

Study on the Curing Velocity of UV Curable Offset Ink

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Abstract

for researching the effect of main components on curing velocity of UV curable offset ink, UV curable offset inks are prepared by different sorts of prepolymer, monomer and photoinitiator. Also the different photoinitiators are mixed and the quantities of photoinitiator and wax are changed during the preparing process of these UV curable offset inks. Then the curing velocities of these ink samples are tested. The results of research indicate that the configuration of prepolymer and the function degree of monomer affect the curing velocity of inks. Other factors accelerating the curing velocity include selecting appropriate photoinitiator whose absorption curve of spectra corresponds with the "transmission window" of pigment and the radiation peak of UV curing lamp, mixing the different kinds of photoinitiators, choosing the proper quantity of photoinitiator, and adding wax.

Keyword: UV curable offset ink; curing velocity; components of ink

Introduction

UV curable offset ink is used widely in the field of offset printing because it has benefits of high producing efficiency and excellent printing quality, is friendly to environment and easy to process, and can be printed on the surface of plastic. Curing velocity is one of vital performances of UV curable offset ink, which will affect the offset printing speed. The components of UV curable offset ink, such as prepolymer, monomer and photoinitiator, influence curing velocity. So for accelerating the curing velocity, it is necessary to research the effect of components on curing velocity.

Experimental

Experimental Raw Materials

Pigment: phthalocyanine blue, red

Prepolymer: 6215-100 (E1), EB3700 (E2)

EB450 (P1), EB657 (P2), EB870 (P3)

Monomer: EO3-TMPTA, NPGDA, TPGDA

Additive: wax, EHA

Photoinitiator: showed in table 1

Table 1: The sorts and absorption peak of UV light of Photoinitiator

Photoinitiator	Absorption peak of UV light (nm)
TPO	269、298、379、393
907	232、307
651	254、337
184	246、280、333

1173	245、280、331
ITX	255、380

Experimental Equipment and Device

Spectrophotometer / UV-2501PC / Japan/Shimadzu

Three-roller grinding mill / SG-65 / China / JinJia

Desk-type UV curing machine / Light Hammer 6 / American / FUSION

Printability tester / AIC2-5 / Holand / IGT

Experimental Process

The preparation of ink

Weigh up proper quantity of materials according to the formulation of ink, and mix them evenly. Then mill these materials with three-roller grinding mill for about one hour.

The preparation of printing sample

Proof the ink with printability tester when the press roller is 3.2 cm wide, the quantity of ink is 0.3825ml, the substrate is coated paper of 128g/m², the printing speed is 0.2m/s, and the printing press is 625N.

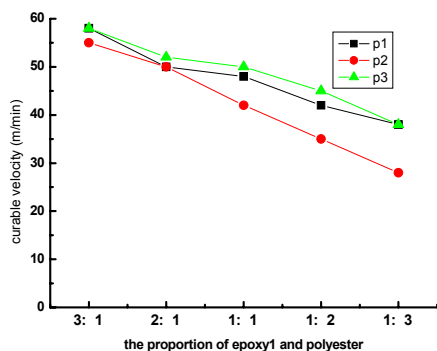
The testing method of curing velocity

Cure the printing proof on desk-type UV curing machine, when the power is 200w/cm. Modulating the speed of machine, the highest curing speed which can cure the printing sample is the curing speed of UV ink.

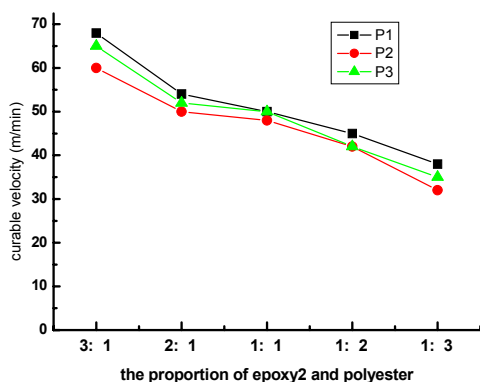
Results and Discussion

The effect of prepolymer on the curing velocity of UV curable offset ink

As the basic resin of UV curable ink, the prepolymer is the main material of photochemical reaction. It influences into the curing velocity of the UV curable ink. Commonly, epoxy prepolymer and polyester prepolymer are mixed to prepare the UV curable offset ink. In this research, different kinds of polyester prepolymer are mixed with two kinds of epoxy prepolymer respectively to prepare magenta inks, also the proportion of two sorts of prepolymer is changed. Then the curing velocities of magenta inks are tested, and the results are showed in figure 1.



