Cure of Cationic Coatings and Inks using the UV LED Cure-All™

Ingredients	1	2	3	4	5	6	7	8	9
CYRACURE UVR-6110	76.4	75.8	60.6	60.6	60.6	76.6	64.6	64.6	64.6
CYRACURE UVR-6000	19.1	18.95	15.15	15.15	15.15	19.15	16.15	16.15	16.15
CYRACURE UVR-6992	4	4	8	8	8				
Isoindolinone yellow pigment*			15				15		
Irgalite NGA blue pigment				15				15	
Phthalocyanine blue pigment**					15				15
DEA photosensitizer		0.75	0.75	0.75	0.75				
Irgacure 250						3	3	3	3
CPTX photosensitizer						0.75	0.75	0.75	0.75
Silwet L7604 silicone surfactant	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100	100	100
1/26/04 11% Relative Humidity									
Clear coating surface-cure rate, s	900	1				1			
Ink thumb-twist cure rate, s			2	3	45		2	2	20

Clear coatings and inks were applied to foil-laminated cards (Leneta AGX-2N) using a #2.5 wire draw-down bar and then exposed to UV from the UV LED Cure-All from UV Process Supply.

Surface-cure test: A cotton ball was placed in contact with the coating surface immediately after exposure to UV. The coating was considered cured if no cotton fibers adhered to the coating.

Thumb-twist cure test: Thumb-twist pressure was applied to the ink immediately after exposure to UV. The ink was considered cured if the ink was not affected by the thumb-twist.

*The yellow pigment was supplied as a dispersion from Penn Color (product 18Y359) that contained 24% isoindolinone pigment and 76% UVR-6110.

**The blue pigment was supplied as a dispersion from Penn Color (product 18S369) that contained 30% phthalocyanine pigment and 70% UVR-6110.

CYRACURE UVR-6110 was a cycloaliphatic, CYRACURE UVR-6000 was an oxetane reactive diluent, and CYRACURE UVI-6992 was a sulfonium salt cationic photoinitiator all from The Dow Chemical Company.

Irgalite NGA was a dry phthalocyanine blue pigment from Ciba that was dispersed in UVR-6110 before adding it to the ink formulation. Irgacure 250 was an iodonium salt cationic photoinitiator from Ciba.

DEA was 9,10-diethoxyanthracene and CPTX was 1-chloro-4-propoxy-thioxanthone both from Aceto Corporation. Silwet L7604 silicone surfactant was from OSi Specialties (GE Silicones).

Formulation #1 is a clear coating containing our standard sulfonium salt cationic photoinitiator (PI) 6992. It cured after 900 seconds (15 min), indicating the sulfonium salt PI did not efficiently absorb the emission from the LED lamp. Formulation #2 contains 0.75% of photosensitizer DEA, which absorbs in the region of the LED lamp. #1 and #2 show that the proper photosensitizer (DEA) is required when using the LED lamp to cure cationic compositions containing sulfonium salts in a reasonable time.

According the studies done in universities and in industrial labs including Dow's, only anthracene derivatives like DEA can photosensitize sulfonium salts. Other photosensitizers, like CPTX and ITX, do not photosensitize sulfonium salts.

Formulations 3, 4, and 5 are inks containing PI 6992 and DEA. #3 contained a yellow pigment. #4 and #5 contained phthalocyanine blue pigments from different suppliers. Irgalite NGA blue pigment in #4 cured much faster (3
sec) than the blue pigment from Penn Color in #5 (45 sec). Irgalite NGA blue pigment in #4 was specially chosen by Ciba for cationic inks. This shows that inks containing yellow and properly chosen blue pigments and commercial sulfonium salts and proper photosensitizer cure well using LED lamp.

Formulation #6 is a clear coating containing iodonium salt Irgacure 250 from Ciba and photosensitizer CPTX. CPTX has been shown to be the most efficient photosensitizer for iodonium salts when mercury vapor lamps were used so we used CPTX with Irgacure 250 and the LED lamp. #6 shows that iodonium salt and photosensitizer cure well using LED lamp. (DEA would probably work with Irgacure 250 when using the LED lamp because iodonium salts are easier to photosensitize than sulfonium salts. DEA works with Irg. 250 using mercury lamps.)

We did not test Irgacure 250 in a clear without photosensitizer. We believed an iodonium salt had no chance of curing using the LED lamp because iodonium salts absorb at wavelengths shorter than sulfonium salts. Sulfonium and iodonium salts have max absorption at about 300 and 250 nm, respectively.

Formulas 7, 8, and 9 contained the same yellow and blue pigments as 3, 4, and 5, but 7, 8, and 9 contained Irgacure 250 and CPTX. Analogous to when the two blue pigments were used in inks #4 and #5, the ink #8 containing Irgalite blue NGA pigment cured much faster (2 sec) than ink #9 containing the phthalo blue pigment from Penn Color (20 sec). The results of inks 7, 8, and 9 show that cationic inks containing yellow and properly chosen blue pigment and commercial iodonium salt and photosensitizer cure well using LED lamp.

The phthalo blue dispersion from Penn Color in formula #9 cured much faster (20 sec) than when we used it in formula #5 (45 sec). This indicated that Irgacure 250 and CPTX was more efficient than 6992 and DEA, especially when a slow curing pigment (Penn Color blue) was used. This shows that the iodonium salt was more active than the sulfonium salt when there was little direct absorption by the onium salt and almost all the UV was absorbed by the photosensitizer. This seems to support the idea that iodonium salts are more easily sensitized than sulfonium salts.