Effect of Monomer on Printing Quality of UV-LED Inkjet Ink

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Abstract

UV-LED inkjet ink has fast response, energy efficient, high environmental protection and other advantages, and it is a highly promising environmentally friendly ink. Monomer is an important component of UV-LED inkjet ink, it has a certain impact on performance of the ink. In order to investigate the effects of monomer on the printing quality of UV-LED inkjet ink, seven kinds of monomers were chosen to prepare ink samples, and dispersion, viscosity and surface tension of each ink was tested. Then ink jet printer was used to print each ink, and the line width, density, fuzziness, roughness and contrast of printing sheets were tested to analyze the effect of monomer on ink printing quality. The results show that inks prepared by different monomers have different performance and it has obvious impacts on the printing quality.

Introduction

As a new kind of environmental protection ink, UV-LED inkjet ink is more and more popular for its energy conservation, environmental protection, and high efficiency and so on, and it'll have great prospects for development in the future.

UV-LED inkjet ink is mainly composed of pigment, prepolymer, photoinitiator, dilution monomer and other additives. Among them, monomer is the important composition of the ink. It not only adjusts the viscosity of ink system, affects curing speed and performances of ink layer after curing, but also has an effect on printing quality. The effect of monomer on the properties of UV-LED inkjet printing ink is discussed in the article in order to provide theoretical basis for the research and development of UV-LED inkjet ink, and it will actively drive the development of UV-LED inkjet ink.

Experiment

Experimental Materials

Monomer: EOEOEA, TPGDA, HDDA, NPGDA, DPGDA, TMPTA, EO3-TMPTA; Pigment: Phthalocyanine blue; Prepolymer: Viajet 100, Viajet 400; Photoinitiator: IHT-PI ITX, IHT-PI TPO, Irgacure 819; Auxiliaries: EHA, 9077.

Experimental Equipments

High speed grinder (GJ-2S, China); Microtrac S3500 laser particle analyzer (Microtrac, America); AR2000ex-Rheometer(TA, America); Static surface tension determine instrument (K-100, Germany); Fourier transform infrared spectrometer (FTIR-8400, Japan); 365nm UV-LED light source (Uvata Precision Optoelectronics Co.,Ltd); Holiness digital inkjet system (SD6600, China).

Methods of Experiment

Preparation of Ink Paste and Printing Ink

Ink paste was prepared by mixing and pre-dispersing binder and pigment, and then grinding in a high-speed grinder to achieve adequate wetting and dispersing, finally the ink sample was made by fixing the other components of the ink and adding different kinds of monomers respectively.

Performance Test

1) Dispersivity: Microtrac S3500 laser particle analyzer was used to test particle size of ink and the value of 95% particle size distribution was used to characterize the dispersion in the paper.

2) Viscosity: AR2000ex-Rheometer was used to test the viscosity of ink samples.

3) Surface tension: K-100 static surface tension determine instrument was used to test the surface tension of ink samples.

4) Curing rate: At room temperature, each ink sample was coated on a PET film respectively by using the No.2 wire bar. After curing under UV-LED light source, infrared spectroscopy [2] was used to test the curing speed of each ink. The double bond conversion rate was calculated by formula (1) [3].

$$Ct = \frac{A_0 - A_t}{A_0} \times 100\% \quad (1)$$

A0 refers to the ink absorption intensity at 810cm-1 band without UV irradiation, At refers to the ink absorption intensity at 810cm-1 band after UV irradiation, Ct refers to double bond conversion rate of the ink.

5) Line printing quality: The ink jet printer was used to print each ink, and then the line width, density, fuzziness, roughness and contrast of printing sheets were tested by CCD image detection and analysis system. The sample of printing test was shown in Figure 1, and the measurement area is the vertical section of Chinese character "油".

