects on toner performance.

Predispersion of Pigments

The final goal of incorporating pigments into liquids or solid matrices is to reach a uniform distribution of the particles. In the case of the predispersions that are discussed in this presentation it is usually the aim to also attain the smallest particles possible (primary particles). In addition, other factors for dispersion quality are final stability of the dispersion (no viscosity changes, settling etc.) and (chemical) purity (= no abrasion).

Selection of Raw Materials for Pigment Preparations

For non-impact printing (NIP) usually pigments are selected which cover the process colors yellow, magenta and cyan (Fig. 1).

Even if two pigments are based on the same chemistry there are large variations in their behavior during the dispersion process. This depends on physical properites such as crystal shape and size as well as on the additives (influencing the surface properties) that are usually modified for each special application. Thermal stability is in some cases also important.

The compatibility of the medium with the pigment is important and influences the ease of dispersion as well; in solid preparations a pigment can show very different final coloristic properties in different resins.

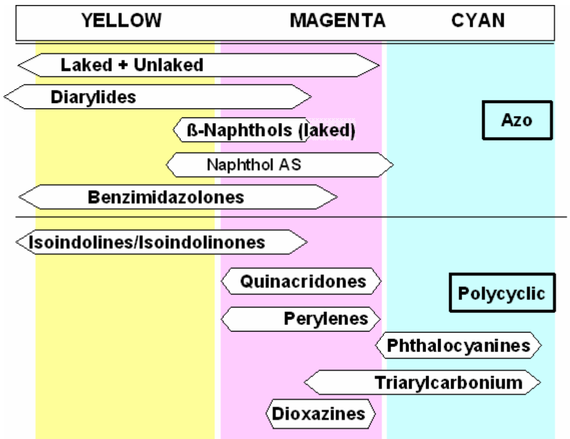

Figure 1. Selection of pigments used in non-impact printing[1]

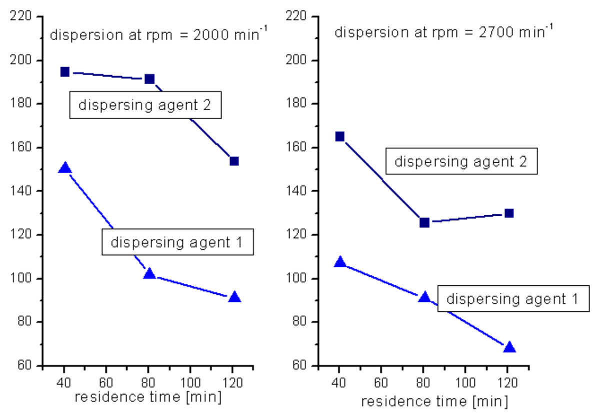

Figure 2. Dispersion of red azo pigment using different dispersing agents

The same holds true for the dispersing agent in liquid preparations, and the most challenging step in developing excellent preparations is normally to find the right combination of dispersing agent and pigment. In Fig. 2 dispersing agent 1 works much better than dispersing agent 2 as can be seen in the comparison of the d_{50}-value plotted against the residence time of the preparation on the bead mill. And also the d_{50}-value that eventually can be reached is better for dispersing agent 1 than for dispersing agent 2. In addition the preparation with dispersing agent 2 exhibits an increase in viscosity on storage whereas the preparation with dispersing agent 1 is stable with respect to that property.

Choosing the Right Process

Depending on the quality of the system, i.e., pigment and dispersing agent/medium more or less energy input is needed to reach the desired product quality. Energy input can be changed by using different machines (kneader, extruder, two roll mills; horizontal or vertical bead mill), by changing the process parameters (viscosity of the batch, shear forces, bead load, rpm). But higher energy input also causes some negative effects as, for example, production of heat (therefore efficient cooling is necessary) and abrasion (Fig. 3).

