Influence of Components on the Properties of Pigment Inks for Textiles

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Abstract

For inkjet printing, pigment inks are suitable for all kinds of fibre, the printing procedure is simple without both pretreatment and after-treatment. In the future, the research and development of pigment ink will be the main trend of the inkjet printing technology. In this paper, the influence of polyhydric alcohol, surfactant, de-foaming agent on ink performance, such as viscosity, surface tension and so on, was analyzed. The compatibility of polyhydric alcohols such as 1, 3-propanediol, diethylene glycol, 1, 6-hexylene glycol, glycerine with pigment ink has been researched, and effect of the amount of polyhydric alcohols on the viscosity and surface tension of ink was discussed. The function of surfactants OP-7,OP-10 and OP-15 in ink has been analyzed, the results show that surfactant OP-7 and OP-10 could decrease the surface tension of inks below 30mN/m when the amount used about 1.0% or lower by weight. The efficiency of reducing surface tension falls down in the sequence of the surfactants OP-7, OP-10 and OP-15. The effect of the amount of surfactant on the viscosity was not very significant. The defoaming effect of n-butyl alcohol on pigment ink has also researched in this paper.

Introduction

Inkjet printing is a non-impact printing technology in which droplets of ink are jetted from a small orifice directly to a specified position on a media to create an image. This technology is used in a wide range of applications including office, industrial, chemical engineering, medical, textile printings and so on[1].

Textile inkjet printing has demonstrated super advantages over the customary textile printing methods, such as excellent pattern quality, environment friendly, and especially rapid response to the frequent shift of fashion. For textile inkjet printing, inkjet inks are one of the significant factors for perfect product. They are usually classified into two categories as dye inks and pigment inks, according to the colorants in them. Pigment inks are suitable to all kinds of fibres, and their printing procedure is very simple, as final products can be achieved by simple heat curing without steaming and washing[. The research and development of pigment inks will be the main trend of textile inkjet printing technology in the future [2-6]. Generally pigment inks were consisted of ultra-fine pigment, water soluble organic solvent, surfactant, defoaming agent, deionized water and other components [7].

In this paper, pigment ink (Nanojet® Pinks Yellow) was prepared by adding additives into ultrafine pigment. Effect of additives on ink properties such as viscosity and surface tension was analyzed, thereof including polyhydric alcohol, surfactants and defoaming agent.

Experimental

Materials

Ultrafine pigment (C.I. Pigment Yellow 14, weight content 25%) was made by Nanocolorants and Digital Printing R&D Center of Jiangnan University. 1,3-propanediol, diethylene glycol, 1,6-hexylene glycol, Glycerin, n-butyl alcohol were reagent grade. Surfactants OP-7, OP-10 and OP-15 are industrial products.

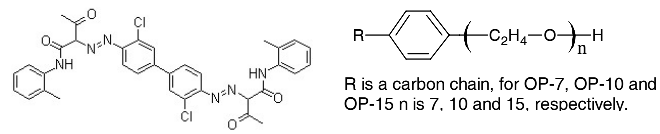

***Figure 1** Schematic structure of C.I Pigment Yelow 14 and surfactants OP-7, OP-10 and OP-15.*

Formulation of the pigment ink

Firstly, known amounts of deionized water, polyhydric alcohols, surfactants and deforming agent were mixed together and agitated to obtain a homogeneous solution.

Then the ultrafine pigment was added to the former solution and stirring at 700rpm for 5 minutes.

Viscosity measurement

The viscosity of pigment ink was measured by DV-III ULTRA Programmable Rheometer (Brookfiled America) at 20 degrees of centigrade.

Surface tension measurement

The surface tension of pigment ink was measured by KRüSS Drop Shape Analysis 100 (KRüSS Germany) at 20 degrees of centigrade.

Defoaming performance measurement

Firstly, pigment ink was added into the foaming-meter (made by ourselves, measuring the foamability of dispersion). The valve of nitrogen cylinder was opened slowly, and then the solution would come into being foam. The valve should be closed as soon as the height of foam arrived at the highest point and keep a record of the time. The time would be noted when the foam declined to its half height and disappeared.