Figure 1: *The sample of printing test*

Results and Analysis

In order to be smoothly jetted from the nozzle, UV-LED inkjet ink need to meet certain performance requirements, especially the surface tension, dispersion, viscosity are very important performances which have certain effect on the formation and the flight path of ink droplet, thus affect the quality of printing sheet. By studying the effect of monomer on surface tension, dispersion, viscosity of ink, then the effect of monomer on printing quality can be analyzed.

Effect of Monomer on Performance of UV-LED Inkjet Ink

Effect of Monomer on Surface Tension of the Ink

Surface tension of ink means the inter-traction of the two adjacent parts of the liquid surface inside the unit length. Low surface tension can cause instability of droplets, while large surface tension may cause tailing phenomenon and affect the image quality [3]. Seven monomers were used to prepare ink and tested its surface tension, the results are shown in Figure 2.

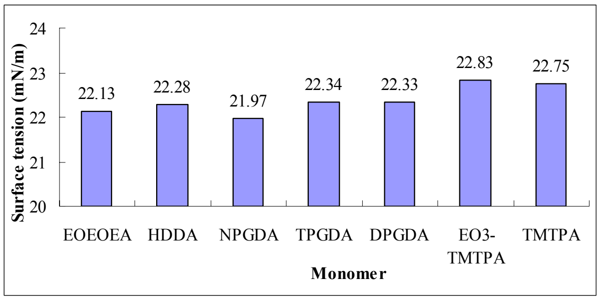

***Figure 2:** Effects of monomers on ink surface tension*

As shown in Figure 2, monomers have influence on the surface tension, NPGDA has the lowest surface tension of the ink while EO3-TMPTA has the maximum value. Because NPGDA has the shortest molecular chain which leads to smallest intermolecular interaction force and the weak ability to automatically reduce the surface, while EO3-TMPTA has a dimensional shaped molecular structure, the branched chain is much longer, and the intermolecular attraction in internal liquid is the largest.

Effect of Monomer on Dispersion of the Ink

The dispersion of pigment particles plays a crucial role in deciding whether it can eject smoothly from the jet nozzle plug or not. To study the effects of different monomers on UV-LED ink paste dispersivity and dispersive stability, cyan ink paste were prepared by changing the monomer species, and the particle size on that day and 15 days later were all tested, which was shown in Figure 3.

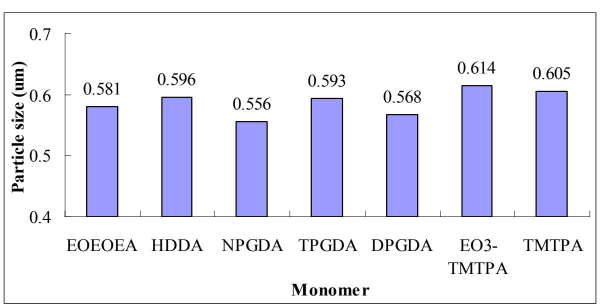

***Figure 3:** Effects of monomers on ink particle size*

As shown in Figure 3, there are differences in the ink dispersion, the ink made of EO3-TMPTA has the maximum particle size and the made of NPGDA has the minimum particle size. This is due to the differences of the molecular structures of monomers during the dispersion process, the different force of different pigments and monomers cause different wetting and dispersing to the pigments [4]. TMPTA and EO3-TMPTA are three-dimensional molecular structures, the inks made of them have larger surface tension, so it is difficult to achieve the best condition of pigment wetting and ink particle has a larger diameter. Monofunctional monomer EOEOEA and bifunctional monomer HDDA, NPGDA, TPGDA and DPGDA molecular are straight chain structure of the body. But NPGDA has the shortest molecular chain and the ink made of it has the lowest surface tension, so it is favorable for the pigment wetting and dispersing, thus it has the smallest ink particle size.

Effect of Monomer on Viscosity of the Ink

Viscosity has an important impact on the formation ability of the ink droplets and the quality of ink during the injection process. In order to ensure smooth ink ejection and good quality printing, the ink viscosity should be controlled within a certain range. Seven monomers were used to prepare ink and tested its viscosity, shown in Figure 4.

