Formulating Pigmented Inkjet Inks More Easily by Using Tailor-made Pigment Dispersions

S. Frahn, G. Tauber and W. Kalbitz
Degussa AG, Hanau, Germany

Abstract

The growing market for inkjet printing in outdoor applications and digital photo printing is creating a need for inkjet inks with high water and light fastness. Such properties can be achieved by using pigmented inkjet inks. For the formulator the following questions arise: Which pigments give the best results? What is the right method for dispersion? Which technology should be used for proper stabilization of dispersed pigments?

This paper will give an answer to these questions and show how Degussa Gas Blacks and newly developed dispersions help to make the formulation of pigmented inkjet inks easier.

Introduction

In the development of pigment dispersions which are tailor-made especially for water based inkjet inks the high standards of two completely different dispersion systems must be met:

- an aqueous pigment dispersion with high pigment content and excellent long-term stability;
- the final ink produced using a wide assortment of ink additives and a very low pigment content.

Furthermore, technical challenges imposed by the specifics of the printing head technology and printing media as well as by the surface chemistry of pigments and the way these pigments are dispersed and stabilized have to be taken into account.

This article summarizes a study on the preparation of some pigment black dispersions using a variety of stabilization systems. Special attention is payed to the properties of these dispersions which are relevant to the final ink formulation.

Experimental

Degussa Gas Blacks are state-of-the-art for inkjet applications when it comes to the choice of black pigments.[1] In the unique gas black manufacturing process properties for use in inkjet inks such as good wettability and dispersibility combined with high purity can be customized.[2,3] Therefore, such a carbon black with a primary particle size of 20 nm and 5% of volatile surface groups was chosen for this study. The dispersants used were commercially available non-ionogenic (→ sample 1) as well as anionic (→ sample 2), cationic (→ sample 3), and polymeric dispersants (→ sample 4). A surface-modified gas black which is stable without addition of dispersant after dispersion in water, was used as well (→ sample 5).

Due to the easy dispersibility of the gas blacks it was possible to prepare the dispersions with a Hielscher ultrasonic disperser UIP 500 in a continuous-flow cell. The following properties of these dispersions were characterized:

- the degree of dispersion by light microscopy;
- the particle size distributions by Photon Correlation Spectroscopy (PCS);
- the flow curves with a rheometer equipped with a double-gap measuring system;
- the dynamic surface tension with a bubble pressure tensiometer;
- storage and compatibility tests, followed by investigating the reagglomeration, sedimentation tendency, changes in viscosity and the pH value;
- the optical density of 6 µm drawdowns on uncoated and coated paper with a spectrophotometer.

Results

The light-microscopic studies of all five samples showed a good, homogeneous basic dispersion and no coarse particles bigger than 1 µm. A good basic dispersion can be obtained for the surface-modified gas black without adding any dispersant, while the other samples require large amounts of such additives. PCS measurements on all dispersion samples showed average particle sizes smaller than 100 nm; no particles larger than 300 nm were found.

Both surface tension and rheological properties of the pigment dispersions are essential parameters that have a strong impact on the flexibility in formulating the finished ink.[4] To ensure a universal use of pigment dispersions, they must have a viscosity as low as possible, ideally in the range of the finished inks, and the highest possible surface tension.

Even with a pigment content as high as 15 % all dispersions gave a viscosity of less than 3.5 mPas which is close to that of finished inks. Sample 3 which was stabilized with cationic additives showed the lowest surface tension of all samples, limiting its use to inks which require a surface tension of more than 40 mN/m. By contrast, the samples 2 and 5 have a surface tensions similar to that of water, thus providing optimum flexibility in ink formulation.

In order to determine the quality of a pigment dispersion storage stability tests and compatibility studies with ink additives are necessary. Any changes in the rheological properties or the particle size distribution by reagglomeration during high-temperature storage or in the dilution step after addition of an adjuvant disqualify a dispersion for use in inkjet applications. In the high-temperature storage test, all five dispersion samples met the required quality criteria. In the compatibility study the anionically and cationically stabilized dispersion samples 2 and 3 led to incompatibilities with some ink additives, as made evident by an increase in viscosity and by reagglomeration. Dispersion samples 1, 4 and 5, however, did not result in an incompatibility.

The next step in judging the quality of a pigment dispersion is the preparation of an printable ink. Evaluation of the optical density of the prepared inks as a function of pigment content and paper grade gave the following results:

- For all five dispersion samples, an increase in pigment content from 4 to 5% in the final ink did not provide a clear improvement in optical density.
- All five dispersion achieved high optical densities on inkjet papers.
- The optical densities of the inks based on the dispersions 1 through 4 on plain paper were dependent on the paper grade.
- Dispersion 5 which contained the surface-modified gas black reached the highest optical densities independent of the paper grade.

For the final check of a pigment dispersion printing tests must be run. For this purpose both a piezo printer and a bubble jet printer are to be used in the SOHO area, as the requirements regarding the ink properties are quite different for the two printer types. Due to a lack of pH stability and an insufficiently low surface tension for some bubble jet ink formulations no printing tests were conducted with dispersion 3.

The physicochemical characteristics of the inks prepared with the ink dispersions were adjusted to the level of the original inks using the same set of additives for all four inks. This was easiest to perform with dispersion 5. In the printing test the ink based on this dispersion also gave the highest optical densities on inkjet and plain paper. In terms of smear resistance, dispersion 4 containing a polymeric dispersant afforded the best results.

Conclusion

Our study on gas black dispersions which were stabilized by different means, clearly shows the importance of the way the pigment is stabilized for the dispersion properties as well as for the inks prepared thereof. The right choice of pigment stabilization facilitates the formulation of inks and allows precise adjustment of the desired ink properties. The present results also illustrate the complexity of the development of tailor-made pigment dispersions. In our study the dispersion with the surface-modified pigment (sample 5) showed the greatest potential for universal applicability. Its low viscosity, high surface tension, good storage stability, and excellent compatibility with ink additives are ideal prerequisites for the formulation of inkjet inks. The resulting inks both for bubble jet and piezo printers showed extremely high optical densities and excellent printing properties independent of the paper grades used.

References

1. Stübbe, A.; Karl, A.; Kalbitz, W. “Investigation of the Applicational Properties of Carbon Blacks used in Pigmented Inkjet Inks”, NIP 14, 1998
2. Degussa Brochure „What is Carbon Black?“
3. Degussa Technical Bulletin Pigments No. 14, “Properties of pigment blacks and methods for their characterization”
4. Pond, S. F. “Inkjet Technology and Product Development Strategies”

Biography

Stephanie Frahn received a Ph.D. in chemistry from the Gerhard-Mercator Universität-GH-Duisburg, Germany. In 1998 she joined an applied technology department of Degussa AG, concentrating on the application of AEROSIL in coatings. In 2004 she assumed the position of a Director Applied Technology Printing Inks and is responsible since for technical service as well as the development of pigments for both traditional printing inks and non-impact printing.