

UV LED BOOSTER TECHNOLOGIES



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Agenda

- Background
- LED Boosters for packaging applications
 - EBECRYL® LED 03 – OPVs, Inkjet and Flexo Inks
 - EBECRYL LED 04 – Litho inks
 - EBECRYL LED 05 – Flexo inks
- Summary
- Acknowledgments

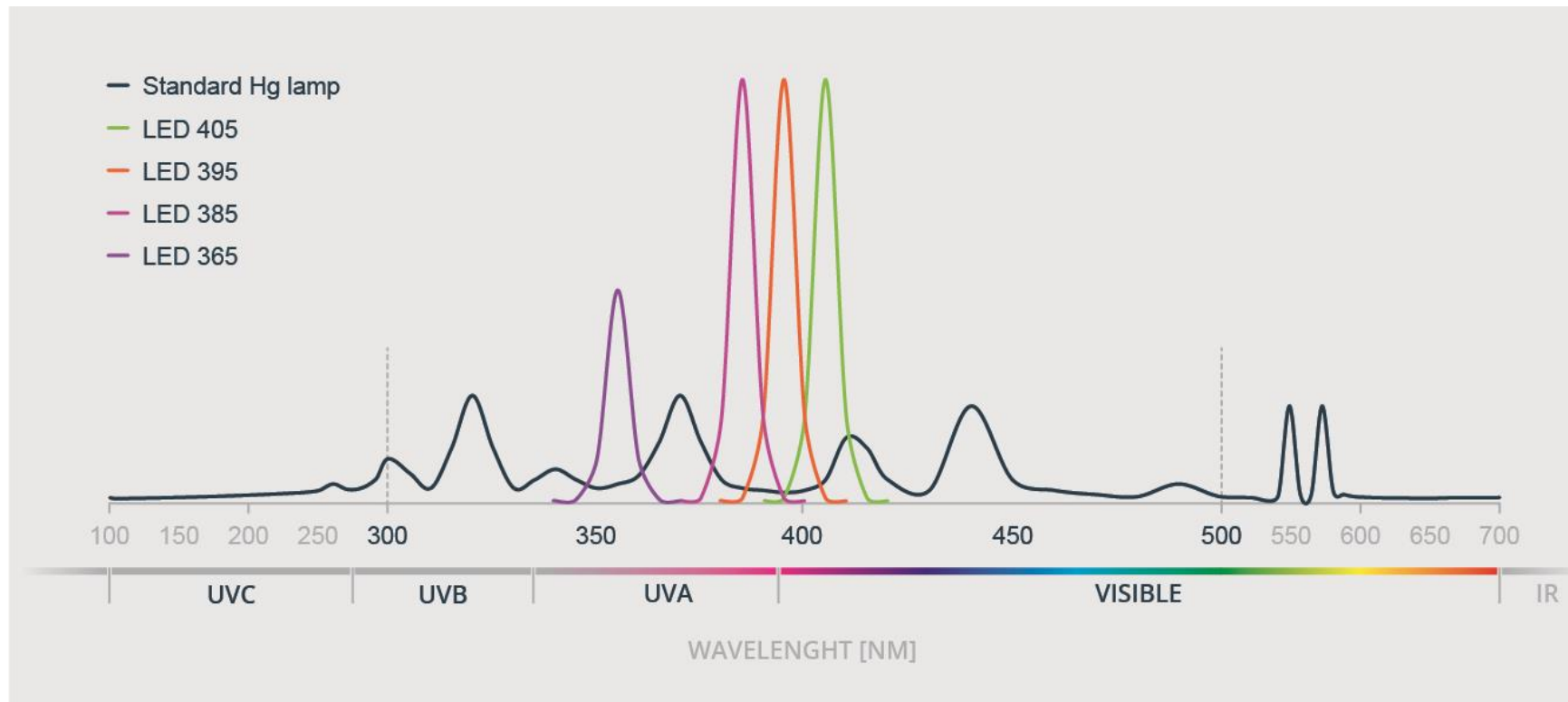
Market Advantages with UV LED

- Compatible and scalable design of production lines
- Constant output – controlled curing intensity
- Less heat output due to lower operating temperatures
 - ease of handling heat-sensitive substrates
- Reduced energy consumption in comparison with Hg lamps
- Instantaneous on and off of lamps
- Increased lifetime
 - Reduced maintenance in comparison with Hg lamps
- No hazardous UVB and UVC wavelengths
- No ozone
- No mercury



