Photoinitiators in Graphic Arts

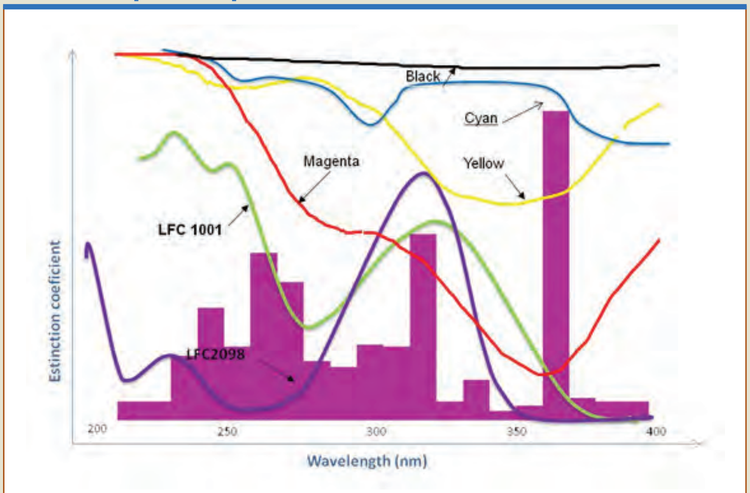
By Elena Bellotti, Emilio Cremona and Barbara Fenzi

The use of energy-curing technology in graphic arts is still marginal, even if it has all the characteristics to become a very important technique for high-speed printing, increasing quality and reduced release of volatile organic compounds. In order to develop these characteristics and to satisfy unmet needs, a continuous improvement of the components of the formulations is required.

Photoinitiators are key components for a successful formulation. Some required characteristics of photo-initiators are high reactivity, good stability in the formulations, no release of odorous photodecomposition derivatives, and low migration from the cured formulations.

Figure 1

UV spectrum of the medium-pressure Hg lamp, transmittance windows of the pigments and UV absorption spectrum of LFC1001 and LFC2098



In graphic arts, two main different applications have been developed: overprint varnishes (OPV) that are mainly clear coatings and inks made up of pigmented systems. Both UV-curable inks and OPVs play a large role in the development of various types of food packaging materials. One of the critical issues regarding food packaging applications is the potential migration of ink and coating components—including both the photoinitiators and the coinitiators—into the foodstuff. These two different applications generally require the use of different photoinitiators.

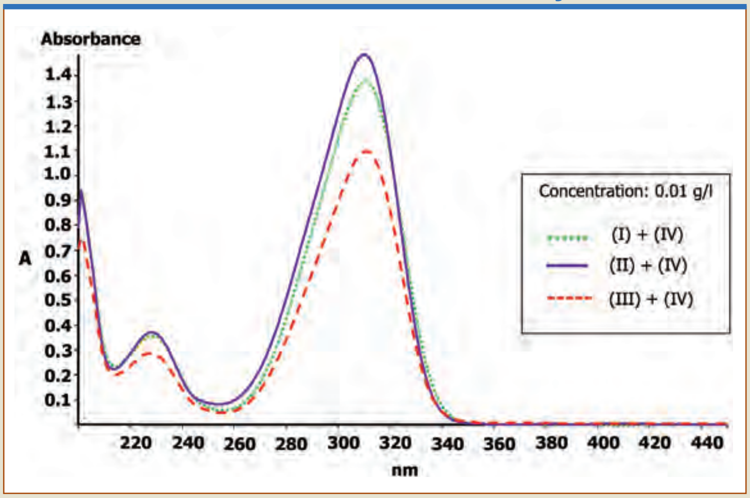
We have developed a photoinitiator that demonstrates very good characteristics in both applications, representing a good compromise among the conflicting characteristics and simplifying the choice of photoinitiators. Moreover, this photoinitiator has a very interesting characteristic of low migration that can help the development of food packaging applications—it is LFC1001 (IV), a difunctional Type II photoinitiator.

As a Type II photoinitiator, it requires a hydrogen donor (called coinitiator) to generate the "curing system." Without the coinitiator, the radical generation necessary to bring about polymerization is very slow and sometimes impossible. A coinitiator is especially appreciated in printing inks and thin-film weight coatings for its activity as an oxygen scavenger and hydrogen donor.

