Study on the Influence of Printing Conditions on the Curing of UV Ink

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Abstract

UV light's radiation parameters and printing speed of printer has important influences to the curing of ink in the printing process. In order to achieve the fast curing of UV ink, fix the UV ink. By changing the printing conditions such as light intensity, irradiation distance and curing speed, test the double bond conversion of UV ink, and analysis the influence of printing conditions on the curing of ink. Meanwhile, change the oxygen concentrations of the test environment; test the double bond conversion of UV ink in different printing conditions, and analyze the influences of printing conditions to the oxygen inhibition in the curing of UV ink. Through the analysis of the test results, discuss the printing conditions that can weaken the oxygen inhibition in the curing, and achieve the fast curing of ink. The results show that the printing conditions such as light intensity, irradiation distance and printing speed have great influence to the curing of UV ink, as well as the oxygen inhibition in the curing. The UV ink can expedite curing by adjusting the printing conditions, making it meet the needs to high-speed printing.

Key words: *printing conditions; UV ink; curing speed; oxygen inhibition*

Introduction

UV curable coating has been widely used in high technology fields, for it has a lot of advantages such as it can save energy, reduce air pollution, cure rapidly, reduce area and suitable for automation, and so on. The cure reaction mostly occurs in the air atmosphere and room temperature, the oxygen in air has inhibitor role on the free radical polymerization. Therefore, how to overcome the oxygen inhibitor, and improve the curing speed by using oxygen becomes one of the important issues for studying UV curable coating [1]. Printing conditions has important influence on the curing of ink in printing process. This article mainly discusses the effect of printing conditions on the inhibitor of UV curable coating.

Experiments

Experimental materials

Pigment: benzidine yellow;

Pre-polymer: acrylate pre-polymer 6311-100, 6325-100, EB450;

Monomer: 2-(2-Ethoxyethoxy) Ethylacrylate (EOEOEA); Neopentyl glycol diacrylate (NPGDA); Trimethylolpropane triacrylate (TMPTA);

Photo initiator: 2-isopropyl thioxanthone（ITX）, Trimethyl benzoyl diphenyl phosphine oxide (TPO);

Other promoters: surfactant; flow agent; dispersant etc.

Equipment

Grinding equipment: GJ-2S high-speed grinding mill (China);

Testing equipment: Fusion Light Hammer 6（USA）;

Shimadzu FTIR-8400 Fourier transforms infrared spectrometer（Japan）;

Vacuum UV curing device (China).

Test method of double bond conversion rate

The samples of UV ink were solidified by using different curing energy on UV-curable apparatus. The Infrared spectrum of UV ink was measured by IR spectra apparatus, and the conversion rate of double bond was calculated, as is shown below:

$$C_r = \frac{A_0 - A_x}{A_0} \times 100\ \%$$

Where A_0 is the ratio of light absorption in 810cm^{-1} and 1730cm^{-1} without ultraviolet radiation, A_x is the ratio of light absorption in 810cm^{-1} and 1730cm^{-1} under different UV radiation energies and Cr is the conversion rate that corresponds to different conditions [2].

Test method of oxygen inhibition

A vacuum UV curing device was made to inspect the oxygen inhibition, as shown in Fig.1. By controlling the vacuum level and the oxygen flow of the device, ink samples were irradiated at atmosphere of different oxygen concentration, and then tested the curing rate of the ink samples.

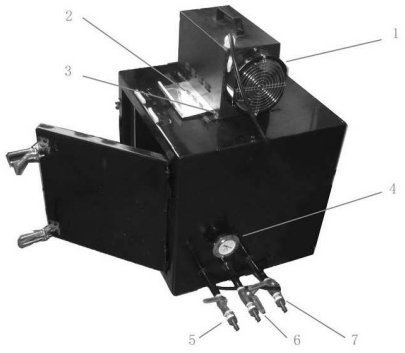

Fig.1 Structure of the vacuum UV curing device

1 UV lamp（100W/cm optional）; 2 Manual shading plate; 3 Quartz plate; 4 Vacuum Gauge; 5 Vacuum pump interface; 6 Oxygen intake; 7 Exhaust port

Results and Discussion

Influence of Light Intensity on the Curing of UV Ink

Printed the ink samples and cured at the UV-curable instrument. Keep the curing speed under 20m/min, ink samples were cured by different light intensity, test the double bond conversion rate of inks and the results are shown in Fig.2.