(a)



(b) Figure 1: The effect of prepolymer on the curing velocity of UV curable offset ink

Figure 1 indicates that the sorts of prepolymer affect the curing velocity of the ink. The more epoxy prepolymer is used, the higher the curing velocity of the ink is. This result indicates that the curing velocity of epoxy prepolymer is higher than the polyester prepolymer. So in order to get the higher curing velocity, more epoxy prepolymer should be added into the ink system. Also Figure 1 indicates that the curing velocities of the ink are different with the different kind of epoxy prepolymer or polyester prepolymer. This difference is caused by the different configurations of the prepolymer. The higher the function degree is, the higher the curing velocity is. The configuration of amine which is brought into the prepolymer also can improve the curing velocity.

The effect of monomer on the curing velocity of UV curable offset ink

Not only the monomer dilutes the ink, but also it participates in curing process. So the monomer also affects the curing velocity of UV curable offset ink. Mixed monomers are used in the UV curable offset ink. In this research, three kinds of monomers (EO3-TMPTA, NPGDA and TPGDA) are mixed to prepare the magenta inks. The curing velocities of the magenta inks are tested, in which the proportion of the three kinds of monomers is changed. The results of tests are showed in figure 2.

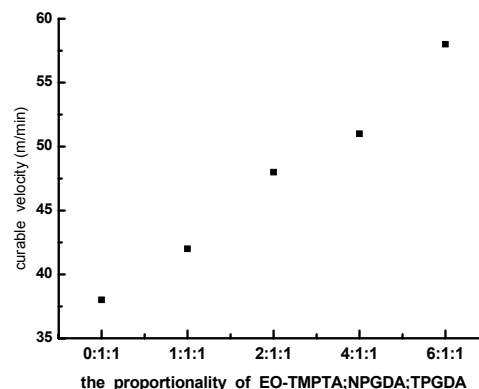


Figure 2: The effect of monomer on the curing velocity of UV curable offset ink

Figure 2 indicates that the curing velocity changed with the different proportion of the three kinds of monomers of UV curable offset ink. The curing velocity increases with more EO3-TMPTA in the mixed monomer. EO3-TMPTA has three function groups, while NPGDA and TPGDA have two. Therefore, the more EO3-TMPTA is, the more the function groups of the mixed monomer are. The curing velocity is higher due to the high sensitivity of mixed monomer in photochemical action.

The effect of photoinitiator on the curing velocity of UV curable offset ink

As the key component of UV curable system, photoinitiator determines the curing efficiency of the prepolymer and the monomer in photochemical action. So the sorts and the quantity affect the curing velocity of UV curable offset ink. Taking cyan ink as an example, the effect of photoinitiator on the curing velocity of ink is studied in this research.

The effect of the sorts of photoinitiator on the curing velocity

The cyan inks are prepared with six different sorts of photoinitiator respectively by fixing the quantity of photoinitiator as 5%. The curing velocities of the cyan inks are tested, and the results of tests are showed in figure 3. Also the absorption curve of spectra of phthalocyanine blue pigment is tested with spectrophotometer, and the curve is showed in figure 4.

