Study on the Effect of Pigment Dispersion on Water-based Ink Rheological Property

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Abstract

With the widely development of digital printing technology and the enhancement of environmental awareness, more and more people in digital printing industry pay attention to environmentally friendly water-based ink. Water-based ink is a kind of dispersed system that made of pigment particles, water, resin and various additives, and dispersion is one important factor that affects the rheological properties of ink. In order to explore the influence of the dispersion of pigment on the rheological properties of water-based ink, we change the grinding time and the ratio of pigment to resin to prepare ink samples with different dispersion state. The particle size distribution of the samples is tested by laser particle size analyzer and the rheological parameters such as viscosity and thixotropy, of the samples are tested by ARES rheometer, and analyze the effect of dispersion on rheological properties of ink. The experiment results show that the ratio of pigment to resin influences the dispersion state seriously, at the same time dispersion state has a great influence on the rheological properties.

0 Introductions

Digital printing technology represents the development direction of printing technology. More and more people in digital printing industry pay attention to water-based ink, due to reducing or eliminsate the organic pollutants, and has stability and low combustion properties. Performance of water-based ink affects the quality of the digital printing quality directly. With the enhancement of environmental awareness, more and more people pay attention to environmentally friendly water-based ink. Pigment determinses the color of the ink and a variety of durability, and the dispersion of pigment in the ink system effect on the rheological properties of ink-jet printing ink and printing eligibility, in pigment type inkjet ink system. The rheological properties of ink directly affect digital printing eligibility, and then decided to printing quality. Pigment dispersion, pigment dispersion stability and the control of viscosity in water-based ink system is the key to the technology. So it is a significant to study the effect of pigment dispersion on water-based ink rheological property.

1 Experiment

1.1 Raw materials and equipments

Raw materials: phthalocyanine blue, Grinding resin HPD 96,dispersing agent 760,antifoaminsg agent 810, deionized water, Acrylic polymer resins Joncryl77, flatting agent 432 and so on.

Equipments: JG-2S digital display high speed mixer, D2004Wpowerdriven force mixer, Microtrac S3500 laser granularity instrument, TA (USA) ARES rheometer, Buhler grinding machine

1.2 Measures

Samples preparation

Based ink preparation: With appropriate ratio of pigment to resin, mix phthalocyanine blue, HPD 96 grinding resin and additives on the high speed mixer mixing completely, and then grind to prepare ink on buhler grinding machine.

Into the ink preparation: According to formula of water-based flexographic ink, mix the base ink, dilute resin and additives on high speed mixer mixing.

Test method of measures:

①Test the size of particle and the particle size distribution of the sample by Microtrac S3500 laser granularity instrument. The smaller the particle size and the narrower of particle size distribution, the better the pigment dispersion.

②Test the relationship between viscosity and shear rate at the shear rate scope of 0.1 ~ 100 s-1 by using ARES rheometer with a diameter of 60 mm rotor under the condition of 25℃.

2 Result and analysis

2.1 Influence of milling time on dispersion of water-based ink

Different grinding time will make different degree of shear force on formed aggregation of pigment particles in ink, and change the dispersion state. Prepare ink samples, which the ratio of pigment to resin is 3:1, then grinding the samples with different time by Buhler grinding machine, testing ink particle size and distribution of size. Statistical the grain size of ink sample of different grinding time and compare particle size of 95% of passed testing, as shown in figure 1, and the figure 2 shows size distribution of ink of 2 hour-grinding time.

As can be seen from figure 1, with the increase of grinding time, the particle size was gradually decreasing trend. The pigment particle size is relatively large when the grinding time is 10mins. The particle size is 0.5μm after grinding of 120mins. As can be seen from figure 2, the ratio of pigment to resin is 3:1 narrow particle size distribution of the sample, more uniform dispersion.

In general, the dispersion of pigment particles can be divided wetting, dispersing, stabilizing three stages [1], the grinding time is short, the surface of the pigment grind resin is insufficient wetting, a considerable part of the pigment particles is still "aggregates" the state, good dispersion state can not be

achieved. The longer the grinding time, the pigment particles of the "aggregate" is gradually destroyed, grind resin to fully wet the pigment surface, and the resin filler particles are ground, a certain spatial effects hinder the mutual contact between the particles, better able to disperse the particles. When the pigment grinding resin particles and has a good affinity between, the pigments particles can be dispersed well adsorbed grind resin, thereby maintaining a good dispersion stability system.