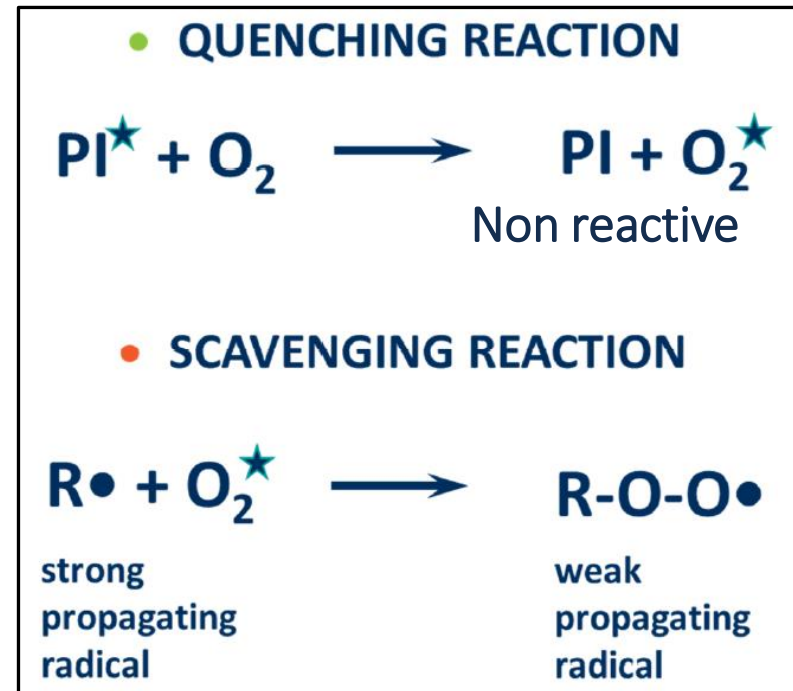
Mercury Lamps versus LED Lamps

- Hg lamps provide a broad spectrum of light, including UVA, UVB, UVC, visible light and some IR
- UV LEDs provide a very narrow emission spectrum, including UVA and visible light
 - These lamps require a very specific photoinitiator as the spectral output is so narrow
 - Significantly restricts the photoinitiator choices.

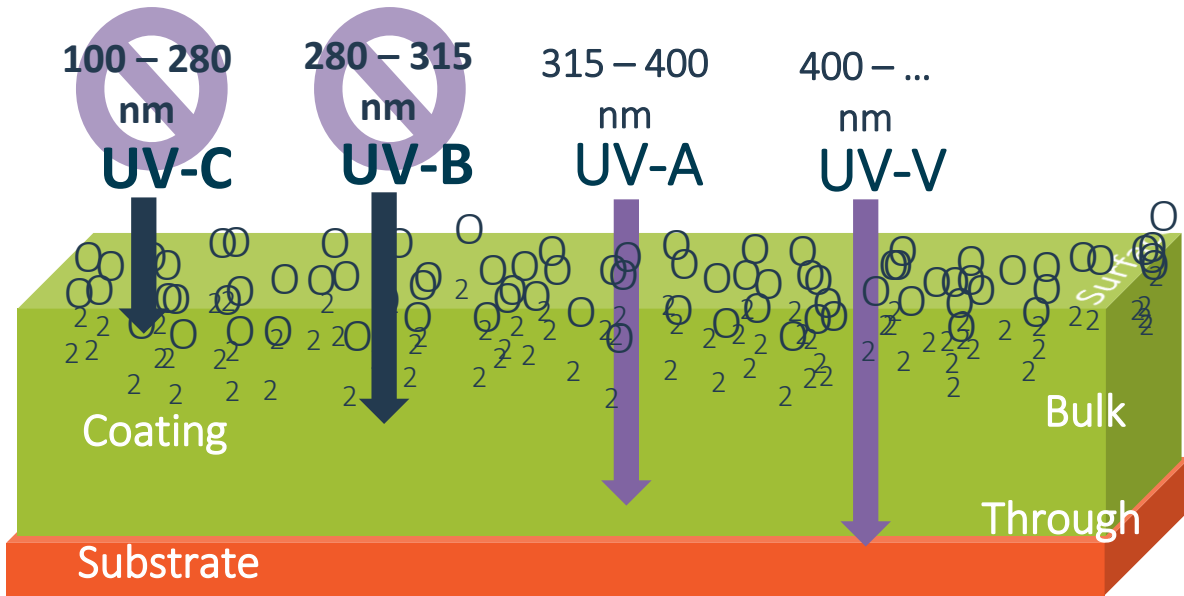


Oxygen inhibition

- Oxygen Inhibition: is the ability of oxygen to quench or scavenge radicals inside free radical polymerization
- Factors that directly effect oxygen inhibition
 - Low viscosity materials – oxygen can permeate the coating more easily
 - Thin coatings – higher ratio of oxygen due to the small coating layer
- This leads to tacky surfaces and reduced coating properties
 - Inability to create high degrees of crosslink density needed