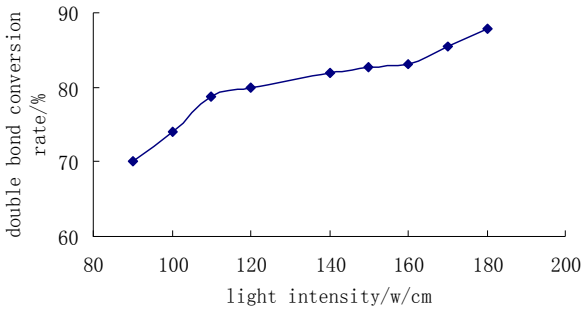

Fig.2 Influence of Light Intensity on the Curing of UV Ink

Fig.2 shows that light intensity has great influence on the curing of UV ink. With the increase of the light intensity, the double bond conversion rate of ink samples increase, too. So does the degree of cure. Because with the increase of the light intensity, photo initiator will decompose greatly, a number of active free radicals generate instantly. The active free radicals can addition polymerization with monomer, the double bond in inks can reaction greatly, and the double bond conversion rate increases [3]. Therefore, by using the higher light intensity can make the UV ink fast curing.

Influence of curing speed on the Curing of UV Ink

Put the printing proofs in the UV-curable instrument; keep the light power under 100w/cm. The samples were cured at different curing speed, the double bond conversion rate of inks was tested, and the results are shown in Fig.3. Change the testing environment, and the printing proofs were cured in the vacuum UV curing device. The double bond conversion rate was tested through changing the curing time and the oxygen concentration, and the results are shown in Fig.4.

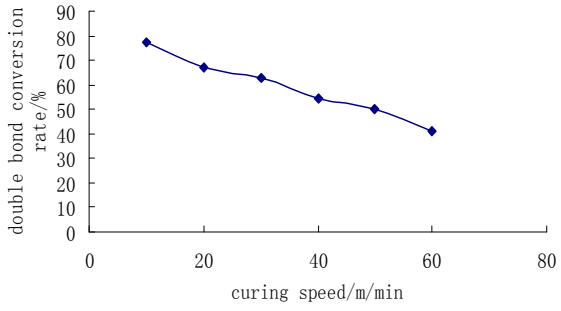

Fig.3 Influence of curing speed on the curing of UV ink

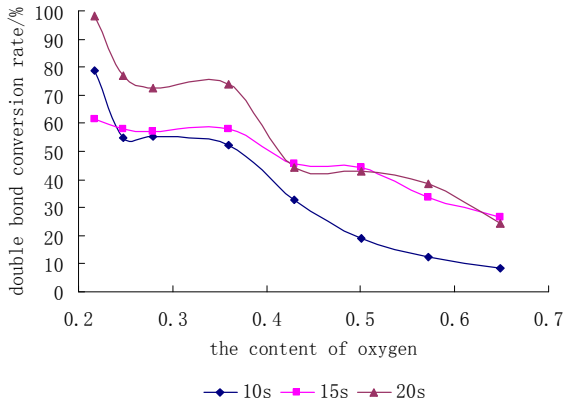

Fig.4 Influence of oxygen concentration on the curing of UV ink at different curing time

Fig.3 shows that curing speed has great effect on the double bond conversion rate of UV ink. When the other conditions fixed, with the increase of the curing speed, the double bond conversion rate of UV ink decreases, so does the cure degree of UV ink. Because with the increase of the curing speed, the time that ink in the UV-curable instrument decreased, as well as the power that the UV ink receives. Under the same curing power, the addition polymerization between free radicals of photo initiator decomposition and monomer has reduced, as well as the reaction of double bond [4]. Therefore, reduce the curing speed (printing speed) properly can make the UV ink cured better.

