Effect of additives on Colloidal properties and printing performance of disperse dye blue inks for inkjet printing

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Abstract

Disperse dye inks as one of the main colorant materials for polyester fiber in textiles inkjet printing have attracted more and more people's attention. In this paper, the nanoscale disperse dye blue dispersion was prepared, and further the effects of additives on colloidal properties and printing performance of disperse dye blue ink were investigated. Particle size distribution revealed that particles were small and uniformly distributed into aqueous media. Amount of polyols, defoamer and surfactants have significantly influence on colloidal and printing performance of the disperse dye blue ink. The optimal formulation of disperse dye blue ink was obtained with polyol 27 wt%, surfactant 1.0-1.2 wt%, and defoamer 0.25 wt%.

1. Introduction

Textile inkjet printing as a novel textile dyeing technology has more incomparable advantages than those of traditional printing technologies [1]. Disperse dye ink as a main colorant for the printing of synthetic fibers should have proper viscosity, surface tension and high stability [2, 3]. It is known that disperse dye ink is a multi-phase system consisting of disperse dye particles, water, surfactant, polyols and so on. Although a number varieties of disperse ink have come up to the market during these years[4], it still remains some defects such as big particles, wide size distribution, easy to clog the nozzles of printing head which limit its wide usage in the field of textile printing.

In order to get a favorable disperse ink with good printing performance, we first prepared a nanoscale disperse dye dispersion, and followed investigated the additives such as surfactant, glycerol, deformer on colloidal properties and printing performance.

2. Experimental

2.1 Materials

Polyoxyethylene nonyl phenyl ether (OP-10) and glycerol were purchased from Shanghai chemical reagent company. Sodium lignosulfonate and defoamer organosilicon was supplied by Ciba specialty chemicals Ltd. china, Demonized water was used for all the experiments.

2.2 Preparation of disperse dye ink

10 g disperse dye and 4g Sodium lignosulfonate was added into 86g demonized water stirred for 30min by a homo-mixer (Shanghai experimental instrument Ltd.) to get a homogeneous mixture. Then the mixture was transferred to the bead mill machine (NetETZSU Company, Germany) and dispersed at 2400r/min for 5 hours. Then the samples were filtrated by 1000nm pore filtering sieve. Inkjet inks were prepared from the dispersions to test their printing performances. The ink formulation based on weight is given in Table1. The ink components were mixed together under stirring at 300r/min until a homogeneous dispersion was obtained. After filtered through a 500nm pore filtering sieve, the inks were loaded for inkjet printing.

Table1. Formulation of inks for inkjet printing

Disperse dye dispersion	20%
Glycerol	x%
OP-10	y%
defoamer	z%
Demonized water	n%
Total	100%

2.3 Measurements

Dispersions were diluted 2000 times, followed by adjusting pH to 8.0. The particle size (d) and particle size distribution (PDI) was measured with Nano-ZS90 (Malvern Instruments Ltd, UK). Centrifuging stability was measured according to our previous research [5]. The apparent viscosity of the disperse ink was measured by viscometer (Brookfield, USA) at 25℃; Surface tension was performed by drop analyzer (DSA-100, Germany); Deforming time was observed by sand cores chromatography column; the clog ratio was calculated according to the following equation:

$$B = (n_0 - n_1) / n_0 \times 100\% \qquad (1)$$

Where: n_0 is the number of unclogging nozzles before printing; n_1 is the number of unclogging nozzles after printing

3. Results and discussions

3.1 Stability of disperse dye ink to additives

20g glycerol, 2g OP-10, 0.5g defoamer and 77.5g demonized water were mixed under stirring at 50℃ for 24 hours to achieve a uniform system, and then its size distribution was measured.

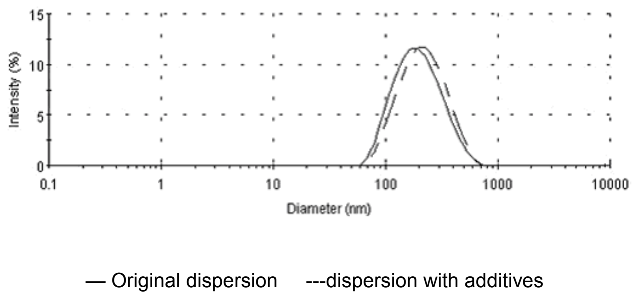

Figure1. *The stability of disperse dye ink to additives*

Figure1 showed that the two curves are almost coincident, and the two peaks keep at 200nm and the width of two curves have no obvious difference, which illustrate that additives have little influence on particle size and its distribution.