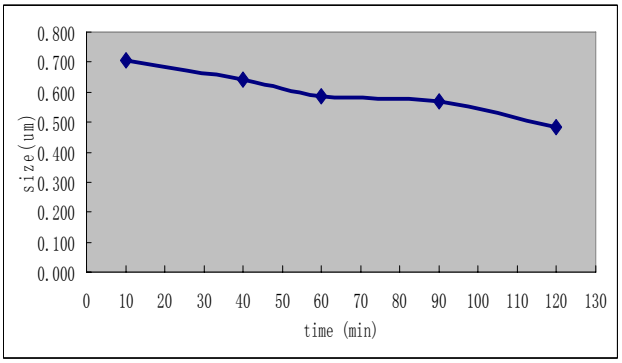


Figure 1 *Relationship between milling time and particle size diagram*

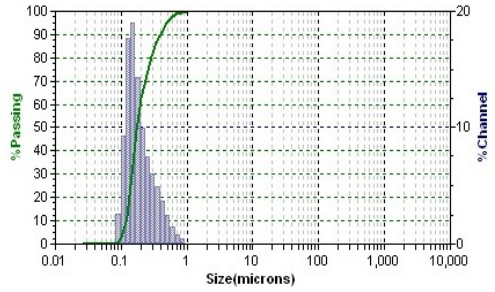
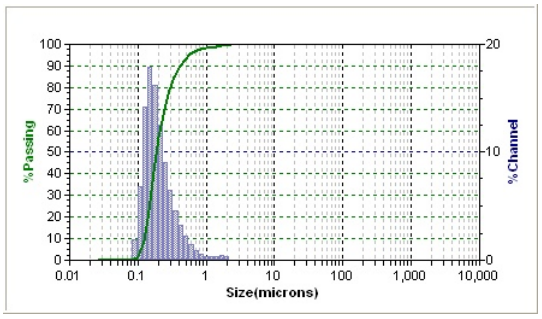


Figure 2 *particle size distribution of ratio of pigment to resin 3:1*

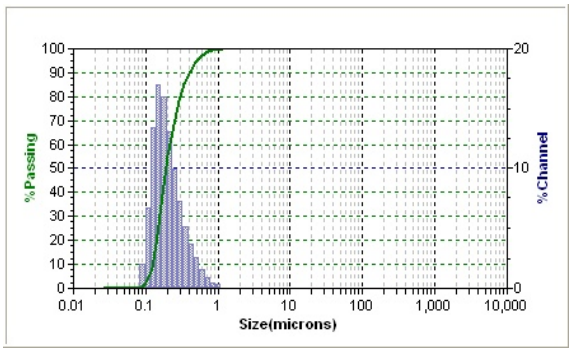
2.2 The influence of ratio of pigment to resin to dispersibility of water-based ink

Ratio of pigment to resin is refers to the ratio between pigment and the solid content of grinding resin. Ratio of pigment to resin affects the dispersion state of pigment particles, because different ratio of pigment to resin affects adsorption of resin solution on the surface of pigment and coating of pigment particles.

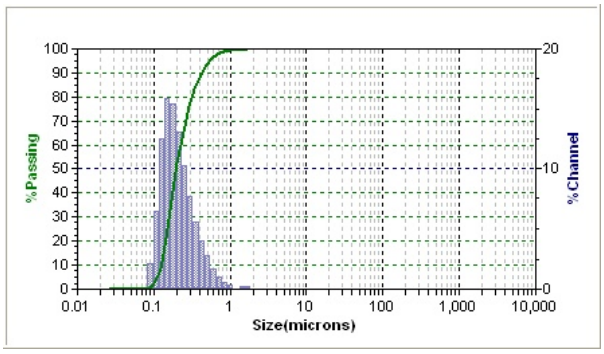
Using different ratio of pigment to resin to make ink samples by grinding 120 mins in digital display high speed mixer, and then test the particle size and the distribution of particle size, the distribution of particle size as shown in figure 3.



(a) ratio of pigment to resin is 2:1



(b) ratio of pigment to resin is3:1



(c) ratio of pigment to resin is 4:1

Figure 3 *different ratio of pigment to resin influence on the particle size diagram*

Figure 3 shows the results of this test, different ratio of pigment to resin have an influence on particle size diagram. Within limits, increasing ratio of pigment to resin can improve the dispersivity of the ink, but when ratio of pigment to resin reaches a certain value that the dispersion is best, and then dispersion will decrease with the increase of the ratio of pigment to resin. When the ratio of pigment to resin is 3:1, particle size is the minsimum, particle size distribution is the narrowest and the dispersivity of the ink is the best. The reason is that the increasing of ratio of pigment to resin, with the decreasing of grinding resin

and increasing of the solvent content, affects the wettability on the surface of the pigment particles. With the decreasing of grinding resin, the viscosity of continuous phase is reduced at the same time, and the spread of pigment particles more easily. Dispersion process is actually the process of flow, only the best flow point of ink can only be effective shearing action [3-4]. Ratio of pigment to resin is 3:1, the pigment particle can both fully wettability, and can prevent the pigment particles together again. The shear force the greater, the dispersion state the better

2.3 Milling time effect on the viscosity of water-based ink

The viscosity of water-based ink is mainly determinsed by the size of pigment particle and the distribution of pigment particle, under the condition of ratio of pigment to resin is 3:1 and the constant components only change the different milling time [2]. In the range of 0.1 ~ 100 s-1 of shear rate, we test the relationship between viscosity and shear rate, as shown in figure 4.

