Textile Ink Jet Printing with Low Viscosity Pigment Inks

Ulrike Hees, Mike Freche, Michael Kluge, John Provost, and Juergen Weiser
BASF Aktiengesellschaft
Ludwigshafen, Germany

Abstract

The development of textile pigment ink solutions is a very complex area were currently available systems have been tailored to individual ink jet print head technologies.

The present paper will outline developments in the area of novel polymer dispersing agents for pigment inks, which allows the production of textile pigment inks with low viscosity profiles suitable for piezo print heads.

These new textile pigment ink jet inks produce ink jet prints, which are comparable to traditional textile pigment screen prints.

Introduction

In conventional textile screen-printing the use of pigments is the major coloration method, with over 50% of the world textile printing market using this method. With improvements in the technology and increasing environmental pressure on dye-based textile printing systems, that require a washing off stage, the use of textile pigment printing will increase further. The predictions from a recent study by BASF are that textile pigment printing will increase from 11 billion square metres in 2002 to 15 billion square metres in 2012.[1]

The developments in conventional textile screen-printing in the coming years will focus on both the physical form of the pigment dispersion formulations and the textile binder and the important chemical components of the textile screen ink formulation. This will produce further improvements in the fastness and handle of the pigmented printed textile. This performance level must also be matched by any textile prints produced by ink jet printing.

The current textile ink jet printing market is still extremely small and amounts to no more than one percent which is confined to the pre print sample and coupon printing areas and a number of markets such as the flag/banner market, sportswear and niche printed fashion articles. From BASF market studies it is estimated that textile ink jet printing will achieve a significant market penetration over the next 10 years with developments in both the hardware and the ink chemistry.

In a previous paper,[1] the current development status with pigment textile ink jet printing was reviewed. One of the major points highlighted was that the addition of the polymer binders to the textile pigment ink jet ink had an affect on the resultant ink viscosity as shown in Figure 1. The usual binder amount required to achieve acceptable fastness performance is approximately 15% in the textile screen ink. If this amount is added to a textile ink jet ink, the resultant viscosity is outside the performance parameters of some of the most popular piezo print heads used in the current generation of textile ink jet printers. (For example in the Mimaki® Engineering Ltd TX series of printers)

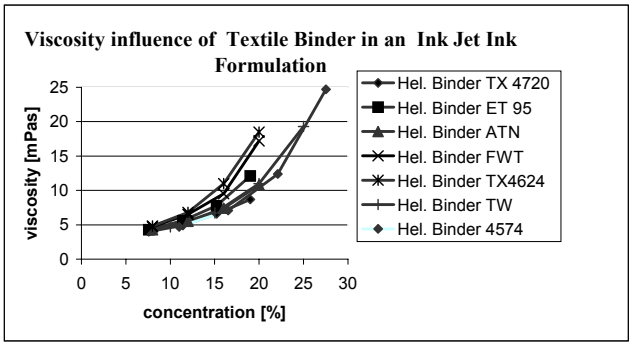

Figure 1. Influence of Textile Binder on Ink Viscosity

There is no universal pigment ink solution as much depends on the print head technology that is being used in the specific textile ink jet systems. The currently available textile pigment ink jet inks, which contain textile binder, have in general been developed for piezo print heads, which can tolerate higher viscosity inks (>10 mPas). For low viscosity piezo print heads (< 5 mPas) the pigment ink jet inks generally contain no binder and the textile binder is applied by a separate post treatment stage.

Table 1 gives a matrix of textile pigment ink formulations and print head types and indicates whether a textile pigment ink jet ink could be developed by the various strategies mentioned.

The general conclusion from our studies is that a new chemical approach is required to produce pigment textile ink jet inks with low viscosity ink jet inks (<5 mPas). Any new approach must achieve similar print performance in terms of color fastness and color yields to conventional textile screen prints.

Table 1- Possible Textile Pigment Ink Jet Approaches to Different DOD Print Head Technologies

	Piezo head-Low viscosity	Piezo Head Higher Viscosity	Thermal Print Head
Pigment Ink No Textile Binder	Yes	Yes	Yes
Pigment Ink with Textile Binder	No	Yes	No
Pigment Ink with Multi-Functional Dispersant	Yes	Yes	No

New Chemical Approach to Textile Pigment Inks

The current paper introduces a new chemistry approach to textile pigment ink jet inks by using novel multi-functional polymeric dispersing agents.

This new system can achieve the fastness and handle performance without the addition of textile binders to the textile ink jet ink. This allows the ink parameters, particularly the viscosity profiles to be tailored to low viscosity piezo print heads.