3.2 Effects of polyols

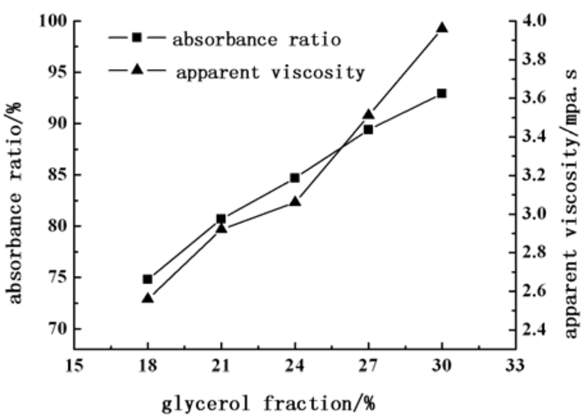

Figure2. *Effects of the amount of glycerol on absorbance ratio and apparent viscosity, OP-10 1.0 wt% and defoamer 0.3wt%*

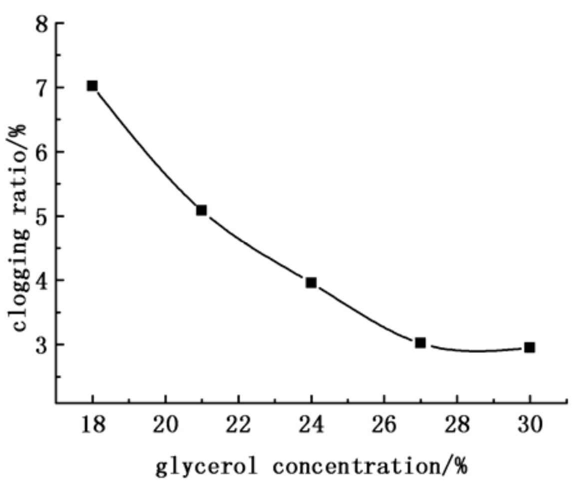

Figure3. *Effects of the amount of glycerol on the clogging ratio, OP-10 1.0 wt% and defoamer 0.3wt%*

Figure2 indicated that the apparent viscosity and stability of the ink increased with increasing glycerol concentration. One molecule of glycerol contains three molecules of –OH which makes it is easy to combine with water by hydrogen bond, resulting in reducing the amount of free water, thus led to large apparent viscosity. The improvement of the stability may be explained by Stokes equation:

$$V = 2r^2 (d_1 - d_2) g / 9v \quad (2)$$

Where: V is particle deposit rate, r is diameter of the dye particle, d_1 and d_2 are density of medium and dye particle, respectively, v is viscosity of medium.

From the Eq(2), it is known that the increase of the viscosity can reduce the particle deposit rate when the particle size changed little.

Fig.3 illustrated polyols can significantly improve the inkjet printing performance. In an experimental range, the more amount of glycerol, the better printing performance was. The reasons may be that the glycerol has other functions besides viscosity regulation such as lubrication and moisturizing which are beneficial to improve the printing performance. When the amount of glycerol reached to 27%, the clogging ratio is no longer decrease with further addition of glycerol.

3.3 Effects of surfactant

Surfactant is another important additive when preparing inkjet printing ink. Figure4 illustrates that OP-10 can decrease the surface tension and improve centrifugal stability of the ink. When amount of OP-10 reaches to 1.2%, there is nearly no changes of surface tension and centrifugal stability. The explanation is that small amount of OP-10 absorbed into the fovea of disperse dye particle playing a good complementary role to the dispersant absorbed on the surface of disperse dye originally.

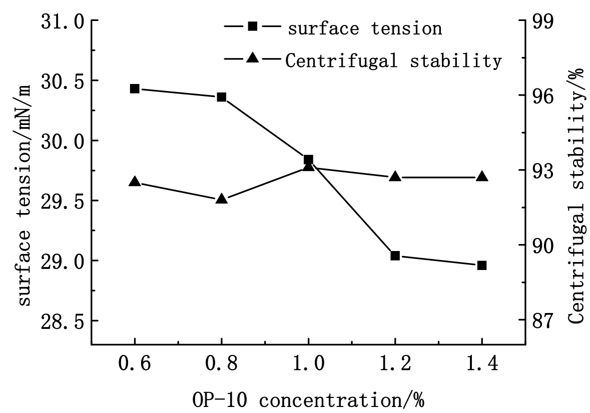

Figure4. *Effects of the amount of OP-10 on surface tension and absorbance ratio, Glycerol 27 wt% and defoamer 0.3 wt%*

The amount of OP-10 can also affect the printing performance of the inks. Figure5 indicated that the ink have good printing performance when the concentration of OP-10 was in the range of 1.0~1.2 wt%. Smaller surface tension may improve the printing performance, therefore the printing performance improved with increasing the amount of OP-10. However, OP-10 has foaming and stabilizing bubble effects, the amount of OP-10 should not be too much, or it will produce a large number of persistent bubbles affecting its printing performance.