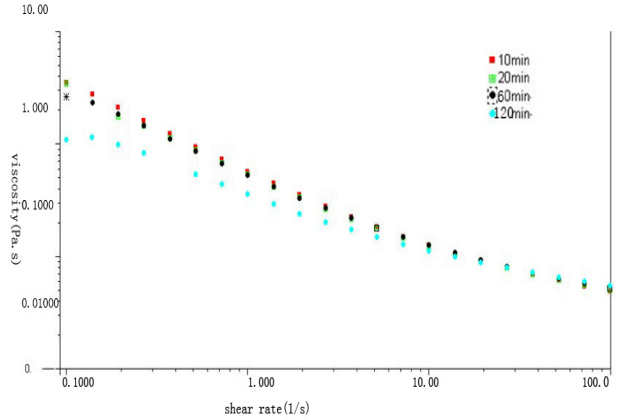


Figure 4 *the relationship between the shear rate and the viscosity under different grinding time*

Figure 4 shows that, system displays typical characteristics of rheological that shear viscosity decreases with increasing shear rate. Different samples with different milling time, extent of decrease of viscosity is different. Grinding 10 mins sample, the degree of decrease of viscosity is the largest and grinding 120 mins the degree of decrease of viscosity is the minsimum.

The reason is that the ink pigment particles in the sample form an aggregation structure. The aggregation structure is destructed under the action of a shear, which led to the decrease of the system viscosity. Usually, particles dispersed more evenly in the system the lower the viscosity and the lower the degree of decrease of viscosity. From figure 1, the sample of grinding 120 mins, the size of pigment particle is the smallest, and distribution is the most evenly; while the distribution is the most evenly with grinding 10 mins. This test results show that the state is consistent with dispersion state of viscosity tested.

2.4 Ratio of pigment to resin on the viscosity of water-based ink

Change the ratio of pigment to resin, ink sample was grinded with JG-2S digital display high speed mixer for 120mins. The results of particle size and the distribution are shown in Table 3. And the relations between viscosity and shear rate of three kinds of inks with different ratio of pigment to resinn can be seen in figure 5.

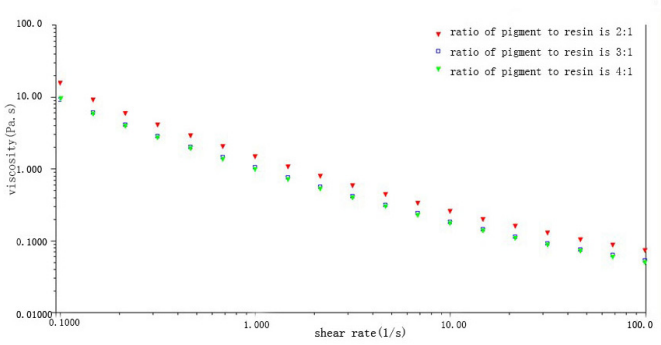


Figure 5 *the relationship between the shear rate and the viscosity under different ratio of pigment to resin*

Figure 5 indicated that with the increase of ratio of pigment to resin, ink's viscosity decreased. Inks, which the ratio of pigment to resin is 2:1, have higher viscosity than inks with ratio of pigment to resin is 3:1 and 4:1,and the relation of viscosity and shear rate ,which concern about inks with ratio of pigment to resinn is 3:1 and 4:1, is highly consistent. This is because when the ratio is 2:1, pigment in ink can not be dispersed well, which lead a bad dispersity state of ink, so the viscosity of ink is low.

Because when the ratio of pigment to resin is 4:1, grinding resin content in the samples is less, and the continuous phase viscosity is low. The surface of pigment particle can't be wetting by grinding resin, and the particles is easy to spread in the continuous phase, So particles exist in aggregate form without good dispersion state, showed higher viscosity. [5]When the ratio is 3:1, particle surface can be fully wettability, continuous phase with high viscosity can inhibit the spread of the pigment particles effectively, so the pigment particle can be spread more evenly. This test results is consistent with the particle size test result.

3 Conclusions

The research indicated that grinding time and ratio of pigment to resin have a great influence on the dispersity of ink. To it can get ink with good dispersity when prepared with ratio of pigment to resin is 3:1, and grind in BUHLER for 120mm. When the content of pigment is under a certain value, the smaller the particle size, the more uniform of particle size distribution, so the viscosity is lower.

Acknowledgment

This work is supported by Beijing Municipal Universities' innovation team building plan—Green printing materials and technology innovative tech team—Research on the green CTP plate and environmental ink (06170113025).

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Author Biography

Baowei Sun, a postgraduate comes from Qufu Normal University. Her main research direction is materials physics and chemistry. Water-based ink is one of her research directions.