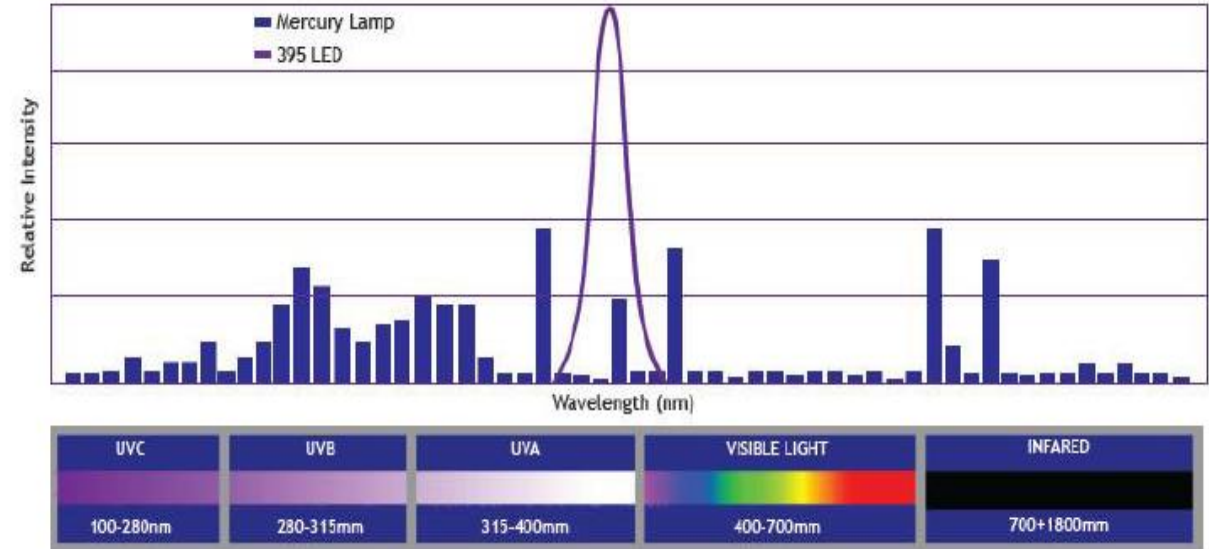


Surface Cure – Challenging for LED Cure



- **UVC** = Cure at top layer-surface cure
- **UVA** = Cure at substrate-adhesion

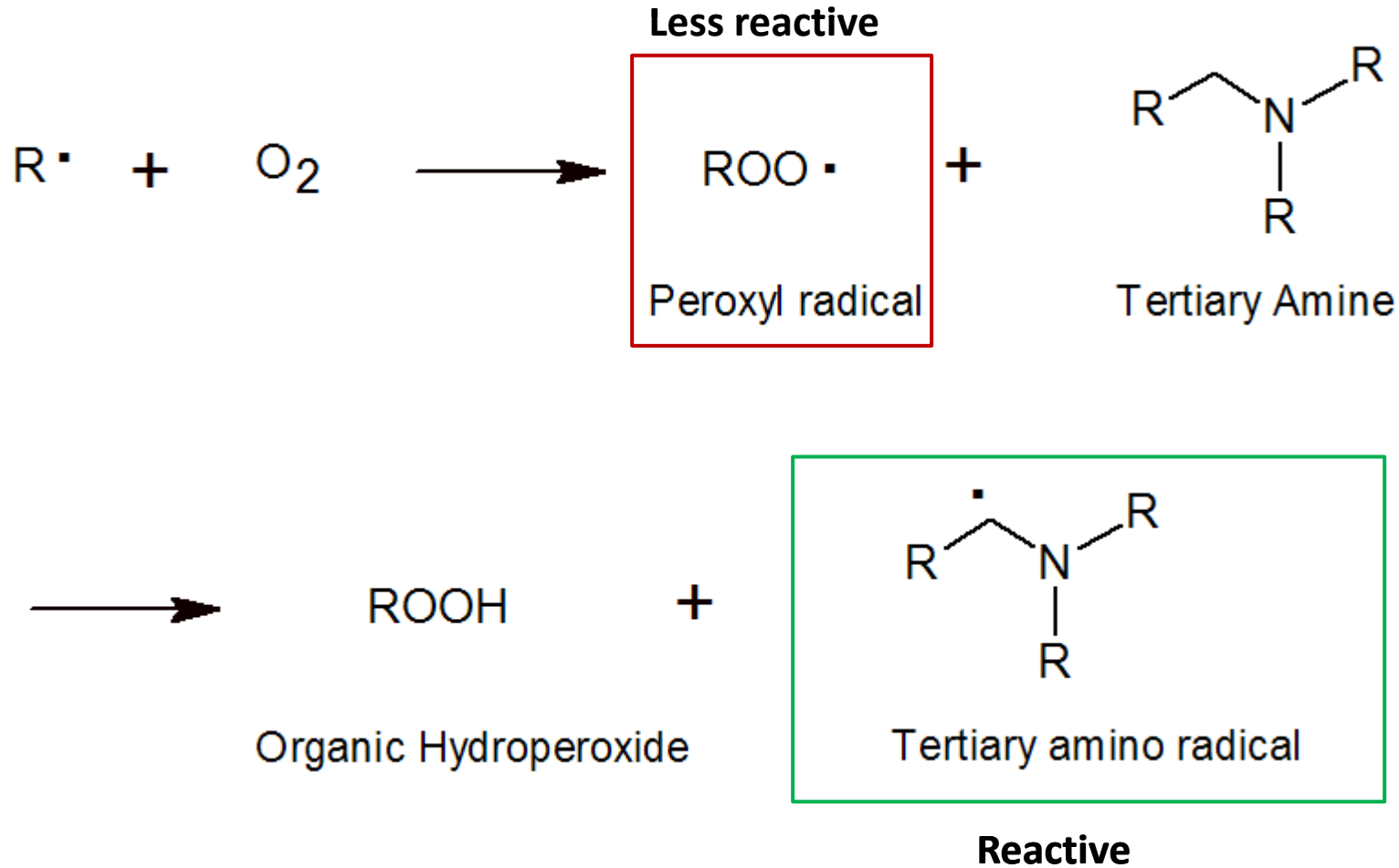
- Surface cure is more challenging in LED cure because of low intensity and lack of short wavelength light
- And is made all that much more challenging by oxygen inhibition