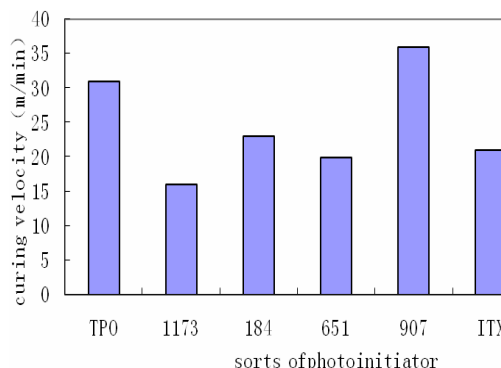


Figure 3: The effect of the sorts of photoinitiator on the curing velocity

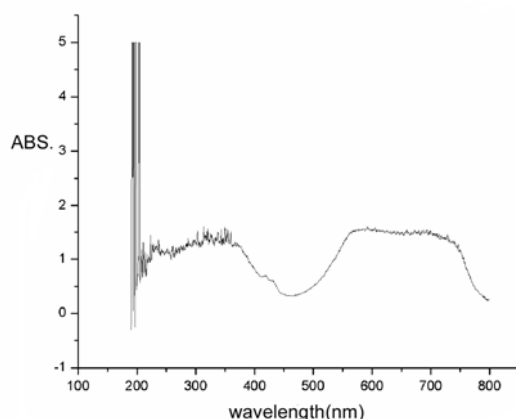


Figure 4: The absorption curve of spectra of phthalocyanine blue pigment

Figure 3 indicates that the curing velocities of cyan UV curable offset ink are higher with the photoinitiator of 907 and TPO. As showed in Figure 4, the “transmission window” of phthalocyanine blue pigment is at the part between 230nm and 290nm, where the pigment has the weak absorption. The absorption peaks of TPO and 907 are at 269nm and 232nm respectively, which are all at the “transmission window” of the pigment. And the absorption peaks are also close to the radiation peak of UV curing lamp. So the curing velocities of cyan UV curable offset ink are higher with these two kinds of photoinitiator. Although other four kinds of photoinitiator also have absorption peaks at the “transmission window” of pigment, their low initiating efficiency results in the difference of curing velocity with TPO and 907.

The effect of mixed photoinitiator on the curing velocity

Maybe the curing quality is not very ideal with only single photoinitiator, so different kinds of photoinitiator are mixed to prepare the UV curable offset ink. In this research, the inks are prepared with mixed photoinitiator of TPO, 907 and 184 by the way of formulation experiment. The curing velocities of the inks are tested, and the results are showed in table 2.

Table 2: The effect of mixed photoinitiator on the curing velocity

Number	x1 (TPO)	x2 (184)	x3 (907)	curing velocity (m/min)
1	1	0	0	26
2	0	1	0	17
3	0	0	1	36
4	0.5	0.5	0	23
5	0.5	0	0.5	38
6	0	0.5	0.5	37
7	0.33	0.33	0.33	34

Calculated by the mathematics model of formulation experiment, the expression of regressive equation is:

$$y=26x_1+17x_2+36x_3+6x_1x_2+28x_1x_3+42x_2x_3-21x_1x_2x_3$$

According to the regressive equation and other correlative qualification, the regressive equation gets the maximal extremum of 39m/min, as x_1 , x_2 , x_3 equal to 0,0.3,0.7 respectively. This result indicates that the curing velocity of UV with mixed photoinitiator is higher than the ink with single photoinitiator. Mixing different kinds of photoinitiator is good for the absorption efficiency and initiating efficiency of the ink system.

The effect of the quantity of photoinitiator on the curing velocity

The cyan inks are prepared by changing the quantity of photoinitiator. The curing velocities of the cyan inks are tested, and the results of tests are showed in figure 5.

