Preparation of Nanoscale Phthalocyanine Blue Pigment Dispersion for Inkjet Printing Inks With Polymerizable Dispersant

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Abstract

Nanoscale phthalocyanine blue pigment dispersion was prepared using allyloxy Nonyl-phenoxy propanol polyoxyethylene ether ammonium sulfate (ANPS) as dispersant, the effect of amount of ANPS and milling time on particle size were investigated, the further performance of the prepared dispersion was also measured. The results showed that the optimal process condition was that the weight ratio of dispersant to pigment 20%, milling speed 1800r/min for 2 hours. The dispersion which prepared as these conditions had small particle size and narrow particle size distribution, the particle size changed small when the dispersion was treated below 60℃ and almost remained the same when pH value was in the range of 6 to 10. The absorbance changed little when the dispersion was centrifuged below 4000r/min for 30min. The fluidity of the dispersion shows shear thinning behavior.

Introduction

Inkjet printing as a new textile dyeing technology has attracted more and more people's attention. The pigment inks which can be applied to all sorts of fabric have become one of the main colorant in inkjet printing technology [1].

However, organic pigment is hard to be dispersed into water for its low polarity, therefore, how to prepare the nanoscale pigment dispersion with high stability has become the hot research [2-5]. There are several successful methods to improve the dispersing performance of the pigment dispersion. Philip M. Karlsson used surfactants to modify aluminum pigment, which resulted in effective preventing the reaction of aluminum and water, thus prepared the waterborne printing inks [6]. Philippe Bugnon coated organic pigment with silicon dioxide, aluminum oxide, titanium dioxide, respectively, which greatly improved the wetting, stability and lightfastness properties of the pigment [7]. K. Landfester [8-10] and E. Bourgeat-Lami [11, 12] led their group using miniemulsion polymerization method to encapsulated organic pigment and further investigated the encapsulation mechanism, respectively.

In this paper, we dispersed the phthalocyanine blue pigment using the polymerizable surfactants as dispersant in aqueous media and prepared nanoscale pigment dispersion. The performance of the dispersion was studied as well.

Experimental

Materials

Phthalocyanine Blue (C.I. pigment 15:3, Purity 99.7%) provided by Wuxi Xinguang Co. Ltd, China. allyloxy Nonyl-phenoxy propanol polyoxyethylene ether ammonium sulfate (ANPS) was obtained from Adeka (Japan, its chemical structure was shown in Fig.1). Sodium 3-(allyloxy)-2-hydroxypropane-1-sulfonate (AHPS, its chemical structure was shown in Fig.2) and Sodium 2-hydroxy-3-(methacry-loyloxy) propane-1-sulfonate (HMPS, its chemical structure was shown in Fig.3) were obtained from Kedi (China). Deionized water was used for all the experiments.

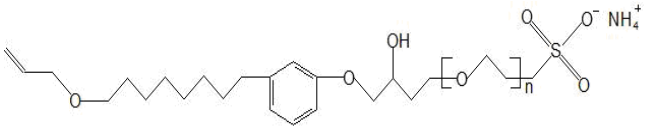

Fig.1 *Chemical structure of ANPS.*

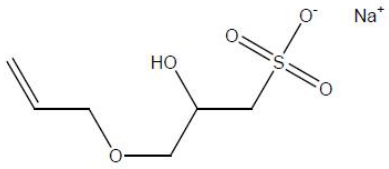

Fig.2 *Chemical structure of AHPS.*

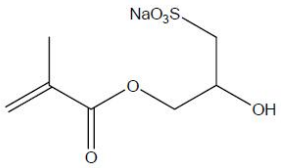

Fig.3 *Chemical structure of HMPS.*

Preparation of the pigment dispersion

Certain amount of dispersant was dissolved in deionized water, and then corresponding of Phthalocyanine blue was dispersed in dispersant solution. The mixture was stirred at 500r/min for 10min, transferred to a bead mill (Minizeta 03E, Netzsu, Germany), and then milled for some time to get an uniform dispersion with 5% weight pigment content.