Source: Phoseon

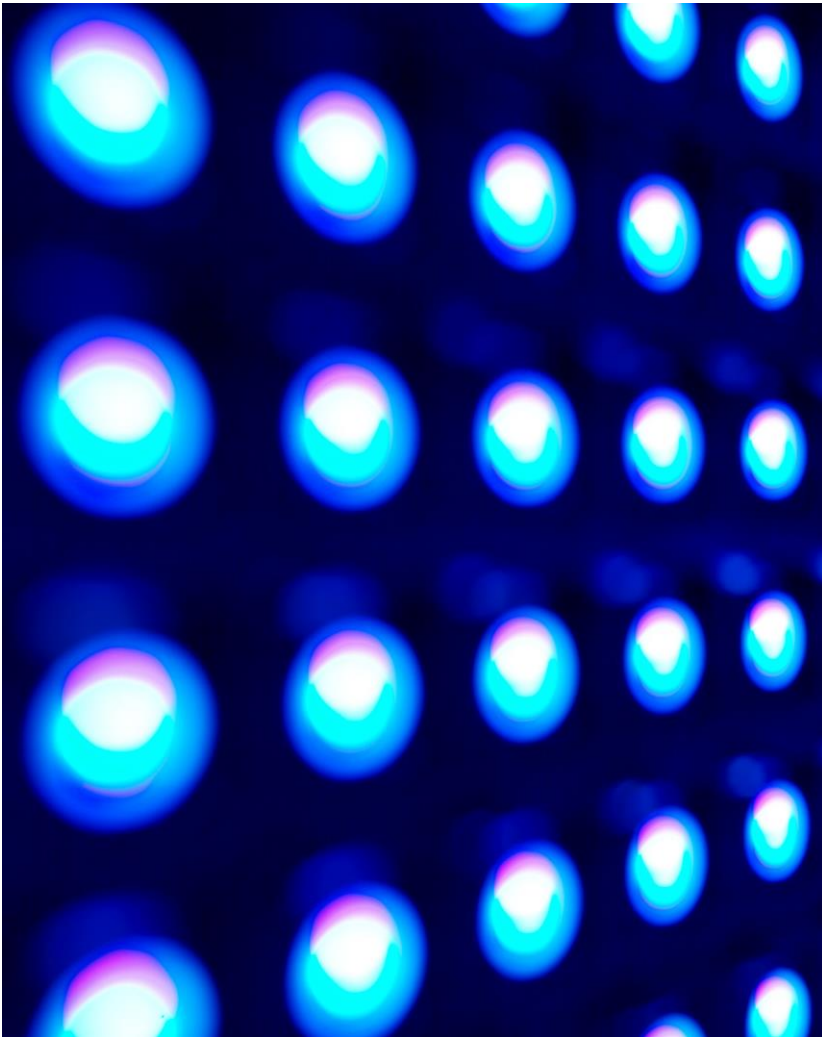
LED wavelength: 405 nm, 395 nm and 365 nm

Amine synergist to overcome oxygen inhibition



- Aminobenzoates (EHA and EBD) are more hydrophobic than simple tertiary amines, so they aren't suitable for lithographic applications where ink/water balance is critical
- Aminobenzoates are less likely to migrate than simple tertiary amines – less blooming to the surface.
- EHA and EDB have been reclassified and are now reprotoxic 1B under REACH laws.