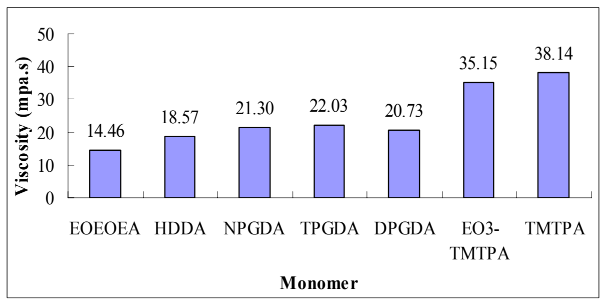

***Figure 4:** Effects of monomers on ink viscosity*

As shown in Figure 4, the viscosity and of each ink speeds up along with the monomer functional group number increases, EOEOEA has the lowest viscosity while TMPTA the highest. As the number of functional groups of the monomer increases, molecular weight monomers increase, this can cause increased interaction force between molecules and lead to larger viscosity. TMPTA and EO3-TMPTA are three-dimensional shaped molecular structure. Due to the introduction of ethoxy groups of EO3-TMPTA, the branched structure is more compact, which leads to low viscosity.

Effect of Monomer on Printing Quality of UV-LED Ink

The ink samples prepared by different monomers were printed on art paper by inkjet printer, and then the line width, density, fuzziness, roughness and contrast of printing sheets were tested by CCD image detection and analysis system after being cured under UV-LED illuminant, the results are shown in Figure 5-9.