Fig.4 shows that curing time has great effect on the double bond conversion rate of ink, and it also related to the oxygen concentration. When at low [O_2], the double bond conversion rate of 15s and 10s have no difference, and less than that of 20s; when at high [O_2], the double bond conversion rate of 15s and 20s have no difference, and higher than that of 10s. This is mainly because the corresponding double bond conversion rates of ink is low for when the [O_2] concentration is high, oxygen inhibitor effect is great and when curing time is short, the photo initiator generating active free radicals are consumed by oxygen, which make free radicals cannot participate in free radical polymerization reaction. When the [O_2] concentration is low, the curing of ink basically is not acted on oxygen. With the curing time increasing, the polymerization reaction between free radicals that photo initiator decomposition generates and monomer is relatively increase and double bond conversion rate increases, so double bond conversion rate will increase. Fig.4 also shows that in the case of the same curing time, the double bond conversion rate of ink increases as the oxygen content decreases. This is mainly because oxygen has inhibitor effects on the curing of UV inks. At low [O_2] concentration, the changing of [O_2] concentration has great impact on the double bond conversion rate. If a high [O_2] concentration is maintained, the double bond conversion decline at a lower rate with [O_2] increased [5]. The figure also shows that appropriately increasing the curing time that the printing speed is reduced in the process of printing can reduce oxygen inhibitor effect, which make UV ink maintain a relatively high double bond conversion rate in

the case of oxygen existent.

Influence of irradiation distance on the Curing of UV Ink

Cured the printing proofs at the vacuum UV curing device, tested the double bond conversion rate of inks by changing the oxygen concentration and irradiation distance, the results are shown in Fig.5.

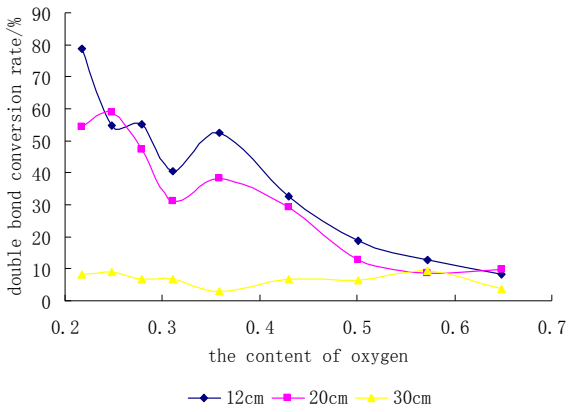

Fig.5 Influence of oxygen concentration on the curing of ink at different irradiation distance

Fig.5 shows that illuminant irradiation distance has a great influence on the double bond conversion rate of UV ink. When the irradiation distance is too far, UV ink will not cure, but it also affected by oxygen concentration. At low [O_2] concentration, the double bond conversion rate of ink greatly influenced by illuminant irradiation distance. With illuminant irradiation distance increasing, the double bond conversion rate will be decreased. But at high [O_2] concentration, the influence is less. This is mainly because as the light irradiation distance increases, the ink surface receiving UV energy will reduce and accordingly the free radical polymerization reaction rate reduces, so the double bond conversion rate decreases. While in high [O_2] concentration, due to the function of oxygen inhibitor increasing, both initiator prime free radical and chain growth free radical react with oxygen to generate relatively stable peroxide that lost the ability to cause polymerization and easy react with other radicals to terminate the polymerization, so oxygen inhibits chain initiation and chain growth, polymerization rate decreases and UV inks can not be cured. Consequently, the double bond conversion rate of ink has less affected by irradiation. Therefore, reducing illuminant irradiation distance can make UV ink faster.

Conclusions

According to study the effect of printing conditions on UV inks curing, the following conclusions can be drawn:

(1) when the curing speed of ink is certain, illuminant intensity, irradiation distance and printing speed and other printing conditions have a significant impact on curing of UV inks. The rapid curing of UV inks can be improved by increasing the intensity of UV illuminant, reducing the irradiation distance and printing speed to meet the printing requirements.

(2) Changing oxygen concentration has a certain influence on curing of UV inks. In printing process, oxygen inhibitor effect can be reduced in curing by reducing the oxygen concentration in order to achieve the fast curing of UV inks.

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