We have developed a difunctional, high-molecular weight amine

Figure 2

Absorption spectra of blend (I + IV) compared to (II + IV) and (III + IV) in an industrial UV cyan offset ink



coinitiator—LFC2098 (I)—that is characterized by high reactivity, low yellowing and low odor properties. This novel coinitiator also shows very low migration in a variety of simulating fluids upon curing into a film. In this work, we wanted to show that the combination of the new photoinitiator with the coinitiator is a high-performing package of photoinitiators in graphic arts (especially for pigmented inks) and offers new solutions for the use of UV-curable technology in food packaging applications.

In general, when dealing with graphic arts and inks, the matching of maximum UV absorbance with the transmittance window of the pigment is fundamental for a good performance of the package coinitiator/photoinitiator. Figure 1 shows the transmittance windows of the principal pigments (cyan, magenta, black and yellow) and the wavelength absorption profiles of the new coinitiator and photoinitiator. As we can observe, the maximum of these two curves matches with the transmittance window of pigments and with the maximum emission of the lamp. This is an important fact that makes the new coinitiator and new photoinitiator suitable for pigmented inks.

Offset Inks Experimental

Formulation

Two industrial offset ink formulations were applied onto a paperboard substrate using an IGT Reprotest model C1 Printability Tester to obtain a film weight of 1.5 or 3 g/m². The industrial formulations must remain undisclosed. LFC1001 difunctional ketosulphone was added to the formula at 3% and the samples were then supplemented with 3% of (I), EDB—ethyldimethylaminobenzoate—(II) and a polymeric amine (III) as coinitiators for performance comparisons.

Test

Through-cure (ThC) is recorded as the fastest belt speed in which the film passes the thumb twist test. Solvent resistance was measured as number of rubs using the reported solvents (at ThC minus 30%). Gloss at 20°C and 60°C were measured by a BYK Micro-TRI-Gloss meter (at ThC minus 30%). All samples were conditioned for 12 hours at room temperature in the dark before testing. All samples were cured using a Fusion UV system apparatus equipped with H-bulb in air.

Migration was tested using simulating fluid such as 95% ethanol, 10% ethanol and acetic acid 3%. Samples were then conditioned for 10 days at 40°C. Specific migration

Figure 3

Performance of (I +IV) in comparison with (II +IV) and (III+IV) in cyan industrial offset ink 1

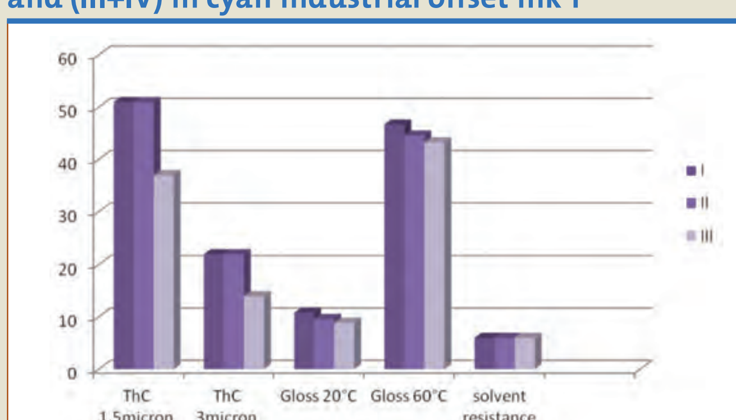
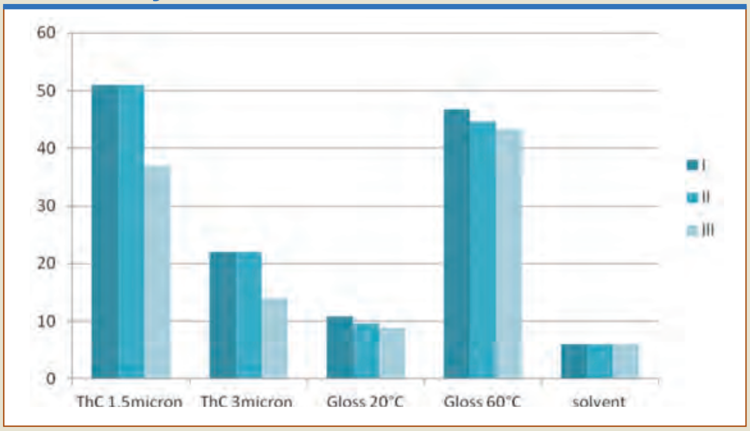


FIGURE 4

Performance of (I+IV) in comparison with (II+IV) and (III+IV) in cyan industrial offset ink 2



was then measured by a validated HPLC method. All migration samples were cured using a Fusion UV system apparatus equipped with H-bulb in air.