The new chemical approach includes various polymeric architectures such as block copolymers, dendritic structures, hyper-branched polymers and comb-like copolymers. The dendritic structures in comparison to the hyper-branched structures shown in Figure 2 are well known and have a perfectly defined branching and globular structure. However the synthesis of these well-defined molecules usually requires many steps and cleaning cycles between each manufacturing stage. For industrial use the hyper-branched polymers supply a non-perfect tree like structure with the same properties but better access via easier synthetic approaches.[2]

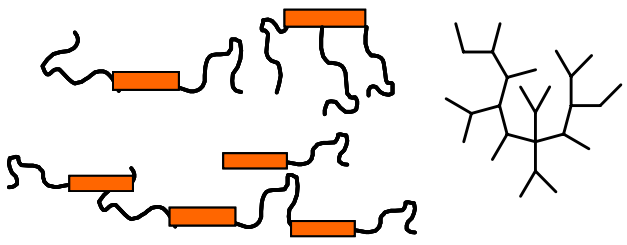

Figure 2. Various Dispersant Polymeric Structures

These structures can be achieved by various polymeric synthesis approaches and can include anionic or cationic groups as well as hydrophilic or hydrophobic blocks. The following polymers can serve as building blocks for the block copolymers mentioned above: Polyacrylic esters, Polyesters, Polyalkyleneglycols, Polyacrylamides, Polyurethanes, Polyvinylalcohol, Polyvinylacetate, Polystyrene, Polyvinylformamide, Polyvinylamine, PolyTHF,

The dispersing functionality can be best achieved by combining hydrophobic and hydrophilic or ionic building blocks. The hydrophobic blocks and or ionic groups provide interaction with the pigment surface, whilst the hydrophilic and ionic parts give the stabilization in aqueous medium by steric and ionic stabilization.[3] For steric stabilization polyethylene glycol, polyvinyl alcohol and hydroxyl fuctionalized polyacrylates can be incorporated into the stabilizing blocks. Electrostatic stabilization is best achieved by incorporating ionic groups, however the influence of counter ions, pH and the total ion concentration has to be taken into account.

For textile applications the glass transition temperature and flexibility has to be take into account. The key textile properties such as the "handle" and crock fastness strongly depend on these parameters.

In general, the ideal molecular weights for polymeric dispersing agents are in the low to medium molecular weight area. Higher molecular weight polymers tend to branch various pigments together resulting in irreversible agglomeration of the particles, also the dynamics of these higher molecular weight polymers is too slow to provide optimal dispersion functionality.

In contrast, lower molecular weight dispersants provide fast wetting of the pigment surface, but sufficient steric stabilization cannot be provided. These low molecular weight dispersants for aqueous systems usually rely on electrostatic interactions only, resulting in systems, which are more dependent on pH, ionic strength and temperature.[4]

Our new multifunctional dispersing agent (MFDA) not only disperses and stabilizes the pigments in the low viscosity aqueous media, it also provides additional functions to the ink jet ink.

Inks with MFDA can be formulated with low viscosity and excellent long-term jettability on a wide variety of piezo drop on demand printers. The resultant MFDA textile ink jet inks produce textile prints with the following properties:

- High color strength
- Increased definition
- High crock fastness
- High wash fastness
- High brilliancy

Results with MFDA Ink Jet Inks on Textiles

The following section will provide quantitative data on fastness and color strength of our new MFDA based inks in comparison to pigment textile ink jet inks formulated with a commercial binder or a commercial textile ink jet ink without binder.

For the fastness comparison tests we compared ink jet inks, which contain textile binder, which usually give poor jettability and not ideal viscosity for low viscosity print heads. For the color strength comparisons we compared our new MFDA ink jet ink system with commercially available

Helizarin® inks,[1] which show already excellent results for color strength with a variety of pigments.

As shown in the previous paper,[1] conventional binders provide excellent fastness if applied in the correct concentration (normally 15% of binder) in conventional textile printing inks. However, for optimum viscosity for low viscosity piezo print heads we can include only 5 % of binder into the ink jet ink (Figure 1). Pigment concentrations in these systems vary from 2 – 5% resulting in a pigment to binder ratio for the conventional binder of 1:1. Conventional screen printing systems usually provide a pigment to binder ratio of 1:5 to meet the fastness requirements. Depending on the pigment concentration even 5% of binder can result in inks of too high a viscosity to be printed in an ink jet printer. However even if the inks can be printed, after drying and fixation, the resulting fastness levels determined by crock tests are poor (as shown in Figure 3). As result we assume that compared to a commercial binder at the same concentration in the ink, the MFDA provides better fixation properties.