Results and discussions

The effect of polyhydric alcohols on the surface tension and viscosity of pigment ink

Polyhydric alcohols were mainly used to adjust the surface tension and viscosity and improve the fluidity of the pigment ink. Known amounts of 1, 3-propanediol, diethylene glycol, 1, 6-hexylene glycol and glycerin were added into the disperse system. The relationship between the amount of alcohols and the viscosity and surface tension of the disperse system was investigated, and the results were shown in Figure 2 and Figure 3.

Figure2 shows that the addition of polyhydric alcohols increased the viscosity of the ink. The viscosity reflects the inner friction of the liquid. There are many hydroxide groups in polyhydric alcohols, which could form hydrogen bonds with H_2O. The hydrogen bonds will increase with the increasing polyhydric alcohols, and the hydrogen bonds are existed among the hydroxide groups of the polyhydric alcohols. So the inner friction of the disperse system will increase when the molecules of the system are moving, and the viscosity will increase with increase of polyhydric alcohols' concentration. Although the polyhydric alcohols can increase the viscosity of the pigment ink, the polyhydric alcohols can also cooperate with the pigment ink well and do not influence the fluidity of the pigment ink much.

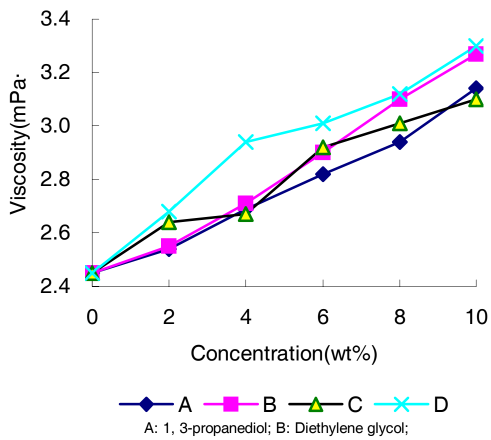

Figure 2 *Effect of polyhydric alcohols on the viscosity of pigment ink*

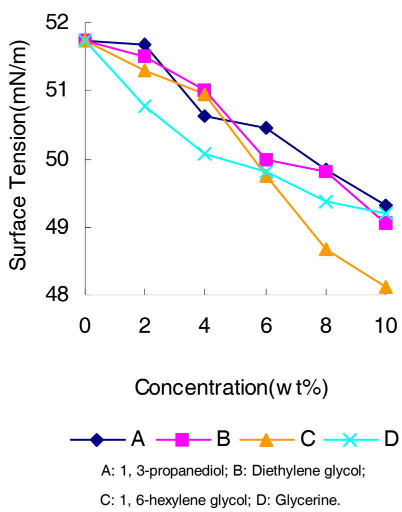

Figure 3 *Effect of polyhydric alcohols on the surface tension of pigment ink*

Figure 3 illustrates that the addition of polyhydric alcohol can decrease the surface tension of the pigment ink. The hydroxide groups of polyhydric alcohol are strongly hydrophilic while the carbon chains are hydrophobic. The hydroxide groups will disslove into water and the carbon chains will run out into air when the polyhydric alcohols dissolve in water, so that the polyhydric alcohols can decrease the surface tension of the solution.

Effect of surfactants on the surface tension and viscosity of the pigment ink

Surfactants are a kind of substance that can greatly decrease the surface tension of solution. So that surfactant can efficiently decrease the surface tension of pigment ink. The relationship of the concentration of surfactant and the surface tension of ink was shown in Figure 4.

Figure 4 shows that the surfactants can effectively decrease the surface tension of the disperse system with an order of OP-7>OP-10>OP-15.

The main function of surfactants is to adjust the system's surface tension. At the same time the surfactants will partially influence the viscosity of the system as shown in table 3. With the increasing of the concentration of surfactants, the viscosity of the system increases. The change of viscosity is small when the concentration of surfactants is below 2.0%. From figure 1 we know that the surfactants could be decreased to the scale of 25-35mN/m when the concentration of surfactants is 0.5-1%.

