The Effect of Initiator on Deep Curing of UV Ink

Ma Xiaoxu, Wei Xianfu, Huang Beiqing, Qiu Lang

(Beijing Institute of Graphic Communication, Beijing 102600, China)

Abstract

The deep curing of UV ink is different, and it has huge effects on the performance of thick ink film. Initiator which is one of important components of UV ink has a greater impact on the curing of ink. It has great help to the deep curing of UV ink by choosing the correct initiator to make UV ink. In order to increase the curing rate of printing thick ink film with UV ink, other components of UV ink were fixed, and the variety and content of initiators were changed to make ink. By printing proofing in different ink thickness, the ink double bonds converted of proofs which were in different ink thickness were tested, and the relationship between the variety and content of initiators and the curing rate of different ink thickness. To make the ink with different kinds of composite initiators, the variety and content of initiators which had higher curing rate at thick ink film were obtained. The results show that After mixing prepolymers 6325-100 and monomer in certain proportion, the ink with light initiator ITX has higher double bond conversion rate than the ink with light initiator TPO or BP; the ink with light initiator TPO or ITX, when the ink layer is thin, the double bond conversion rate increased with the increase of the thickness, when the ink layer is thick, the double bond conversion rate decreased, the ink with light initiator BP, the double bond conversion rate increased with the increase of the thickness. The double bond conversion rate of the UV ink increased with the increase of UV light power. When the ink layer is thin, content of light initiator ITX at 8%, the double bond conversion rate is the highest; when the ink layer at the thickness 40um, content of light initiator ITX at 10%, the double bond conversion rate is the highest.

***Key words**: initiator; UV ink; deep curing*

Introduction

The thickness of the UV ink layer plays a key role in the curing effect. If the ink layer is too thick, while the UV energy is shortage, the UV ink will not completely cure. The main conditions of the deep curing under the ultraviolet radiation is that the molecular must absorb the light quantum which has enough energy, then the molecular will become the inspire molecular and decompose into free radicals or ions, at last, the chemical reaction, such as polymerize, grafting and cross-linking will happen during the unsaturated organic, and the purpose of curing is realized. Therefore, the difficulty of curing the UV ink deeply has very big effect to the thick ink film printing quality. As one of the important components of curing inks, Photoinitiator has an important effect to the curing of the ink. In this article, the author prepared the UV ink by using different kinds and levels of photoinitiator, and did the samples with different ink layer thickness, then tested the ink double bonds converted of proofs, Conversion of a double, Provide theoretical basis for the relationship between photoinitiator and UV deep curing.

The Experiment

Material:

Pigment: Benzidineyellow

Pre-polymer: acrylate pre-polymer 6325-100

Monomer: hexanediol diacrylate(HDDA), 2-(2-Ethoxyethoxy) Ethylacrylate (EOEOEA);

Photo initiator: 1-hydroxyl-ring has base-a ketone phenyl (184), Trimethyl benzoyl diphenyl phosphine oxide (TPO), benzophenone (BP), 2-isopropyl thioxanthone (ITX)

Other promoters: 2-Ethylhexyl 4-dimethylaminobenzoate (EHA), surfactant, flow agent, dispersant etc.

Equipments:

EXAKT three-roller grinding mill(Germany);Magnetism Msier (China), Shimadzu FTIR-8400 Fourier transform infrared spectrometer (Japan), Vacuum UV curing device (China)..

Sample preparation:

Mix the prepolymers, monomer and fertilizer in a certain proportion, then add three kinds of photoinitiator: ITX , TPO and BP, into the mixture respectively. Give fully grinding for mixing better. Then Dilution the mixture and will get the UV ink. Mix the prepolymers, monomer and fertilizer in a the same proportion, then add into photoinitiator ITX with different content and made the UV ink.

Conversion of a double test method:

After the samples with different ink thickness cured by the ultraviolet radiation energy, test the infrared absorption spectrum curve of the ink film, then calculated the double bond conversion rate by using the rate of the spectral bands absorption strength under different radiation energy. Such as type conversion of a double 1 shows:

$$C_r = \frac{A_0 - A_x}{A_0} \times 100\% \quad (1)$$

In the above formula, A_0 is the strength ratio of the spectrum absorption in 810cm^{-1} and 1730cm^{-1} which were not radiate by the ultraviolet light. A_x is the strength ratio of the spectrum absorption in 810cm^{-1} and 1730cm^{-1} which were radiate by the ultraviolet light in a certain time t. C_r means the double bond conversion rate in the corresponding conditions [2].

