Study on the dispersivity of UV-curable inkjet ink

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Abstract: In order to obtain a good dispersivity of UV-curable inkjet ink, the primary ink of UV-curable inkjet ink were prepared by using different grinding equipment, different type and content of dispersant, different type of pre-polymer and the ratio of pigment to pre-polymer, and different type of monomer. Through testing the particle distribution of primary ink, thereby the influencing factors of dispersivity of UV-curable inkjet ink were studied on. The results show that the use of recycle high pressure isotropic machine can achieve the good dispersivity of the primary ink, the correct choice of type and content of dispersant, type of pre-polymer and the ratio of pigment to pre-polymer, as well as monomer type can obtain the good dispersivity.

Key words: UV-curable inkjet ink; primary ink; dispersivity

1. Introduction

Now, with the wider use of digital technology in printing and the printing industry, inkjet imaging technology as an important digital technology has also been rapid development. UV-curable inkjet ink has some advantages, for example low VOC, instantaneous drying, apply to a variety of printers, and will not be dried before curing so that nozzle will not be blocked, ink composition stability, and higher quality printing, so it is being used more and more extensively [1]. The dispersivity of ink is one of the important performance, which is not only affects the optical properties of ink, such as the tinctorial strength and transparency (hiding power) and so on, but also has a definite impact on the viscosity of the ink and ink transfer properties [2-3]. The dispersivity of ink is the degree of subdivision of pigment in the link material. In order to have a good dispersivity, first of all, pigments should be wet greatly by link material, and the dispersivity of pigments relates with the function between pigments and link material[3-4]. The research of the influencing factors of dispersivity of UV-curable inkjet ink is beneficial to improve the performance of UV-curable inkjet ink.

2. Experiment

2.1 Materials

Pre-polymer: CN2300、CN2302、Viajet100、Viajet400

Monomer:

Mono-functional Monomer: IBOA、EOEOEA

Di-functional Monomer: HDDA、NPGDA、TPGDA、DPGDA

Tri-functional Monomer: TMPTA
Pigment: phthalocyanine blue
Photo-initiator: TPO, 184, 651, 907, 1173, ITX;
Dispersant: CH-13, BYK-9077, BYK-2001, disper-685

2.2 Equipment

Grinding plant:
YM-I milling equipment (self-made);
GYB40-10S emulsifying isotropic machine (Bei Jing);
Niro Soavi high pressure isotropic machine (Italy);
Testing machine:
S3500 Laser particle sizer

2.3 The method of experiment

Preparation of UV-curable inkjet ink can be divided into two parts, first of all, primary ink with the good dispersivity can be prepared, and then mixing primary ink, pre-polymer, monomer and photo-initiator. The dispersivity of primary ink determines the dispersivity of ink, therefore, the dispersivity of primary ink is studied mainly.

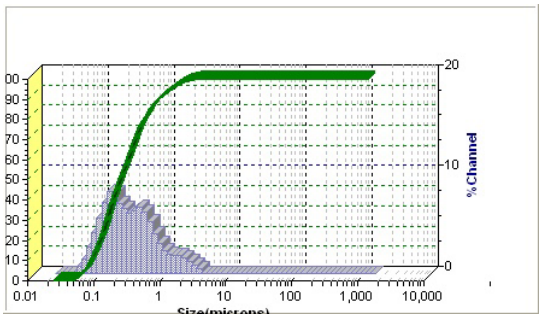
The dispersivity of ink can be tested by Laser particle sizer, the particle size and distribution of ink can be obtained from the figure of particle size distribution.

3. Results and discussion

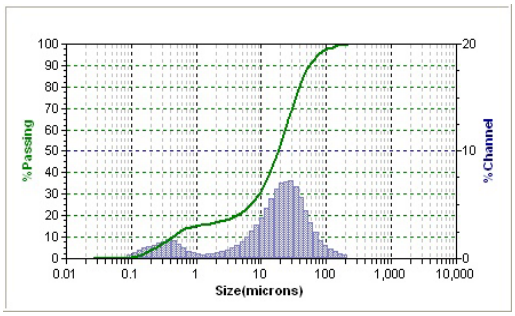
3.1 The effect of grinding equipment on the dispersivity of UV-curable inkjet ink

Relying on grinding equipment, pigment can be dispersed very well in the ink system. Different grinding equipment will have great impact on the dispersivity of ink because of different ways of action.