Measurement

The samples were diluted to 1000 times, and then the particle size, its distribution and zeta potentials were measured by dynamic light scattering technique (Nano-ZS90, Particle size analyzer, England). The stability to temperature was tested as follow: the dispersion was sealed and stored at different temperature for 1 hour, and then its particle size was measured. The dispersion was

adjusted at different pH value using HCl and NaOH, respectively, and then its particle size and zeta potential were measured. The dispersion was centrifuged at different speed and its absorbance was tested to measure its centrifugal stability. The dispersion was balanced at 25℃ for 10 min, and then its apparent viscidity was measured at different shear rate.

Results and discussions

Preparation of pigment dispersion

Effect of dispersant

In order to get an optimal polymerizable dispersant to aid of preparation of phthalocyanine blue pigment dispersion, we choose ANPS, AHPS and HMPS as polymerizable dispersant to disperse the pigment, respectively, the results were shown in Fig.4.

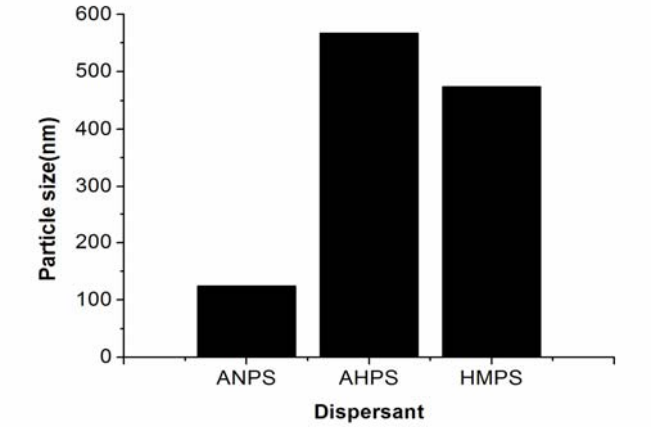

Fig.4 *Effect of dispersant on dispersing performance of phthalocyanine blue. Process conditions: the weight ratio of dispersant to pigment 20%, 1800r/min milled 2h.*

Fig.4 indicated that the particle size of the dispersion reached to its minimum when ANPS was used as dispersant. The dispersing performance of the dispersant was closely related to its molecular structure. Comparing the three dispersant molecular structure, we conclude that the attractive forces between AHPS or HMPS and pigment was weak for short length of the hydrophobic chain, and the dispersant can easily be desorbed from the pigment surface, thus led to large particle size.

Effect of the amount of dispersant

Fig.5 shows that the particle size of the pigment dispersion decreased with increasing the amount of ANPS, and almost remained a constant when the weight ratio of dispersant to pigment reached to 20%. It is known that the whole pigment surface can not be occupied by dispersant when amount of dispersants was small, the "naked" pigment surface can easily attractive each other, thus led to large particle size. Fig. 5 also indicates that the optimal weight ratio of dispersant to pigment is 20%.

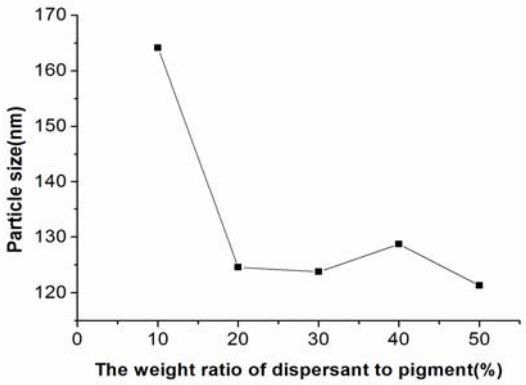

Fig.5 *Effect of amount of dispersant on dispersing performance of phthalocyanine blue. Process conditions: 1800r/min milled 2h.*