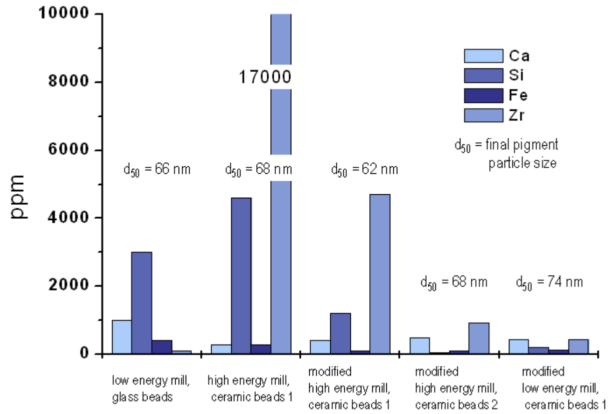

Figure 3. Contamination of yellow azo pigment preparations (in ppm of total non volatile solids)

Table 1. Possible Effects on Toner Ingredients

Quality parameter		Possible effect
small d_{50} in dispersion	+	high color strength
small d_{50} in dispersion	+	high transparency
small d_{50} in dispersion	-	problems in stabilizing: viscosity increase
recrystallization during dispersion	-	hue changes
"wrong" dispersing agent	-	final stability: viscosity increase
"wrong" dispersing agent	-	possible final d_{50} higher; low color strength and transparency
"wrong" dispersing agent	-	high energy input needed: more abrasion
high energy input needed	-	abrasion

Possible Effects

With respect to classical printing, toner ingredients have to fulfill some special requirements[2]; therefore, special care has to be taken in producing preparations that are used as raw materials in toners like e. g. Hostacopy® pigment preparations.[3] Table 1 lists some quality parameters and their possible effects on the performance in the final application of electrophotography.

Dispersing CCAs

In most toner systems CCAs are the main ingredient for adjusting the triboelectric charge of the toner particles. The function of the CCA is to provide a quick charge up to a sufficient charge level and to maintain the long term charge stability of the toner.[4,5] For supporting the charge properties of the CCA, external additives like fumed silica are often used by adding them externally to the toner. The basic function of such external additives is to provide the required flow properties of the toner powder.

From a historic consideration, the first products used as CCAs were azo-metal complex dyes in the late 1960s/early 1970s. The history of market relevant CCA types is shown in Fig. 4.

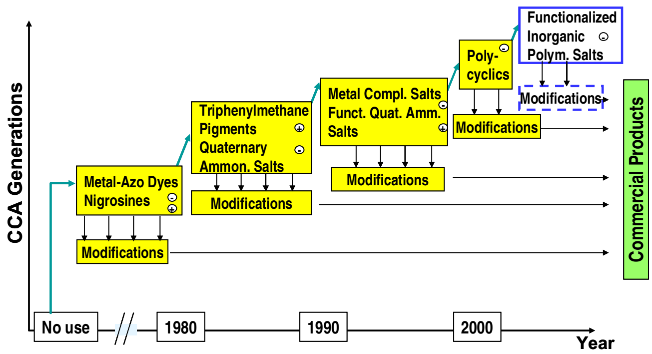

Figure 4. History of CCAs

An example of a CCA from the latest group of functionalized inorganic salts is a hydrophobically modified layered metal oxide (HMLM).

In order to obtain the optimum charging properties with a CCA in a toner the usual course of action is to obtain the highest dispersion quality in the toner polymer. But when using a colorless CCA (which is an important prerequisite for CCAs for color toner applications) it is almost impossible to observe by simple methods the distribution of colorless particles within the colorless polymer. Microscopic investigations which are normally used for checking pigment dispersion quality cannot be applied due to the missing contrast of the colorless additive in the polymer. Therefore for the detection of a colorless CCA in a polymer (and therefore its dispersion quality) a different method is necessary.

ToF-SIMS (Time of Flight-Secondary Ion Mass Spectroscopy) fulfills both requirements based on a chemical characterization by mass spectroscopy.

Surface Analysis by ToF-SIMS

By scanning the surface of toner particles pixel by pixel one obtains characteristic mass fragments of either the polymer matrix or any kind of additive or pigment dispersed inside. The resolution of this method is around 1 micron. The resulting mass fragment distribution can be visualized by a so-called overlay image of the toner surface using different colors for the different characteristic mass fragments detected. Consequently the surface distribution of the different ingredients in a toner particle can be measured. For a conventionally-prepared toner (by extrusion, grinding and classifying) the particle surface distribution represents also the inside particle distribution because the only difference is a crushing step. Fig. 5 shows the distribution of a HMLM-based CCA in a polyester toner.