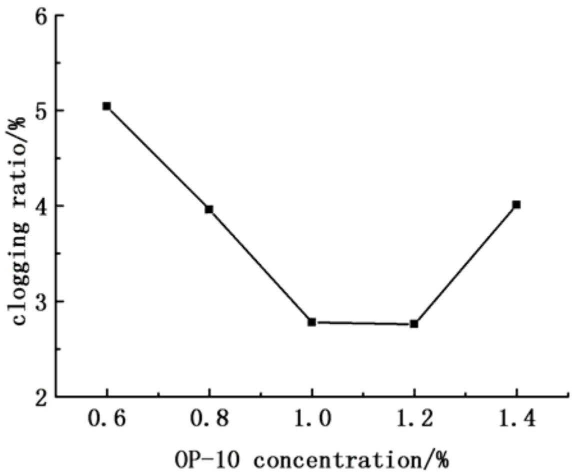

Figure5. *Effects of the amount of OP-10 on clogging ratio. Glycerol 27 wt% and defoamer 0.3wt%.*

3.4 Effects of defoamer

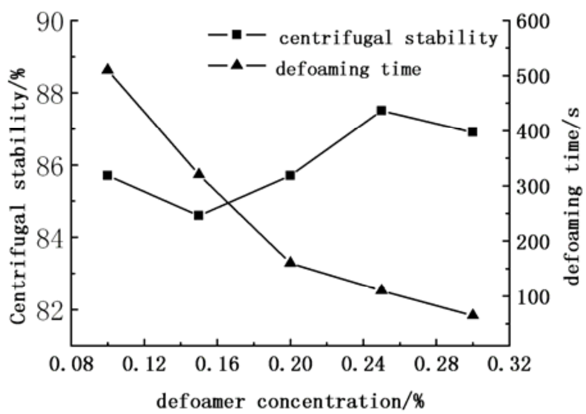

Figure6. *Effects of the amount of defoamer on absorbance ratio and defoaming time, Glycerol 27 wt% and OP-10 1.2%*

Figure6 exhibited that the defoaming time decreased sharply while the stability changed small with an increase of the defoamer concentration. Figure7 illustrated that the optimal amount of defoamer is about 0.25%.

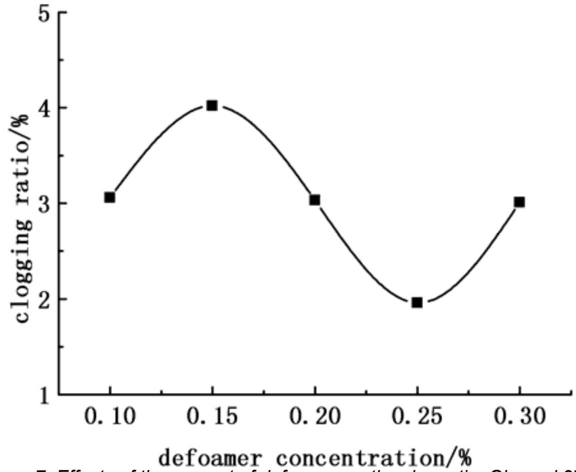

Figure7. *Effects of the amount of defoamer on the clog ratio, Glycerol 27 wt% and OP-10 1.2%*

Conclusions

The following conclusions can be drawn from this investigation: the stability and printing performance of the ink were improved with the increase of the amount of glycerol, and within a certain concentration range glycerol had viscosity regulation effect; OP-10 could adjust the surface tension, but too much usage affected printing performance; small dose of defoamer exhibited an outstanding improvement in breaking bubbles and printing performance. An optimal ink formulation is with dispersion 20 wt%, glycerol 27 wt%, OP-10 1.0-1.2 wt%, defoamer 0.25 wt %, and the rest is distilled water.

References

[1] Gucel, Modern Digital Textile Printing: Providing a Competitive Edge in an Evolving Market. Nedim1 International Dyer. Pg.25-27. (2008).

[2] Hak, Lae Lee. Jung, Won Jang, Sang, Gillee, Role of cationic additives and binders on color development in ink jet printing. Appita Annual Conference, v 1, 61st Appita Annual Conference and Exhibition, Proc. Pg. 327-333. (2007).

[3] Chang, S. Y. Peggy, Chao, Y.C., Preparation of microemulsion based disperse dye inks for thermal bubble ink jet printing. Sci. and Technol., pg. 413-418. (2007).

[4] Krüger, C. Dieleman, C., Kluge, M., Innovative ink jet inks for textile printing .International Conference on Digital Printing Technologies, Final Program and Proceedings of IS and T's NIP20, pg. 610. (2004).

[5] Fu Shao-Hai, Fang Kuan-Jun, Effect of Additives on Stability of Waterborne Nonsocale Pigment Red 122 Dispersion, Sci. and Technol., pg.29, 115-119. (2008).

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