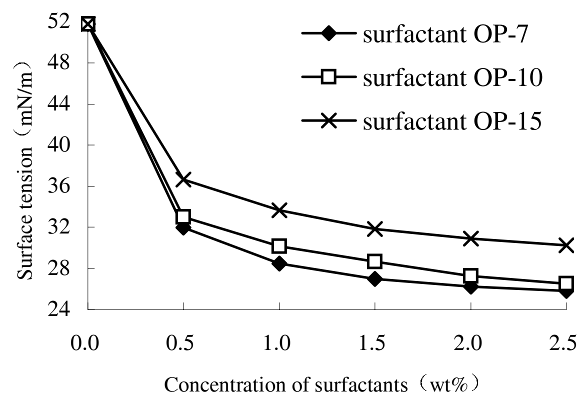

Figure 4 *Effect of the surfactants on the surface tension of pigment ink*

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Table1 Effect of surfactant on the viscosity of pigment ink (mPa·s)

Concentration (%)	OP-7	OP-10	OP-15
0	2.45	2.45	2.45
0.5	2.46	2.55	2.46
1.0	2.38	2.54	2.51
1.5	2.52	2.51	2.60
2.0	2.63	2.49	2.56
2.5	2.71	2.66	2.69

The defoaming performance of n-butyl alcohol in pigment ink

The foamability of the pigment ink is important for its use. Because the foam may result in the jam of the nozzle, so the defoamer is necessary for the ink. The defoaming agent can reduce the foam and break the foam in little time.

As our experiment shows that n-butyl alcohol has favorable defoaming performance. The experiment results were exhibited in table 2.

It was shows in table 2 that the defoaming time of the pigment ink decreases as the increase of the n-butyl alcohol's concentration. When the concentration of the n-butyl alcohol is 1%, it will reduce the defoaming time evidently. As the concentration of n-butyl alcohol increases build up to 4%, the defoaming time of the pigment ink will never change. So the defoaming performance will be best when the concentration of the n-butyl alcohol is about 3%-4%.

Table 2 the effect of n-butyl alcohol on the defoaming time of pigment ink

Concentration (%)	Half Defoaming Time[a](min)	Defoaming Time[b](min)
0	38	120
1.0	18	40
2.0	15	32
3.0	12	27
4.0	8	17
5.0	8	16
6.0	9	17
7.0	8	17

[a] The time needed that the height of foam decreases from its highest point to its half height.

[b] The time needed that the height of foam decreases from its highest point to its disappearance.

Table 3 the effect of n-butyl alcohol on the properties of pigment ink

Concentration (%)	Viscosity (mPa·s)	Surface Tension (mN/m)
0	2.45	51.75
1.0	2.52	50.06
2.0	2.65	46.55
3.0	2.77	38.43
4.0	2.84	35.26
5.0	2.91	33.26
6.0	3.05	33.12
7.0	3.21	32.96

Table 3 shows that the defoaming time of the pigment ink decreases as the increase the concentration of n-butyl alcohol. When the concentration of the n-butyl alcohol is 1%, the defoaming time of pigment ink will reduce evidently. As the concentration of n-butyl alcohol increases build up to 4%, the defoaming time of pigment ink will never change. So the defoaming performance will be best when the concentration of the n-butyl alcohol is about 4%.

The viscosity and surface tension of pigment ink was influenced by adding n-butyl alcohol, which was shown in table 3. The viscosity of the system increases as increasing the concentration of n-butyl alcohol. While the surface tension of the system decreases. In the case of concentration of n-butyl alcohol builds up to 3%, the surface tension decreases sharply. But the surface tension will not keep on decreasing when the concentration increases more than 3%.

Conclusions

This work indicated that additives such as polyhydric alcohols, surfactants, and defoaming agent had influences on the viscosity and surface tension of pigment ink. Polyhydric alcohols may result in the viscosity increasing and the surface tension decreasing. They can be mixed with the ultrafine pigment (C.I. Pigment Yellow 14) and only change the properties of the system a little. Surfactants used in the experiment can decrease the surface tension of pigment ink effectively. Thereof surfactant OP-7 may decrease the surface tension of the system more effectively than surfactants OP-10 and OP-15. The surface tension could be decreased to the scale of 25-35mN/m when the concentration of surfactants is about 1%. The defoaming time of ink would decrease sharply when n-butyl alcohol was added into the ink. Due to n-butyl alcohol brings a little change on the viscosity and surface tension of the system, it can be used as defoaming agent of the water-based pigment ink.

Acknowledgement

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Xia Zhang, postgraduate. She has worked in the College of Textiles & Clothing, Jiangnan University. Her research interest focused on the development of pigment inkjet printing inks.