Results and the Analysis

Different kinds of photoinitiator UV curing deep influence of ink:

Make the UV ink which contain three different photoinitiator (TPO, ITX and BP) into samples with different ink thickness. Cured the sample cured in a a 120 w/cm power in the UV-curable instrument and tested the infrared absorption spectrum curve , then calculate the double bond conversion rate its result conversion as shown in figure 1 below:

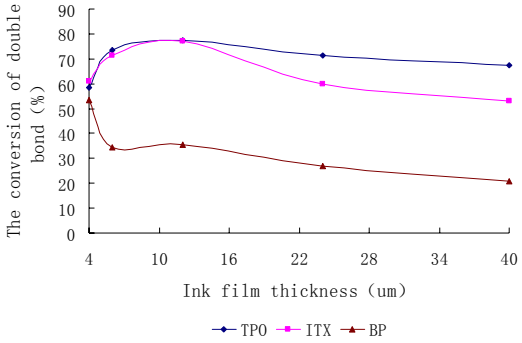


Figure 1 The relationship of ink film thickness of ink with different photoinitiator and the double bond conversion rate

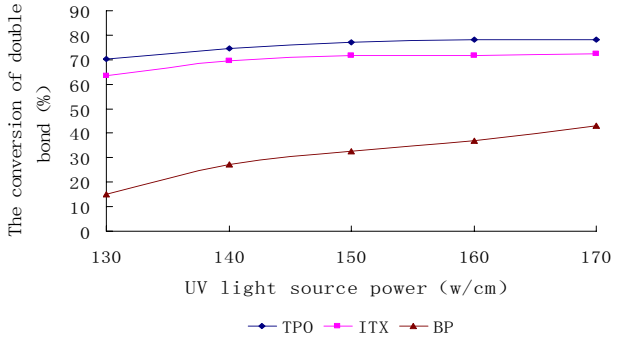
The figure 1 shows that the double bond conversion rate of the ink sample which contain the photoinitiator TPO is higher than that contain ITX and BP. When the thickness of the ink sample which contain TPO and ITX is small, the double bond conversion rate increase along with the increase of the ink layer thickness, When the thickness become thicker, the double bond conversion rate of the ink samples which contain BP increase along with the increase of the ink layer thickness, the absorption spectrum of the photoinitiator must match with the emission spectral bands of the radiation light source[3]. The photoinitiator TPO and ITX have a high efficiency in absorbing light when they in the spectral range of the UV light source which is 250 ~ 400 nm inside, the free radicals can be produced and react with the unsaturated group from the link material of the UV ink, and has a high curing rate compared with the UV ink which contain BP, Therefore, the double bond conversion rate is more higher, When the ink layer is more thicker, the surface curing first and the radiation of the UV light source is blocked, this leads to the deep layer of the ink film is not completely curing, and the the double bond conversion rate reduced.

Different UV light source of UV curing inks power influence:

Make the UV ink which contain three different photoinitiator (TPO, ITX and BP) into samples with same ink thickness. Cured the samples in the UV-curable instrument with 130 w/cm、140 w/cm、150 w/cm、160 w/cm and 170 w/cm power, tested the infrared absorption spectrum curve and calculate the double bond conversion rate, the results calculated conversion as shown in figure 2.

The figure 2 shows that the double bond conversion rate of the UV ink increase along with the increase of the power, Among them, the ink which contain TPO has the highest conversion rate, along with the increase of the power, the increase amplitude of the double bond conversion rate of the ink which contain ITX and TPO is small, the double bond conversion rate of the ink which contain BP has a large increase. When the power of the UV light source increased, the energy that the photoinitiator absorb increased, the free radical produced by the stimulate initiator molecules increased, which cause the monomer polymerization[4], Therefore, the curing efficiency increased, and the double bond conversion rate increasing. The TPO has the highest activity, the next is the ITX, the BP has a low activity, so, in the same curing power, the ink which contains the BP has the lowest the double bond conversion rate.

Figure 2 The double bond conversion rate of the ink with different photoinitiator under the different light source power



Different content of UV photoinitiator ink deep influence of curing:

Prepare samples in different UV ink layer thickness, and make sure the UV ink contain ITX in 4%、6%、8%、and 10% , cured the samples in UV-curable instrument in a 120w/cm power respectively, tested the infrared absorption spectrum curve and calculate the double bond conversion rate, the results calculated conversion as shown in figure 3.