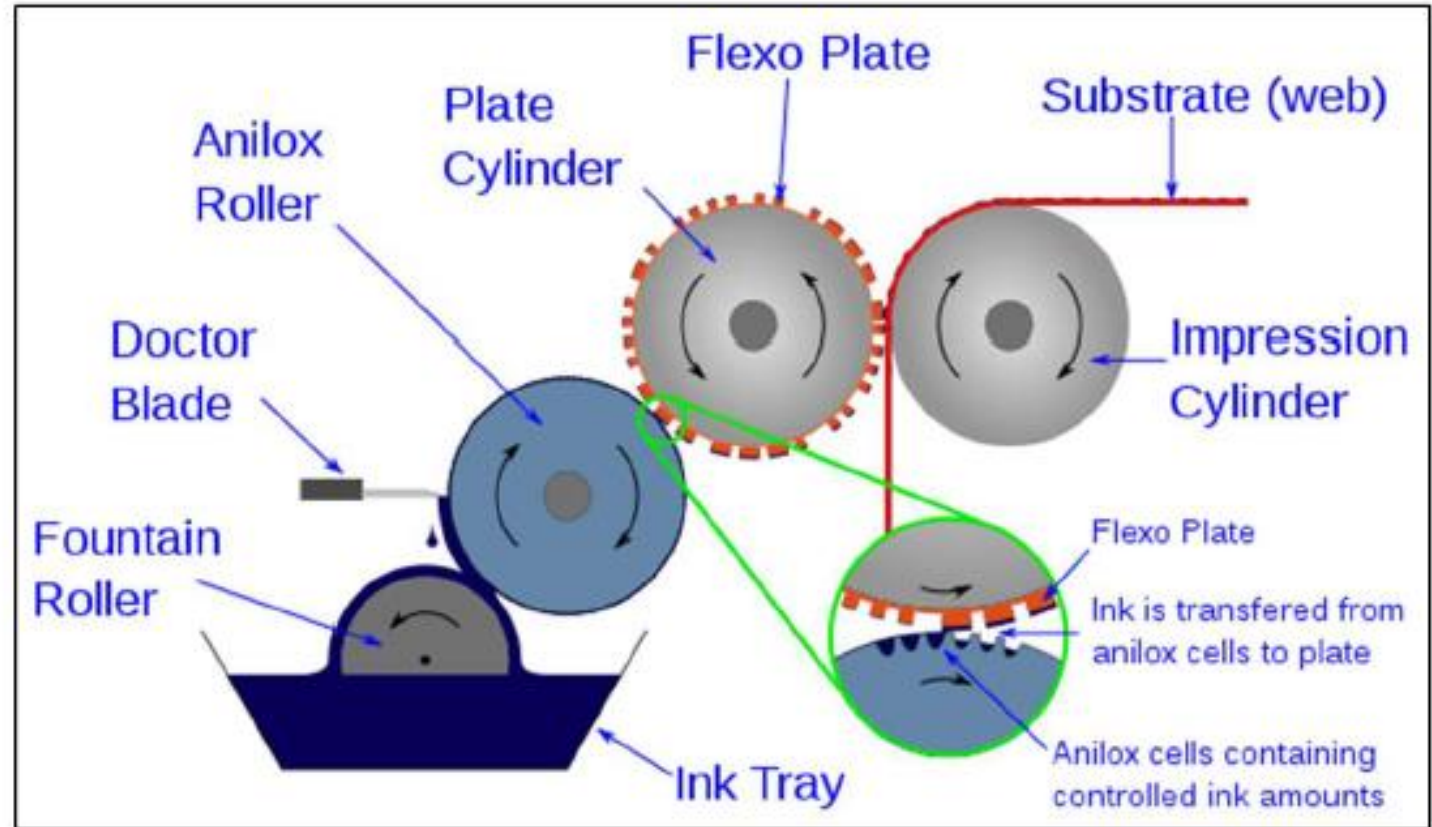
New Amine Synergists for Graphics Applications



- LED booster for Inkjet, OPV, flexo inks: **EBECRYL LED 03**
 - Reactivity, low viscosity, low yellowing upon cure
- LED booster for litho inks: **EBECRYL LED 04**
 - Ink-water balance
- LED booster for flexo inks : **EBECRYL LED 05**
 - Pigment stability

Part 1: EBECRYL LED 03 – Inkjet, Overprint Varnishes (OPVs) and Flexo Inks

- Low viscosity inks (<1000 cps) and fast printing speed (300-1000 fpm) make surface cure to be a challenge in flexo printing.



EBECRYL LED 03 - for OPV, Inkjet and Flexo inks

- Low Viscosity
- High amine content which leads to a strong boosting effect
- Low Color and Low Odor

Properties	Value
Viscosity at 25°C (mPa.s)	~ 450
Amine value (mg KOH/g)	165
Acrylate functionality	~2
Gardner color	< 1