Results

The applications were carried out in two different industrial offset inks of different colors (cyan, magenta, yellow and black). Figures 2-4 show the tests effectuated on cyan offset inks. Two generic formulations were used for the reactivity. One of them was used for a migration test. Three different UV combinations (photoinitiator and coinitiator) were compared in the industrial inks.

They all included 3% of the difunctional photoinitiator (IV) due to its low potential for migration in special applications (such as food packaging) along with 3% of each of the different coinitiators (I), (II) and (III).

The UV absorption spectra of each final UV cyan industrial offset ink is also represented in Figure 2, while the results of all the performance testing are shown in Figures 3 and 4.

Migration

Legislation doesn't allow us to put inks in direct contact food; therefore, this test was carried out using set-off conditions. The surface of the cured ink was pressed onto a substrate for 10 days at room temperature under a pressure 20kg. The substrate that was in contact with the cured ink surface was put into the simulating fluids—10% ethanol, 95% ethanol solution and 3% acetic acid solution as reported in the experimental section. The results are shown in Tables 1 and 2.

Conclusions

The package of difunctional coinitiator (I) and difunctional ketosulphone (IV) shows very interesting results in pigmented printing inks. These experiments also show that (I) + (IV) are an advancement in UV-cure technology. The combined use of these two products is suitable for application where low migration values are required. The relatively high molecular weight and the fact they are difunctional is likely responsible for their low tendency to migrate from the cured films even when tested with very aggressive simulating fluids such as 95% EtOH.

These results show that the new photoinitiator and coinitiator are suitable for food-packaging application and become a further innovative help to develop UV technology in a safe way.

TABLE 1

Specific migration comparison of (I), (II) and (IV) in cyan ink 1

UV Cyan Industrial Offset Ink 1		
Curing in air	CoI and PhI in formulation **%**	Migrated Co-I and PhI **ppb**
Ethanol 95%	(I) 3%	<25
	(II) 3%	264
	(IV) 3%	<25
Ethanol 10%	(I) 3%	<25
	(II) 3%	247
	(IV) 3%	<25
Acetic Acid 3%	(I) 3%	<25
	(II) 3%	70
	(IV) 3%	<25

Photoinitiator = PhI , Coinitiator = CoI

References

1. Bellotti E. et al., Proceedings Conference RadTech Europe 2005, Barcelona (Spain)
2. Lundahl S. et al., Proceedings Conference RadTech USA 2008, Chicago, (USA)

—Elena Bellotti is a research and development manager; Emilio Cremona is a technical assistant; and Barbara Fenzi is a photocuring technical development manager at Lamberti S.p.A., in Albizzate, Italy.

Table 2

Specific migration comparison of (I), (II) and (IV) in cyan ink 2

UV Cyan Industrial Offset Ink 2		
Curing in air	CoI and PhI in formulation **%**	Migrated Co-I and PhI **ppb**
Ethanol 95%	(I) 3%	<25
	(II) 3%	286
	(IV) 3%	<25
Ethanol 10%	(I) 3%	<25
	(II) 3%	256
	(IV) 3%	<25
Acetic Acid 3%	(I) 3%	<25
	(II) 3%	84
	(IV) 3%	<25

Photoinitiator = PhI , Coinitiator = CoI

Duncan Inducted Into Honor Society

Don P. Duncan, Ph.D., was inducted into the prestigious Ben Franklin Honor Society of Printing Industries of America during a black tie event held Nov. 15, 2013, at the Palmer House Hilton in Chicago, Ill. Duncan was one of 11 industry leaders inducted that evening.

The Ben Franklin Honor Society recognizes and honors industry leaders who have made lasting contributions to advancing the printing and graphic communications industries. Printing Industries of America is the world's largest graphic arts trade association, representing an industry with approximately one million employees. It serves the interests of thousands of member companies.

Duncan is director of Research at Wikoff Color Corporation and serves as president of both RadTech North America and the Technical Association of the Graphic Arts. Duncan is also an active member of FTA, TAPPI, ASTM and the American Chemical Society. Additionally, he served on the board of the Sustainable Green Printing Partnership, and is active in the chemistry and regulation related to food packaging for the printing industry.

A native of Texas, Duncan received his bachelor's degree in chemistry from North Texas State University. He earned his doctorate in organic chemistry from the Massachusetts Institute of Technology. Duncan is the holder of two U.S. patents; author of more than 30 technical papers; a frequent author in graphic arts industry trade journals; and a presenter in graphic arts-related conferences.

Photo courtesy of BFHS

Wikoff's Ed Slezycki and Don Duncan.