Dispersed Dye Ink for Ink jet Textile Printing

Kazumasa Matsumoto and Hideyuki Anzai
Konica Corporation
1 Sakura-machi Hino-shi, Tokyo/Japan

Abstract

Several dispersed dye inks for ink jet textile printing were developed. These inks are use for the textile made of polyester fiber. Dispersing technology according as dispersed dyes are insoluble or slightly soluble to water base solvent is necessary in order to make fine particle of dyes and good storage stability. Distribution of particle size (average size of dye particle) was necessary smaller than 250nm because of stable firing. To make fine particle size, selection of dispersing agent and dispersing mill condition was important factor and then we obtained stable dispersing dye inks for firing and storage.

Introduction

Recently, the development of ink-jet recording method that comprises adhering flying ink (recording liquid) droplets onto recording media, thereby forming color images. Particularly, the printing for textiles relates to an ink-jet recording method for recording full-color images with a wide range of reproducibility of colors and with good gradation. Therefor the time has come to recognize ink jet as a mainstream digital printing technology for textile printing. Although ink jet printing system as using digital data is expected from continued growth, the market forecast for color ink jet printing in dyeing industry is indeed bright for the benefit of saving resources and energies.

Inks for textile printing are using a several kind of dyes.

For example, acid dyes are used for textile of silk or wool and reactive dyes are used for textile of cotton. These dyes are very soluble in water based solvent. For the textile of polyester, disperse dyes are used but these dyes are insoluble or slightly soluble in water based solvent for inks.

The color pigments that are insoluble in water and organic solvents are used to the inks for office and industrial ink jet printers. But the concentration of dispersed particles in the dispersed dye ink for textile printing is higher than in the pigment ink for paper by the dyeing industry's requirement. Therefore that the dispersed dye ink for ink jet textile printing has both characteristics of stability for firing and storage is difficult. Generally, when a ink contains high concentration dye particles, the viscosity of the ink becomes higher than in the case of low content of dye particles. Furthermore, dye particles apt to close the ink jet nozzles of firing head in the case of high content of dye particles and apt to precipitate during storage of ink.

Selection of Dye

The terms for the selection of dyes are as follows.

1. The safety for human health (not noxious dyes)
2. The hues of dyes after printing and heat treatment
3. The appropriate characteristic for printing
4. Durableness for sunshine, friction, sweat, washing and etc.
5. A high light absorbance
6. Insoluble property for water and organic solvents of dispersing dye ink

There is not sufficient dye that pass all above terms. The hues of typical printings are indicated Figure 1

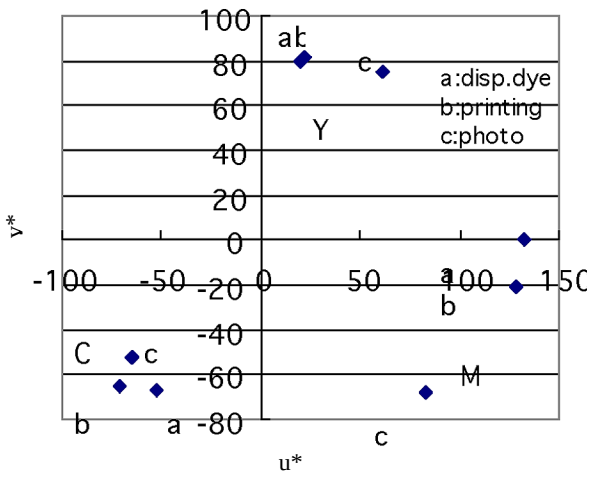

Figure 1. The hues of dyes after printing

The dye of black ink are consist of the mixture of deep yellow, deep magenta and deep cyan because of that there is not a single dye which is sufficient for the requirement.

To make a decision of dye concentration, several inks that are made in different of dye concentration were printed onto polyester textile (180micron thick) and treated by heat and washing. The results show Figure 2.

In order to obtain the deep colored printing, the dye concentration in ink is high as a necessity and the degree of dye concentration is different from a kind of dye. The dye concentration of each color is determined by balance of each color.

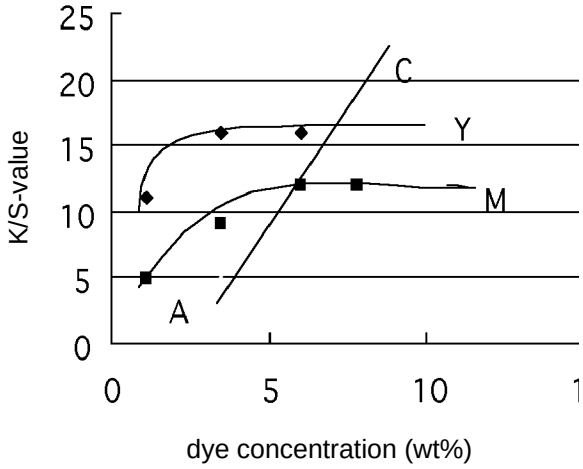

Figure 2. Influence of dye concentration in ink

When the concentration of dye particles is high, the viscosity of ink become high and the viscosity of ink has to be necessary within the limits because the viscosity of ink has an effect on droplet size.