Low migration structure : Nestle / Swiss compliant

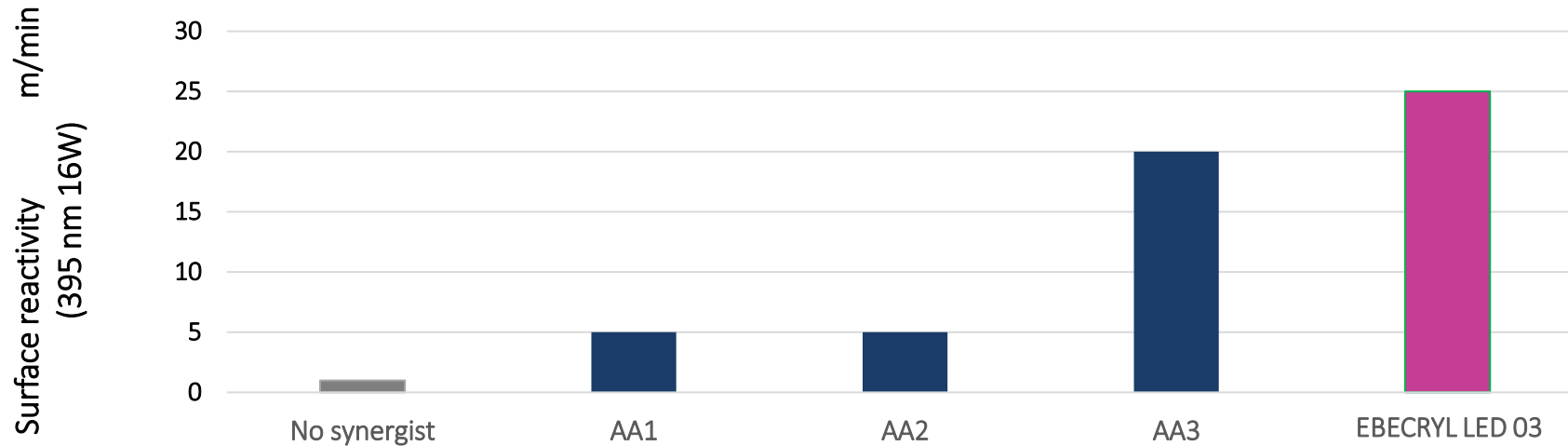
EBECRYL LED 03 – Overprint Varnish (OPV)

Formulation	OPV-Ref	OPV – 1	OPV – 2	OPV – 3	OPV-LED 3
Biobased 2f acrylate	55	48	48	48	48
TMPOETA	32	24	24	24	24
DPGDA	7	7	7	7	7
Comp. Amine synergist 1		15			
Comp. Amine synergist 2			15		
Comp. Amine synergist 3				15	
EBECRYL LED 03					15
TPO-L	4	4	4	4	4
BAPO	2	2	2	2	2
	100	100	100	100	100

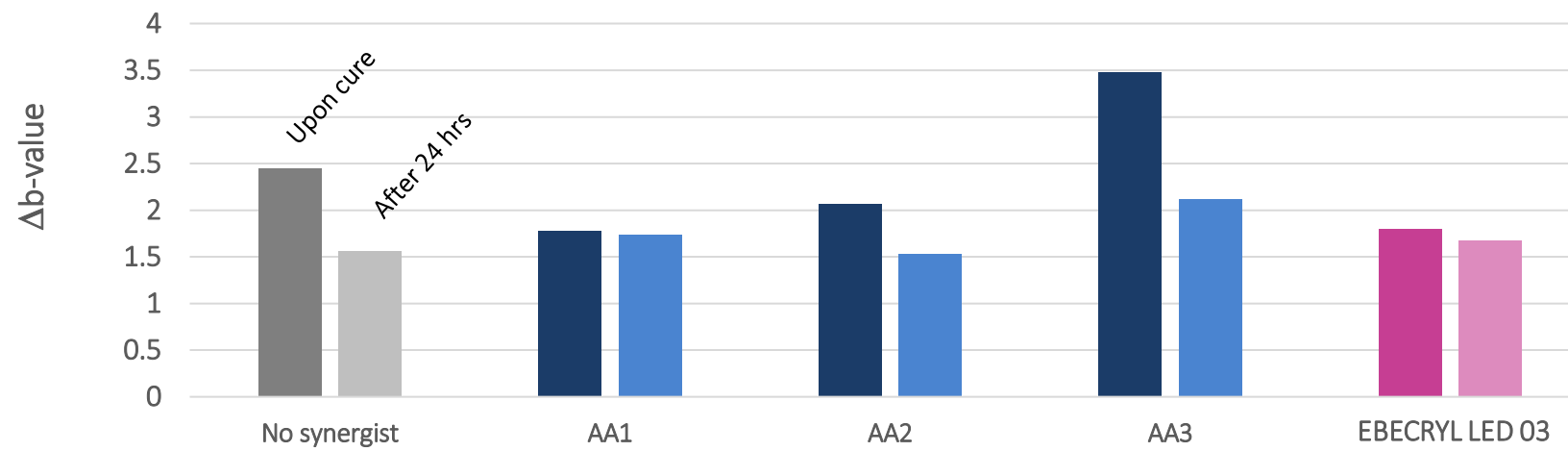
Viscosity @ 25°C, mPa.s	360	310	423	560	590