Effect of the amount of dispersant

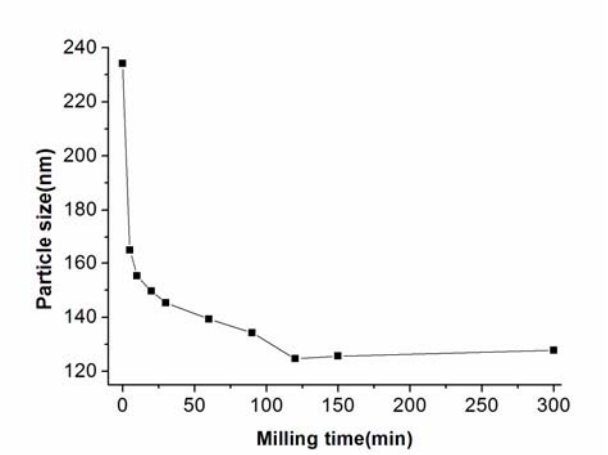

Fig.6 *Effect of milling time on particle size of the dispersion. Process conditions: the weight ratio of dispersant to pigment 20%, 1800r/min.*

Fig.6 indicates that the particle size of dispersion decreased with an increase of the milling time, when the milling time is above 120 min, the particle size was not changed with further increasing the milling time. It is known that the pigment would be dispersed under shear forces, and the dispersed pigment would be aggregation again via wan der warrls forces. First, the dispersing rate is higher than the aggregation rate, therefore, the particle size decreased with increasing the milling time. When particle size reduced its minimum, the dispersing and aggregation reached to a balance, thus the particle size would not change with further increasing the milling time. From analysis above, we choose the optimal process conditions that ANPS was used as the pigment dispersant, the weight ratio of dispersant to pigment is 20%, milling speed 1800r/min and milling time is 2 hours.

Performance of Dispersion

Particle size distribution

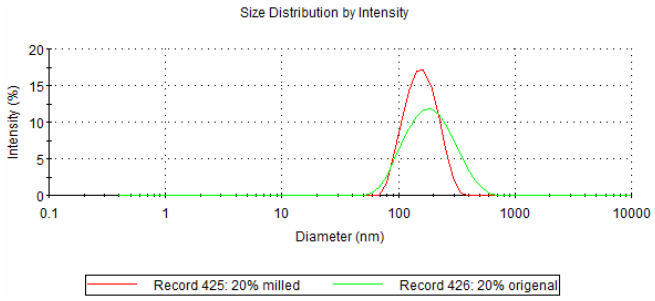

Fig.7 *Particle size distribution of the dispersion. Process conditions: the weight ratio of dispersant to pigment 20%, 1800r/min with 2 hours.*

Fig.7 shows that the particle size of the dispersion was smaller and its distribution was narrower than that of original pigment, which indicates that ANPS is an optimal dispersant for phthalocyanine blue.

Particle size distribution

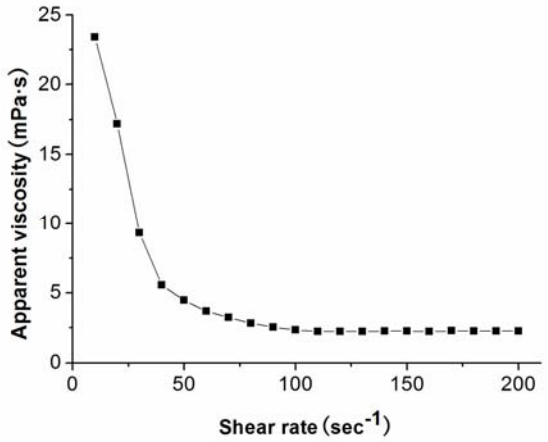

Fig.8 *Effect of shear rate on apparent viscosity at 25 □. Process conditions: the weight ratio of dispersant to pigment 20%, 1800r/min with 2 hours.*

Fig.8 indicates that the prepared dispersion was belong to pseudoplastic fluid and shows the shear thinning behavior with an increase of shear rate. The reason may be due to that the weak flocculation existed among the particles in the dispersion, under high shear rate, the weak flocculation was broken up, thus led to sharply reduce the apparent viscosity. When all the weak flocculation was disappeared, the apparent viscosity would not change any more with further increasing the shear rate.

Centrifugal stability of dispersion

The centrifugal stability of the prepared dispersion was investigated by measuring the absorbance at different centrifugal speed. Fig.9 shows that the absorbance was almost unchanged when the centrifugal speed was below 4000r/min. these results indicate that the dispersion have high stability against weight.