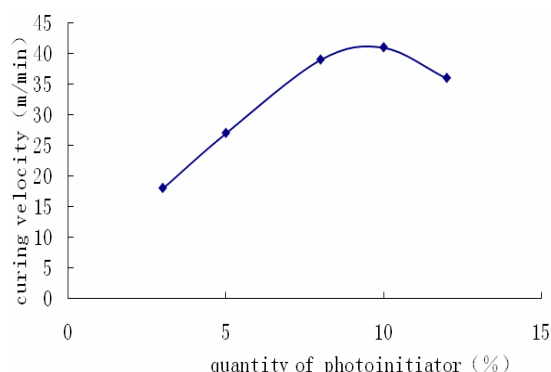


Figure 5: The effect of the quantity of photoinitiator on the curing velocity

Figure 5 indicates that the curing velocities of the cyan inks increase with adding the photoinitiator just below a certain quantity. If the photoinitiator is higher than this quantity, the curing velocity reduces instead. When the quantity of photoinitiator is very low, only very few of free radical produced and some is used up by oxygen. So it is difficult to initiate photochemical action. The quantity of free radical will increase when more photoinitiator is used. The curing velocities of ink will increase accordingly. However, too many free radicals are produced as the quantity of photoinitiator increases continuously, these free radicals will crash with each other. The action between the free radicals makes them lose ability of initiating photochemical action. The curing velocity reduces instead, when the quantity of photoinitiator is too high. So the photoinitiator should not be used too much. For this research, the curing velocity of the cyan ink is highest when 10% of mixed photoinitiator are used in the preparation process of ink.

The effect of wax on the curing velocity of UV curable offset ink

Some wax is often added during the preparing process of UV curable offset ink. Wax can make dots full and even, improve the resistance of rubbing and the disadvantages of smear, it can also make the presswork smoother. The wax affects the curing velocity of UV curable offset ink. The inks are prepared by changing the quantity of the wax, then the curing velocities of inks are tested, and the results are showed in figure 6.

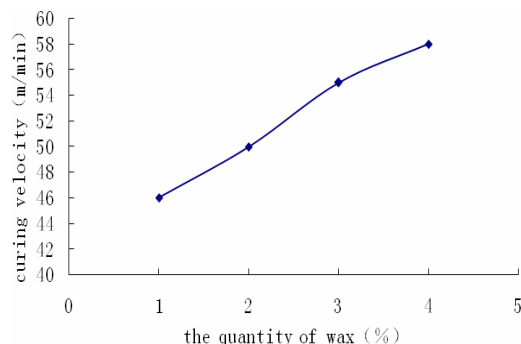


Figure 6: The effect of wax on the curing velocity of UV curable offset ink

Figure 6 indicates that adding a little of wax is helpful for the curing velocity of UV curable offset ink. The film of offset ink is so thin that the oxygen is easy to go into the ink film. As the oxygen can resist the photochemical action, the curing velocity is affected by the oxygen. When wax is used in the UV curable offset ink, it transfers to the surface of the ink film due to its bad compatibility with the ink system and its low surface tension. The wax isolates the oxygen, so adding wax is helpful for the curing velocity.

Conclusion

1. The configuration of prepolymer influence to the curing velocity of UV curable offset ink. Commonly, the velocity of epoxy prepolymer is higher than the polyester prepolymer.
2. The function degree of monomer influence to the curing velocity of UV curable offset ink. Commonly, the higher the function degree of monomer is, the higher the curing velocity is.
3. In order to get higher curing velocity, the absorption peak of spectra of photoinitiator should correspond with the transmission window of pigment and the radiation peak of UV curing lamp, and the photoinitiator should have high initiating efficiency.
4. The curing velocity of UV curable offset ink can be advanced by using mixed photoinitiator under the given conditions of experiment.
5. The photoinitiator should not be used too much, because the curing velocity of UV curable offset ink increases with adding the photoinitiator just below a certain quantity. If the photoinitiator is higher than this quantity, the curing velocity reduces instead.
6. Adding a little of wax is helpful for the curing velocity of UV curable offset ink.

References

- [1] Yang Jianwen, Chen Yong-lie, Zeng Zhaohua. 2005. Light Curing Material And Application [M]. Chemical Industry Press. P. 26-27.
- [2] Huang Beiqing. 2005. The description of national ink market [J] China Printing Materials Market. P. 13-14
- [3] Wei Jie, Jin Yangzhi, 2005, Light Curing Material [M]. Chemical Industry Press. P. 15-16.
- [4] Chen Yonglie, Zeng Zhaohua, Yang Jianwen. 2003. Radiation Curing Material And Application [M]. Chemical Industry Press. P. 39-41.

- [5] Wang Deihai, Jiang Ling. 2001. UV curable Material [M]. Science Press. P. 85-86.
- [6] Li Yunyan, Hu Chuanrong. 2005. Experiment Design and Data Processing [M]. Chemical Industry Press. P. 143-144.