The relationship between viscosity and droplet size is shown in Figure 3 and the behavior is shown linear.

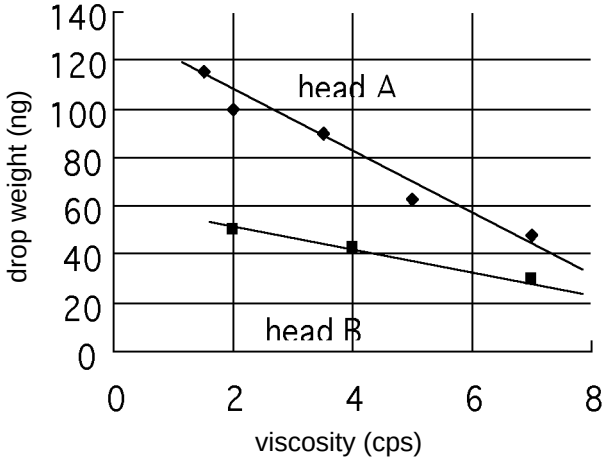

Figure 3. The relationship between viscosity and droplet size

The nozzle head must fire sufficiently stable to produce drops with a volumes of around 50pl for textile substrates. The relation ship between droplet volume (droplet weight) and the size of each printed pixel on the fabric (assuming no lateral spread) is able to calculate that the 360dpi of printed pixel on the fabric is necessary to 50pl of droplet volume.

The particle size of dispersing dye (particle diameter) is an important factor for stable firing from the capillary tube of ink jet nozzle. There is a experimental law that the pigment size is necessary smaller than 1/50 of diameter in ink flow system for stable firing.

The dependence of stable firing upon the particle size of dispersing dye in our ink jet printing system is shown Figure 4. As this result, the average particle size of dispersing dye is necessary smaller than 250nm in our system.

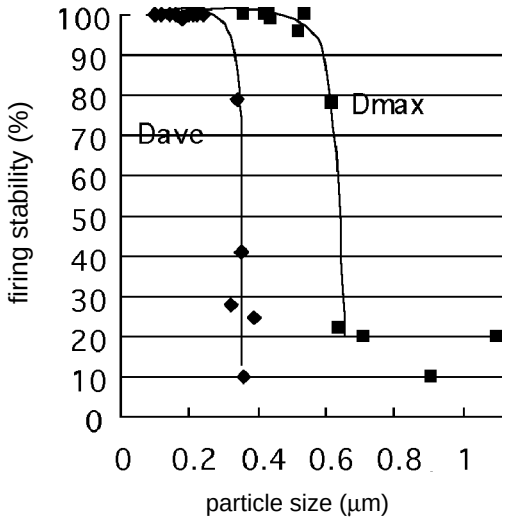

Figure 4. Dependence of firing upon particle size of dispersed dye

Properties and Behavior of the Dispersion

Dispersion behavior, itself a kinetic process, is understood as the behavior of a solid dye formulation used when preparing an aqueous dispersion under defined conditions.

The important terms for dispersability are as follows.

1. Chemical affinity (dye, dispersing agent, solvent)
   The wettability, rate of formation of the dispersion and the fine distribution achieved are the decisive factors that affect the properties of the dispersion.
2. Mechanical energy (media mill condition)
   The properties of the dispersion are the size distribution and shape of the dye particles or agglomerates, and the stability of the aqueous dispersion under defined conditions.
3. Physical stability (Stokes law etc.)
   The stable properties of the dispersion during storage and dye application are given at thermodynamic laws.

To make a fine particle size of dispersing dye, the common dispersing apparatus what is called media mill is used and the average particle size of dispersing dye is controlled by the kinetic energy of dispersing mill. When the dispersing mill of a different type is used, the time to achieve the prescribed size is different but the kinetic energy of machine (dispersing mill) is a same value.

The fine particles of dispersing dye become large during storage by aggregation without optimum conditions. As a result of aggregation, the average particle size of dye become over 250nm diameter and then the large particles will clog the orifice of jet nozzles and the dye concentration in the upper layer of ink will decrease by the precipitation of dye particles. Accordingly affinity of dispersing dye and dispersing agent is important.