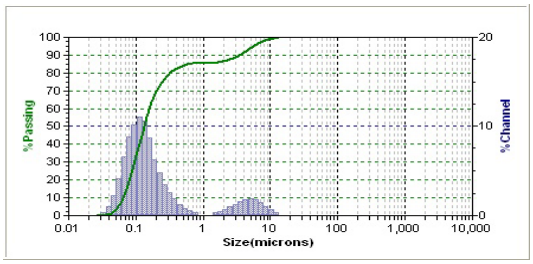
Fixed formulation, and then three grinding equipments including YM-type ball mill, GYB40-10S emulsifying isotropic machine and Niro Soavi experimental high pressure isotropic machine were prepared for primary ink, using a ball grinder for 24 h, emulsifying isotropic machine and high pressure isotropic machine for 30 min, and then test the dispersivity of primary ink, as shown in Figure 1.



(a) ball grinder (24h)



(b)emulsifying isotropic machine(30min)



(C) high pressure isotropic machine (30min)

Seen from Figure 1, using emulsifying isotropic machine to disperse pigment, the distribution of particle size is not homogeneous and particle size is larger, but using ball grinder and high pressure isotropic machine, the distribution of particle size is homogeneous and particle size is smaller. In addition, using high pressure isotropic machine can get the smallest particle size among three equipments. Both the high pressure isotropic machine and emulsifying isotropic machine are producing a strong shear and impact to grind ink under high pressure, so that the pigment particle can be super-fine. The difference between them is that the high pressure isotropic machine is rotative, but the emulsifying isotropic machine cannot circulate. The ball grinder uses the high speed and mutual impact role about crystal balls or other grinding mediums to achieve the homogeneous dispersion of pigment particles, but because the force is smaller, it will take on a longer time to achieve dispersion. Therefore, the high pressure isotropic machine and ball grinder should be able to obtain good grinding effect. Relatively speaking, the high pressure isotropic machine can get high efficiency, better dispersivity. Because the emulsifying isotropic machine cannot circulate, all parts of ink can not be fully forcing, thus pigments are not easy to disperse homogeneously.

3.2The effect of pre-polymer and the ratio of pigment to pre-polymer on the dispersivity of UV-curable inkjet ink.

The pre-polymer is the most important basic component in the UV-curable inkjet ink. It is film forming material, is also pigment's dispersion medium and has very important function to pigment's dispersion. During the process of making ink, in order to obtain the good dispersivity, the grinding of ink needs the

effective shear action which has important relation with the ratio of pigment to pre-polymer. Therefore, the ratio of pigment to pre-polymer has very important influence to the dispersivity of UV-curable inkjet ink.

Provided that addition of other component of UV-curable inkjet ink is constant, preparing primary ink with different pre-polymers and different ratios of pigment to pre-polymer, testing dispersivity of primary inks, comparing 90% of the particle size of the ink, the result is showed in Figure 2:

Figure 2 shows that the particle size of primary ink prepared by V100 is smaller than the primary inks prepared by CN2300and CN2302. The particle size of the primary inks prepared by CN2300 is largest of all. This is because the structures of three pre-polymers are different, the effects of wetting to pigment are different. The better effect of wetting is, the better dispersivity of pigment is.