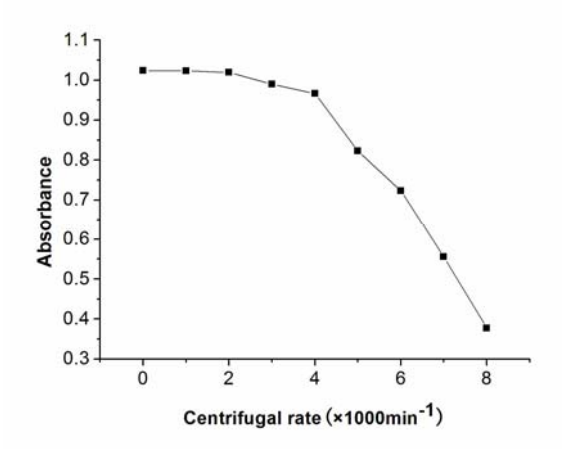

Fig.9 *Effect of centrifugal speed on absorbance of the dispersion. Process conditions: the weight ratio of dispersant to pigment 20%, 1800r/min with 2 hours.*

Stability to pH value

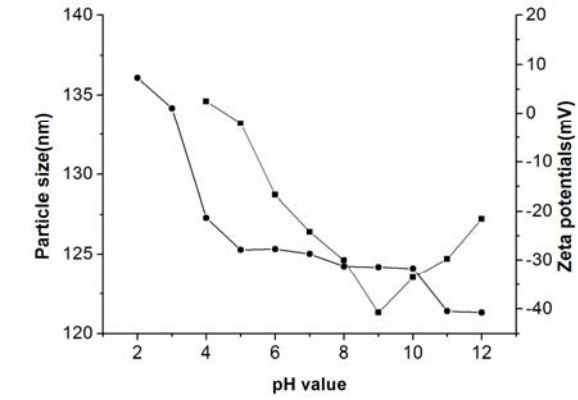

Fig.10 *Effect of pH value on stability of the dispersion. Process conditions: the weight ratio of dispersant to pigment 20%, 1800r/min with 2 hours. ■: Particle size ●: Zeta potential*

Fig.10 shows that the particle size changed small when pH value was in the range of 6 to 10, the zeta potentials decreased with an increase of pH values, and isoelectric point appeared when pH value was about 3.2. These results indicate that the prepared dispersion can be applied to prepare the inkjet printing ink with the pH value at 6 to 10.

Stability to temperature

Fig.11 shows that the particle size changed small when the dispersion treated temperature was below 60 ℃. At high temperature, the motion of the particles increased, and some of the ANPS would be absorbed from the pigment surface, thus the small particles were easily combined each other and formed a large particles.

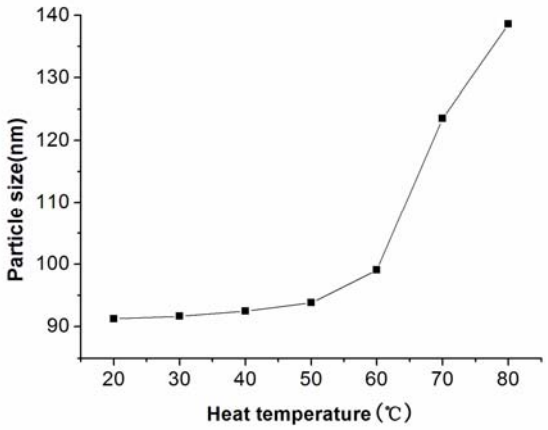

Fig.11 *Effect of temperature on stability of the dispersion. Process conditions: the weight ratio of dispersant to pigment 50%, 1800r/min with 5 hours.*

Conclusions

The nanoscale pigment dispersion can be prepared when ANPS was used as dispersant, the optimal process condition is the weight ratio of dispersant to pigment 20%, milling speed 1800r/min for 2 hours. The dispersion which prepared as these condition have small particle size, narrow particle size distribution and high stability to temperature, centrifugal forces and pH values, these results indicates that the prepared dispersion can be used in inkjet printing inks.

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