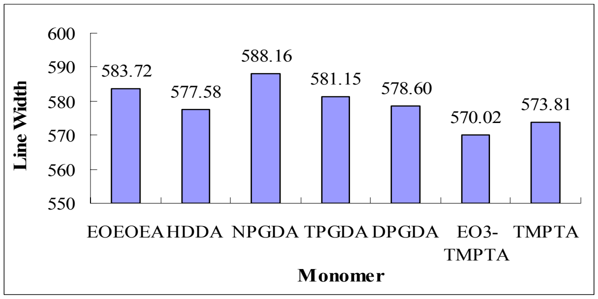

Figure 5: *Effects of monomers on line width*

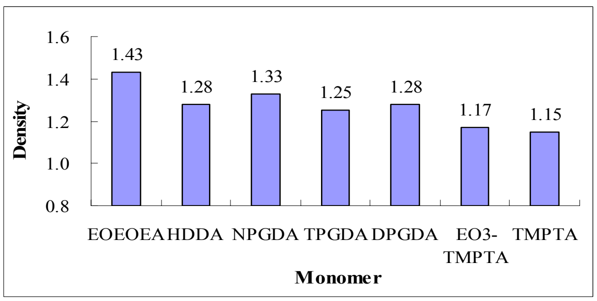

Figure 6: *Effects of monomers on line density*

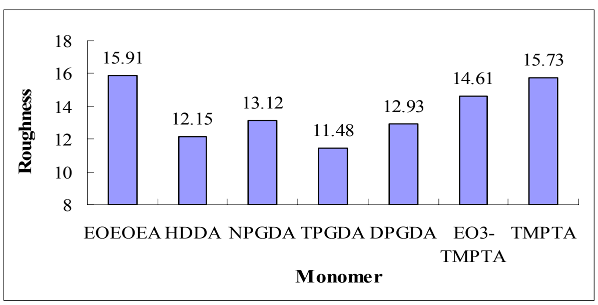

Figure 7: *Effects of monomers on line roughness*

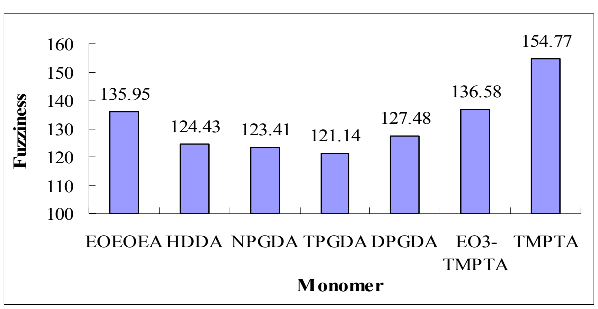

Figure 8: *Effects of monomers on line fuzziness*

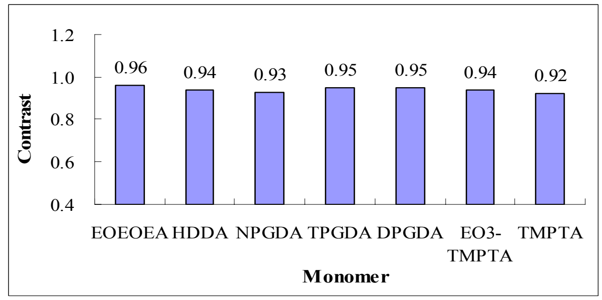

Figure 9: *Effects of monomers on contrast*

As shown in Figure 5 and Figure 6, the monomer of ink has an impact on line width and density, the inks made of EOEOEA and NPGDA have larger line width and density and the inks made of EO3-TMPTA and TMPTA have smaller line width and density. According to ISO 13660 standard [5], density is defined as the mean density within edge of reflectivity R75; line width is defined as the average width of the line so as to measure the accuracy of line copy. Because the inks made of EOEOEA and NPGDA have smaller particle size and lower surface tension, is causes pigment particles arranged closely in the ink layer and more incident absorption of ink layer, thus it has larger density. Besides, lower surface tension causes easy ink spreading on coated paper and larger line width. However, the inks made of EO3-TMPTA and TMPTA have larger particle size and surface tension, so it causes smaller line width and density.

As shown in Figure 7 and Figure 8, the monomer of ink has an impact on fuzziness and roughness, the inks made of EOEOEA and TMPTA have larger fuzziness and roughness, and the inks made of TPGDA has the least line fuzziness and roughness. Fuzziness refers to the blurred appearance of line edge, and it was defined as the average distance between the inner boundary and outer boundary. Roughness was defined as the standard deviation of distance from the position of reflection coefficient R60 to the fitted straight line [6]. The ink made of EOEOEA has low viscosity, because of the low cohesion of ink, ink drops have greater tail length and line was easily to be rough and serrated, thus the fuzziness and roughness became larger. While, the ink made of TMPTA has too large viscosity and the force between molecules was large, it causes greater tail length, so it has large fuzziness and roughness. The ink made of TPGDA has moderate viscosity, and it has the higher surface tension compared with monofunctional and other bifunctional monomers, is causes stronger ability of shrinking ink surface and shorter tail length of ink drop, so the ink made of TPGDA has the minimum fuzziness and roughness.

As shown in figure 9, the line contrast of different inks are both within 0.92-0.96, which means that monomer has no obviously effect on line contrast.

Conclusions

By above analyses, such conclusions can be obtained under certain experiment conditions.

(1) Monomers have different effects on performance of UV-LED inkjet inks. The ink made of NPGDA has the minimum particle size while has the maximum particle size when made of

EO3-TMPTA; the ink made of NPGDA has the lowest surface tension and has the highest when made of EO3-TMPTA; the viscosity of each ink speeds up along with the monomer functional group number increases.

(2) The UV-LED inkjet inks made of different monomers have different printing quality. Line width of the inks which made of EOEOEA and NPGDA was larger, while it was smaller when made of EO3-TMPTA and TMPTA; line fuzziness and roughness of the inks which made of EOEOEA and TMPTA were larger, while the ink made of TPGDA has the least line fuzziness and roughness; there is no obviously effect on contrast of different types of monomers.

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Acknowledgement

Materials and Technology Innovation which belongs to the promotion plan of Beijing Municipal Education Commission creative talents "Study of environmental CTP plate and printing ink" (NO.06170113025).

Author Biography

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