	AA 1	AA 2	AA 3	EBECRYL LED 03
Amine content (mg KOH/g)	250	40	130	165
functionality	~0	~5	2	~2

EBECRYL LED 03 – OPV: reactivity and yellowing



Highest surface cure reactivity with EBECRYL LED 03



Lower yellowing upon cure with EBECRYL LED 03

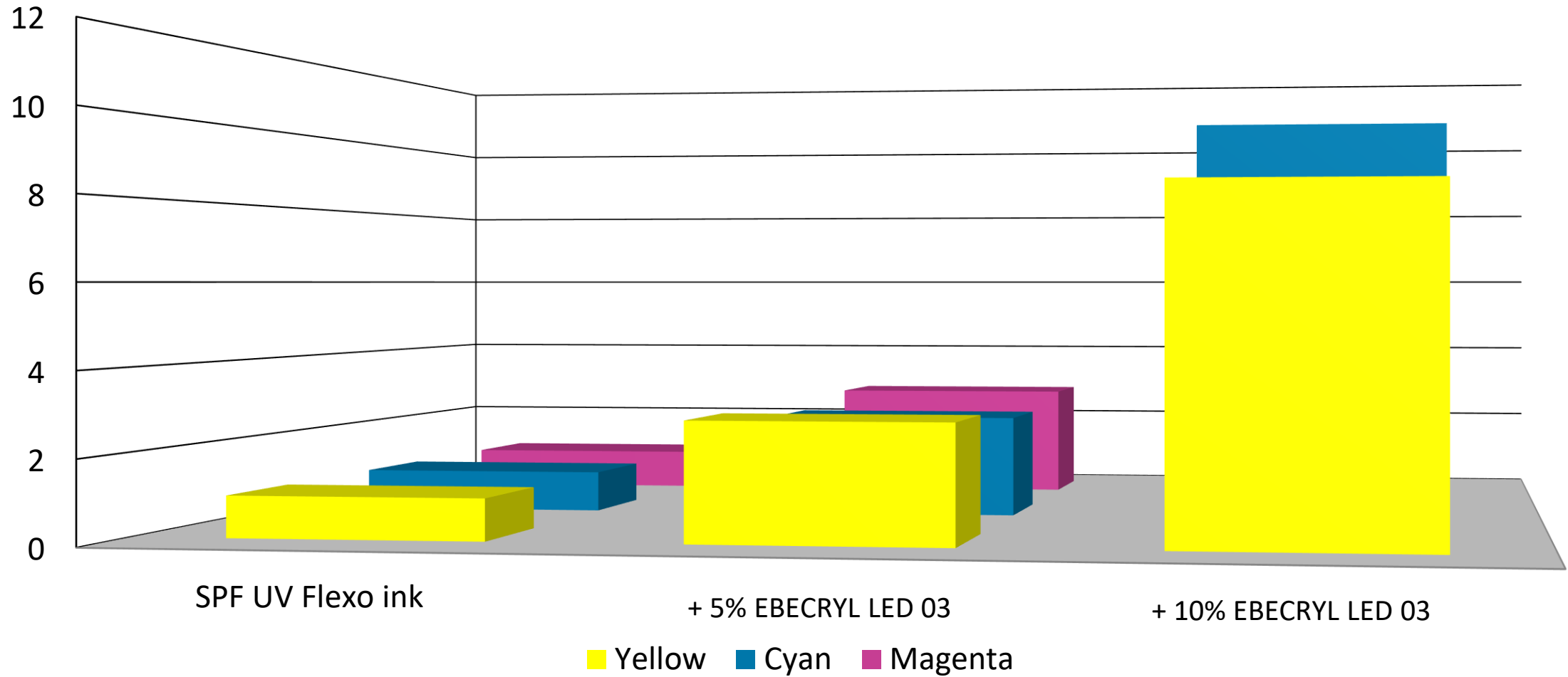
	Comp. AA1	Comp. AA2	Comp. AA 3	EBECRYL LED 03
Amine content rmg KOH/g	250	40	130	165
functionality	~0	~5	2	~2

EBECRYL LED 03 – Flexographic Ink

	Reference	LED mod. 1	LED mod. 2
Polyester acrylate (4f)	26,7	25	23,4
NPG(PO)2DA	26,7	25	23,3
PETIA	26,6	25	23,3
Pigment (C:PAC 15:4)	20	20	20
Dispersing agent	3,8	3,8	3,8
PI (DETX/TPO-L) (50/50)	6	6	6
EBECRYL LED 03	-	5	10

Viscosities @ shear rate			
Shear rate 1.1 (mPa.s)	803	1410	1370
Shear rate 2500 (mPa.s)	439	573	712