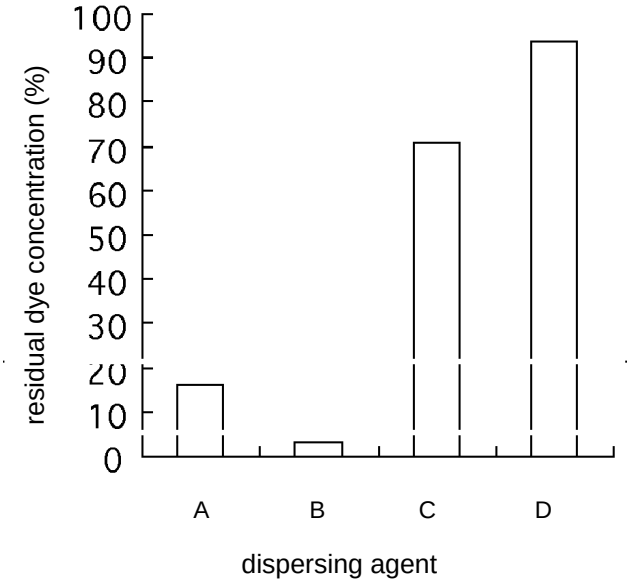

Figure 5. Dependence of storage upon a kind of dispersing agent

We measured the stability test by the below mentioned method. A diluted aqueous dye dispersion (dispersing dye ink) is heated at 60 centigrade in polypropylene bottle and the distribution of particle size and the concentration of dispersing dye are measured by each instrument.

Dependence of storage upon a kind of dispersing agent shows in Figure 5. These dispersing agents are different from surface tension of ink and solubility of dye.

Further more the ratio of dispersing agent and dye and the amount of dispersing agent have influence on storage stability. Each dye has a different condition that is the species, the amount and the ratio of dispersing agent as against dye. Figure 7, 8 show the dependence of aggregation upon the ratio of dispersing agent.

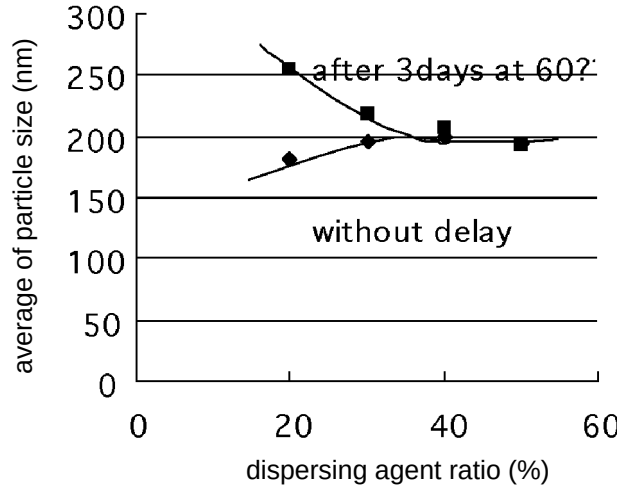

Figure 6. Dependense of aggregation upon the ratio of dispersing agent at accelerate condition

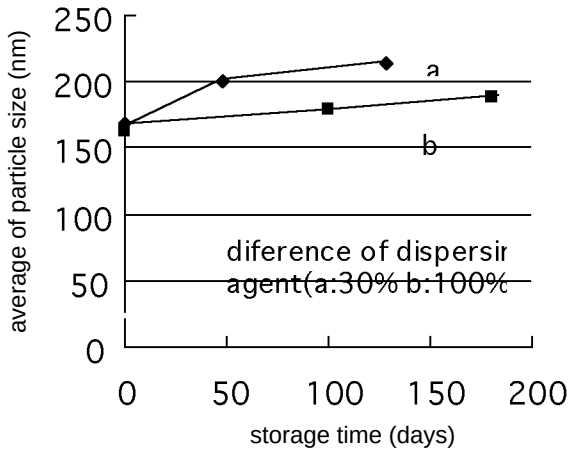

Figure 7. Dependence of aggregation upon the ratio of dispersing agent

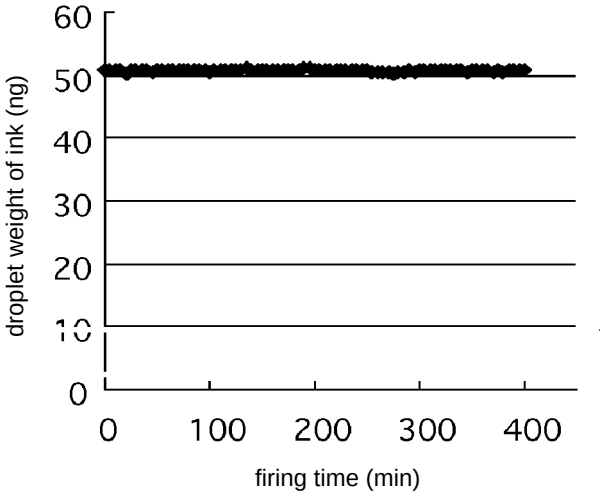

Figure 8. The weight change of droplet during firing

The dispersing dye ink made by above mentioned method shows continuously stable that the weight of droplet is invariable during firing in Figure 8.

Conclusion

Dispersed dye ink for ink jet textile printing was developed for ink jet textile printing machine of 1600mm wide, namely Konica KS-1600, in order to print out the digital design onto polyester textures. These inks achieved good stability for ink drop firing and for storage by means of dispersing technology that adopt the appropriate conditions and agents for dispersing. And these inks printed out the deep color picture onto polyester textiles.

We continue developing the stability for firing and storage and the characteristic colors.