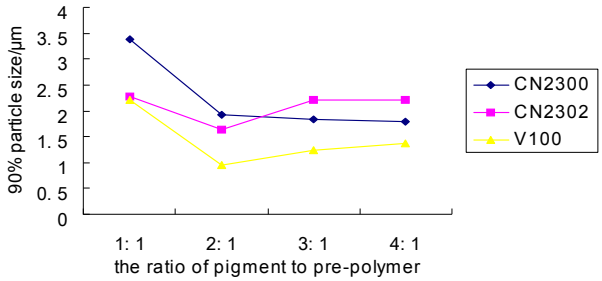


Figure2. The effect of pre-polymer and the ratio of pigment to pre-polymer on the dispersivity of UV-curable inkjet ink

Figure 2 also shows that dispersivity of inks is greatly influenced by the ratios of pigment to pre-polymer. When the ratio of pigment to pre-polymer is 2□1, the particle size of primary ink is smallest. This is because that the process of dispersing is actually process of moving. Dispersivity is best and inks are imposed effective shearing when the inks obtain the optimal ratio of pigment to pre-polymer. The viscosity of the inks and shearing are different when the ratios of pigment to pre-polymer are different[5-6]. In the result, in order to obtain the inks with best dispersing state, the optimal ratio of pigment to pre-polymer is determined firstly and then inks is prepared by with the optimal ratio of pigment to pre-polymer.

3.3 the effect of dispersant on the dispersivity of UV-curable inkjet ink

Dispersant is the indispensable additives to improve the dispersivity of ink, which enables the pigment and link material to wet greatly and disperse homogeneously[7]. Dispersant which palys an important role in the preparation of primary ink can shorten the grinding time of manufacture of ink, lower oil absorption of the pigment to create high concentration ink, and prevent the flocculation and settlings of pigment particles of ink.

3.3.1 The effect of types of dispersants on dispersivity of UV-curable inkjet ink

The primary inks were prepared by fixing other components of UV-curable inkjet ink and changing the type of dispersant. The dispersivities of primary inks were tested and studied by using the size of 90% particles, as shown in Figure 3.

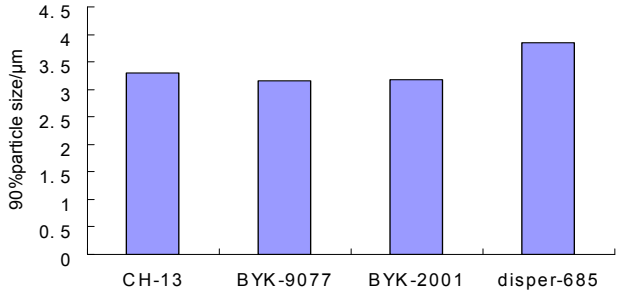


Figure3. The influence of types of dispersants on dispersivity of UV-curable inkjet ink

The Figure 3 shows that the effects of dispersing of three different dispersants are same expect for the disper-685.The particle size of primary ink prepared by dispersant CH-13 is smaller than two other dispersants, 90% of the particle size was below than 1μm. This is because that anchoring combination is formed between anchoring group in the structure of CH-13 and the pigment of phthalocyanine blue, and anchoring group in the structure of CH-13 is dissolved in the solution of acrylate to bring the particle of pigment a state of homodispersing. And the dispersivity of the inks is better now. But dispersant of disper-685 is not compatible with the entire system, and it can not form the strong anchoring combination with the pigment of phthalocyanine blue. The large quantities of pigments are in state of reunion which dose not dispersed well. So the dispersivity of the UV-curable inkjet ink can be improved prepared with dispersant which forming strong anchoring combination with pigment and being dissolved in the acrylate solution as soon as quickly.

3.3.2 the effect of the content of dispersant on the dispersivity of UV-curable inkjet ink

The primary inks were prepared by fixing other components of UV-curable inkjet ink and changing the content of dispersant CH-13. The dispersivities of primary inks were tested and studied by using the size of 90% particles, as shown in Figure 4.