Conventional textile prints provide fastness levels of 4 (ISO Scale) depending on the printed color and application method (which is the generally accepted minimum international standard).

Figure 3 shows the comparison of MFDA produced textile ink jet inks compared to ink jet inks containing 5% commercial textile binder. After printing and fixation of the prints, the crock tests show improved results for the MFDA based ink jet ink.

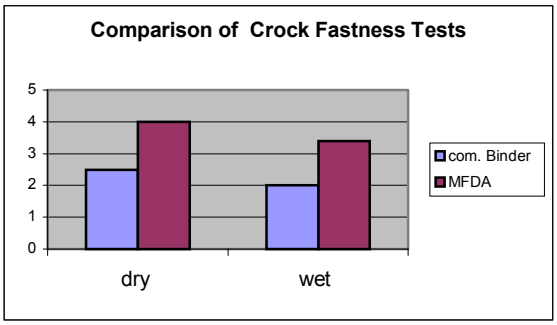

Figure 3. Crock Fastness Results Ink Jet with commercial textile binder compared with MFDA ink jet inks (Blue pigment ink)

The color fastness results from the MFDA ink jet inks are producing the same results compared to conventional screen-printed pigment/binder inks.

We have also found that the color strength with MFDA ink jet inks is also greater than textile ink jet inks that have been produced by the use of conventional dispersing agent, which contain no binder.

The results from this comparison is shown in Figure 4, the commercial inks are set as standard to 100% in color strength (left columns), the right columns show the increase of color strength by using MFDA based ink jet inks for the various pigments (CMYK set).

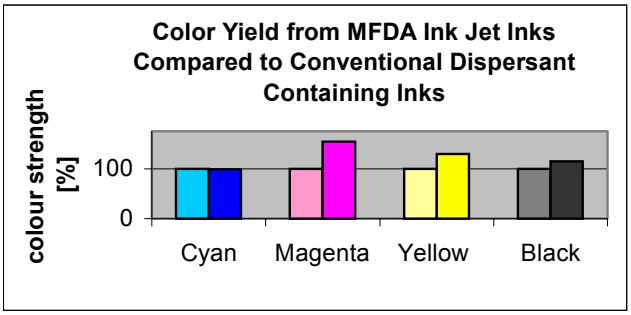

Figure 4. Color Yield of printed samples from Ink Jet inks produced with MFDA and Commercial dispersant

The reason for these improved ink properties is due to the increased dispersion stability and permanent attachment of the MFDA to the pigment, which leads to no agglomeration of the pigment itself upon the addition to the textile surface.

As we have discussed before,[1] for textile printing applications the fastnesses performance to mechanical abrasion is one of the most important parameters. Table 2 shows the results from crock fastness tests conducted on an ink jet printed textile with MFDA inks after a conventional bake fixation (150°C, 5 minutes).

Table 2. Crock Fastness Results from MFDA ink jet inks printed on Cotton

	Crock test-Dry	Crock test-Wet
Cyan	4	3-4
Magenta	4-5	3-4
Yellow	4-5	3-4
Black	4	3

Compared to the fastness levels in conventional textile pigment screen-printing the results are similar.

In addition the use of MFDA based inks does not interfere with the textile properties such as soft handle.

Conclusions

In conclusion textile ink jet inks produced with this new MFDA approach can achieve the fastness performance and color yields with textile ink jet printers which are using low viscosity piezo print heads. This new approach combines various functions into one multi functional dispersing agent and importantly eliminates the requirement for the addition of a textile binder. These MFDA textile ink jet inks are particularly suitable for piezo print heads, which have the requirement for very low viscosity (such as found in the Mimaki ® (Japan) printers TX Series).

These experimental Helizarin® ink jet inks are currently undergoing beta testing with promising results.

References

1. U. Hees, M. Freche, M. Kluge, J. Provost, J. Weiser, I.S.&T. NIP18: 2002, International Conference on Digital Printing Technologies, 242-245
2. E. Malmström, A. Hult, "Hyperbranched Polymers: A Review", J. M. S. Rev. Macromol. Chem. Phys. 1997, C37 (3), 555 - 579
3. J. Schofield, Progress In Organic Coating, **45**(2002), 249
4. Z. Wicks, F. Jones, S. Pappas, J. Coating Tech., **73** (2001), 25

Biography

Dr. Ulrike Hees received her Ph.D. degree in chemistry from the University in Mainz. (During her studies she did research at UCSB and Stanford University in the USA). In 1998 she joined BASF AG in their Research Department in Ludwigshafen and carried out research on novel polymer systems. In 2001 she joined the Global Business Management Ink Jet Inks and is currently head of the Product Development team, developing industrial ink jet printing solutions, including textile applications.