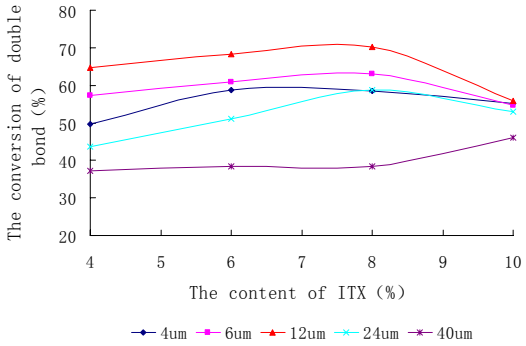


Figure 3 The relationship of ink film thickness of ink with different content of photoinitiator and the double bond conversion rate

The figure 3 shows that if the light initiator in a certain concentration range, the double bond conversion rate of the UV ink increase along with the increasing of the light initiator concentration, when the thickness of the ink is small, the double bond conversion rate decrease along with the increasing of the

light initiator concentration, In the small thickness of the ink layer, when the light initiator concentration is 8%, the UV ink has the highest the double bond conversion rate, when the ink layer has the biggest thickness, 40 um, the double bond conversion rate of the ink increase with the increasing of the light initiator concentration, It reaches maximum when the concentration of the ITX is 10%. When the initiator concentration is very low, A few free radicals produced by the initiator is mainly consumed by the oxygen, It is very difficult for the curing reaction to happen, so the curing rate is slow. As the light initiator improving in a certain concentration range, the double bond conversion rate increase, too. When the initiator has certain efficiency and the certain constant of decomposition into primary free radicals, if the concentration of the light initiator increase, the light trigger rate increase and the curing rate increased, After the concentration of the initiator become higher, because of the increase of the initiator In a certain range, the light energy absorbed by the initiator increased, so the chain trigger speed increase, but the high concentration of the initiator will make the increasing of the free radicals, it will make the reaction induced period become shorter, the chance of the Coincidence reaction between the free radicals become big [5], this will lead to the low cure rate.

Photoinitiator concentration is not the higher the better, after it get the certain concentration, the double bond conversion rate have a downward trend while the concentration increase. When the ink layer is thicker, the UV ink in which the photoinitiator content is 10% has the highest the double bond conversion rate. Because of the increasing of the film thickness, the density of the free radicals in the system decline, and the chance of coincidence reaction reduce, therefore, the double bond conversion rate is high compared with the same ink layer thickness in which the photoinitiator has a low concentration, the cure rate of the ink increase, but, as the ink layer become thicker, the the double bond conversion rate of the ink decline, the surface of the ink layer curing completely while the deep is not curing completely instead because of the too thick ink layer, so if the ink contain the photoinitiator in the same concentration, the sample which ink layer is thicker will have a lower double bond conversion rate.

Conclusion

(1)After mixing prepolymers 6325-100 and monomer in certain proportion, the ink with light initiator ITX has higher double bond conversion rate than the ink with light initiator TPO or BP; the ink with light initiator TPO or ITX, when the ink layer is thin, the double bond conversion rate increased with the increase of the thickness, when the ink layer is thick, the double bond conversion rate decreased, the ink with light initiator BP, the double bond conversion rate increased with the increase of the thickness.

(2) The double bond conversion rate of the UV ink increased with the increase of UV light power.

(3)When the ink layer is thin, content of light initiator ITX at 8%, the double bond conversion rate is the highest; when the ink layer at the thickness 40um, content of light initiator ITX at 10%, the double bond conversion rate is the highest.

References

[1] Wang Tao, Song Lijuan; Net printing technology. pg. 22-23(2004)

[2] HYO-SOOK JOO, YOUNG-JUN PARK, HYUN-SUNG DO, eds, The curing performance of UV-curable semi-interpenetrating polymer network structured acrylic pressure-sensitive adhesives, J. Adhesion Sci. Technol.(2007)

[3] Yan Yanni; Research of UV flexo ink curing speed, Beijing, Beijing Institute of Graphic Communication2010

[4] Wang Haide, Jiang Ling; Uv curable materials.Beijing, Science Publishing Company,(2011)

[5] Wu Shikang, Polymer photochemical introduction- Basic and applied], Beijing, Science Publishing Company.(2003)

Author Biography

Ma Xiaoxu (1987-), the postgraduate of Beijing Institute of Graphic Communication, and the main direction is printing material.

Wei Xianfu (1963-), the professor of Beijing Institute of Graphic Communication, and engaged in the design and exploitation of new environmentally friendly printing ink, printing technology and the rheolgy of disperse system.

Huang Beiqing (1965 -),the associate professor of Beijing Institute of Graphic Communication, and the main direction is printing technology and printing material.