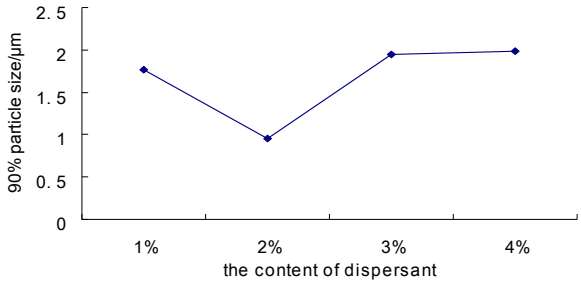


Figure4. The effect of the content of dispersant on the dispersivity of UV-curable inkjet ink

From Figure 4, with the increase of the content of dispersant, the dispersivity of ink can be improved. But when the content of dispersant is to 2%, the increase of the content of dispersant makes the dispersivity of ink worse. Dispersant is the role of pigment evenly dispersed in acrylic solution, to form a stable system. In the wetting role of dispersant and pigment and acrylic solution, it will be the best wetting effect with the increase of dispersant content.

While the ratio of dispersant is 2%, dispersant and acrylic solution and pigment can get the best wetting effect, the dispersion of pigment particle is homogeneous, and the particle size is smaller. While the ratio of dispersant content is less than 2%, it cannot supply sufficient thickness of the adsorbed layer, making the wetting effect of pigment and acrylic solution poor, and then lead to bad dispersion effect. When the content of dispersant is more than 2%, dispersivity of inks is bad as the stable structure of inks is destroyed by the excessive dispersant.

3.4 The effect of monomer on the dispersivity of UV-curable inkjet ink

Monomer and pre-polymer constitute the link material of UV-curable inkjet ink, and the link material is dispersive medium for pigment. Therefore, monomer has a certain affect for the dispersivity of UV-curable inkjet ink.

The primary inks were prepared by fixing other components of UV-curable inkjet ink, changing the type of monomer, and testing the dispersivity of primary ink. Choose the 90% of particle size for comparison, as shown in figure 5.

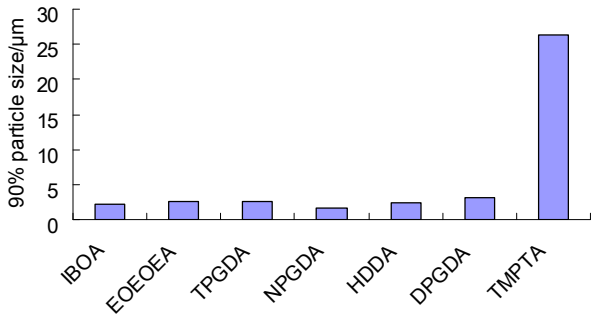


Figure5. The influence about monomer to the UV-curable inkjet ink dispersivity

Seen from figure 5, the ink which is prepared by the TMPTA has the largest particle size and the worst dispersivity. However, the ink using NPGDA for preparation has the smallest particle size and the best dispersivity. The viscosity of TMPTA is higher. It cannot achieve optimal fluid state while dispersing pigment, the ink cannot be effectively sheared while stringing, thus less dispersivity. NPGDA has a moderate viscosity, and the ink can be effectively sheared. Meanwhile, NPGDA has a good wetting property for phthalocyanine blue pigment, and so the UV-curable inkjet ink which processes a good dispersivity can be obtained.

4. Conclusion

By experiment studies, the following conclusions can be got:

(1)Grinding equipment has a great effect to the dispersivity of UV-curable inkjet ink, and using the high pressure isotropic machine can homogeneously disperse pigments and make ink particle size very small.

(2)The type and content of dispersant have great effect to the dispersivity of UV-curable inkjet ink. The dispersant which can connect strongly with pigment and dissolve fast in the acrylic solution should be chosen for the primary ink, and the appropriate content of dispersant can improve the dispersivity of ink. For the phthalocyanine blue pigment, using 2% of CH-13 dispersant for the preparation of primary ink can give ink a good dispersivity.

(3)The type of pre-polymer, the ratio of pigment to pre-polymer and the type of monomer also have great effect on the dispersivity of primary ink. The pre-polymer and monomer which are good for the pigment wetting property should be chosen, and the viscosity of monomer is moderate，and then using the right ratio of pigment and pre-polymer for the preparation of the primary ink can improve the dispersivity of ink. For the phthalocyanine blue pigment, using 2:1 for the preparation of ink can give ink a good dispersivity.

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