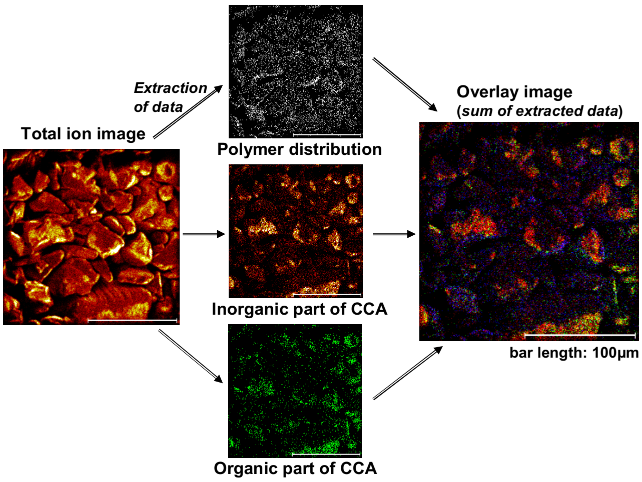

Figure 5. Distribution of a HMLM-based CCA in a polyester resin detected by ToF-SIMS

For the qualitative investigation of the dispersibility of the HMLM-based CCA a one-step dispersion of 1% of the CCA in a polymer with a diluted predispersed preparation of the CCA was compared with the same final concentration of 1% in the polymer. This means the latter dispersion is a two-step process: a) dispersing the CCA into a 40% preparation, b) diluting that preparation down to 1% CCA content in a second dispersion step. The result of the ToF-SIMS investigations of these both dispersion approaches is shown in Fig. 6.

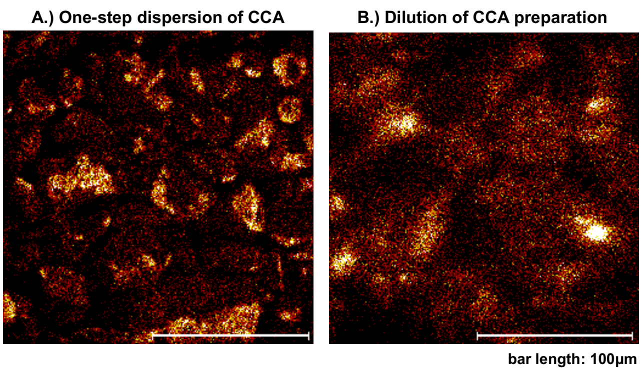

Figure 6. Visualized ToF-SIMS results of the one-step dispersion of the HMLM-based CCA in comparison to the two-step process using a predispersed 40% preparation

The dispersion quality of the diluted preparation is much higher than directly dispersing the CCA into the resin resulting in a much more homogeneous distribution of the CCA in the diluted preparation.

Interaction between CCA Dispersion and Tribocharge

When checking the triboelectric properties of these differently-dispersed CCA systems a higher tribo charge was observed for the diluted preparation (see Fig. 7).

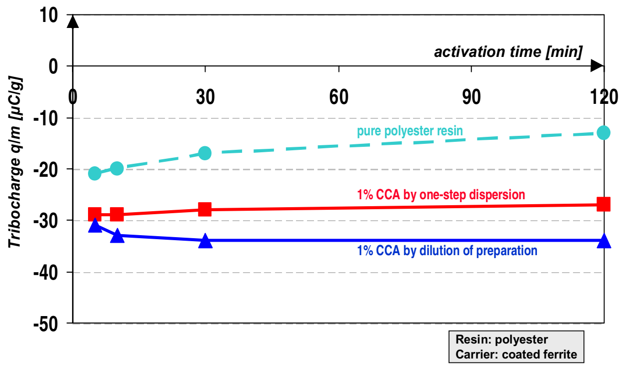

Figure 7. Tribocharge results of the one-step dispersion of the HMLM-based CCA in comparison to the two-step process using a predispersed 40% preparation

Therefore one can conclude that when using the HMLM-based CCA in a toner, a finer and more homogeneous distribution in the polymer results in an enhanced tribo charge of the system.

Conclusion

In dispersing toner ingredients particle size is a very important parameter. In pigment preparations it influences the coloristic properties very significantly. When considering the dispersing of a CCA one can conclude that in the use of a HMLM-based CCA in a toner, a finer and more homogeneous distribution in the polymer results in an enhanced tribo charge of the system. Therefore, "the smaller – the better" refers to the most important property that has to be considered in producing preparations for toner applications, but in addition, further parameters have to be evaluated carefully as these can have significant impact on the performance of the preparation in the final toner application.

References

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Biographies

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