EBECRYL LED 03 - Flexographic ink

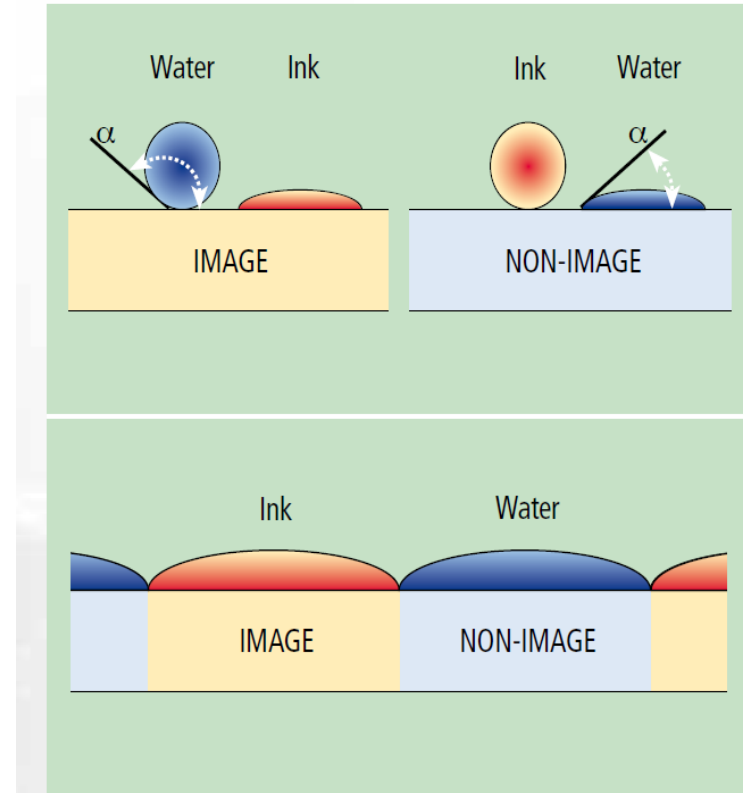
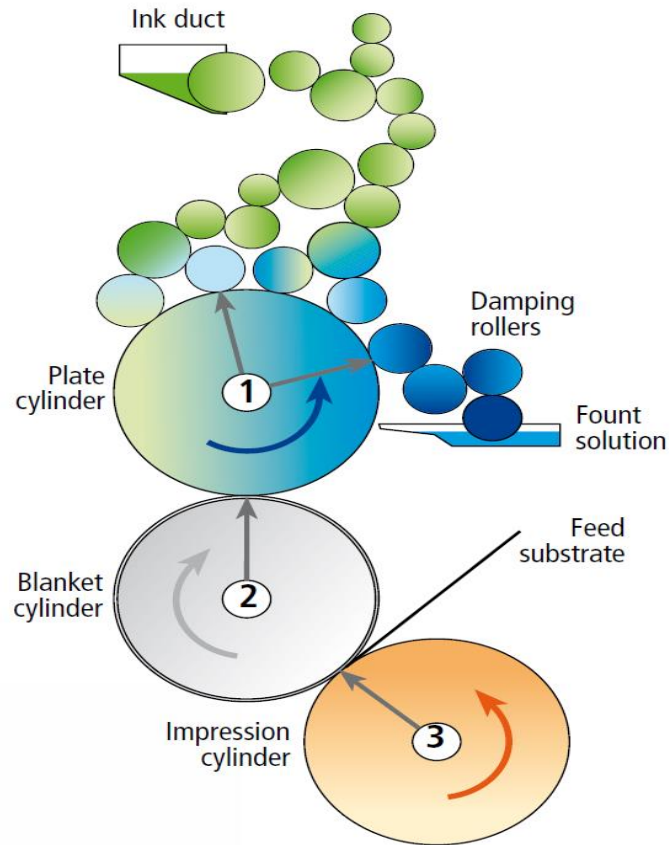


EBECRYL LED 03 – an answer to PI shortage in Flexographic inks

	Reference	LED mod. 1	LED mod. 2
Polyester acrylate (4f)	26,7	23,4	22,4
NPG(PO)2DA	26,7	23,3	22,3
PETIA	26,6	23,3	22,3
Pigment (C:PAC 15:4)	20	20	20
Dispersing agent	3,8	3,8	3,8
PI (DETX/TPO-L) (50/50)	6	6	4
EBECRYL LED 03	-	10	15

Relative reactivity			
	1	10	10

Part 2: EBECRYL LED 04 – LED Booster for Litho Inks



- If the ink too hydrophilic: ink gets to non image area causing scumming and a loss of optical density
- Ink too hydrophobic: uneven mottled ink
- Good ink-water balance: forms fine and stable emulsion

EBECRYL LED 04 - Properties and value proposition

Properties	Ethyl 4-dimethylaminobenzoate (EDB)	Polymeric amino benzoate	EBECRYL LED 04
Acrylate functionality	0	2	6
Appearance	White solid	Pale yellow liquid	Clear liquid
Viscosity at 25°C(cP)	/	~ 1400	~ 17, 500
Amine content (%)	7.3	3.8	2.7

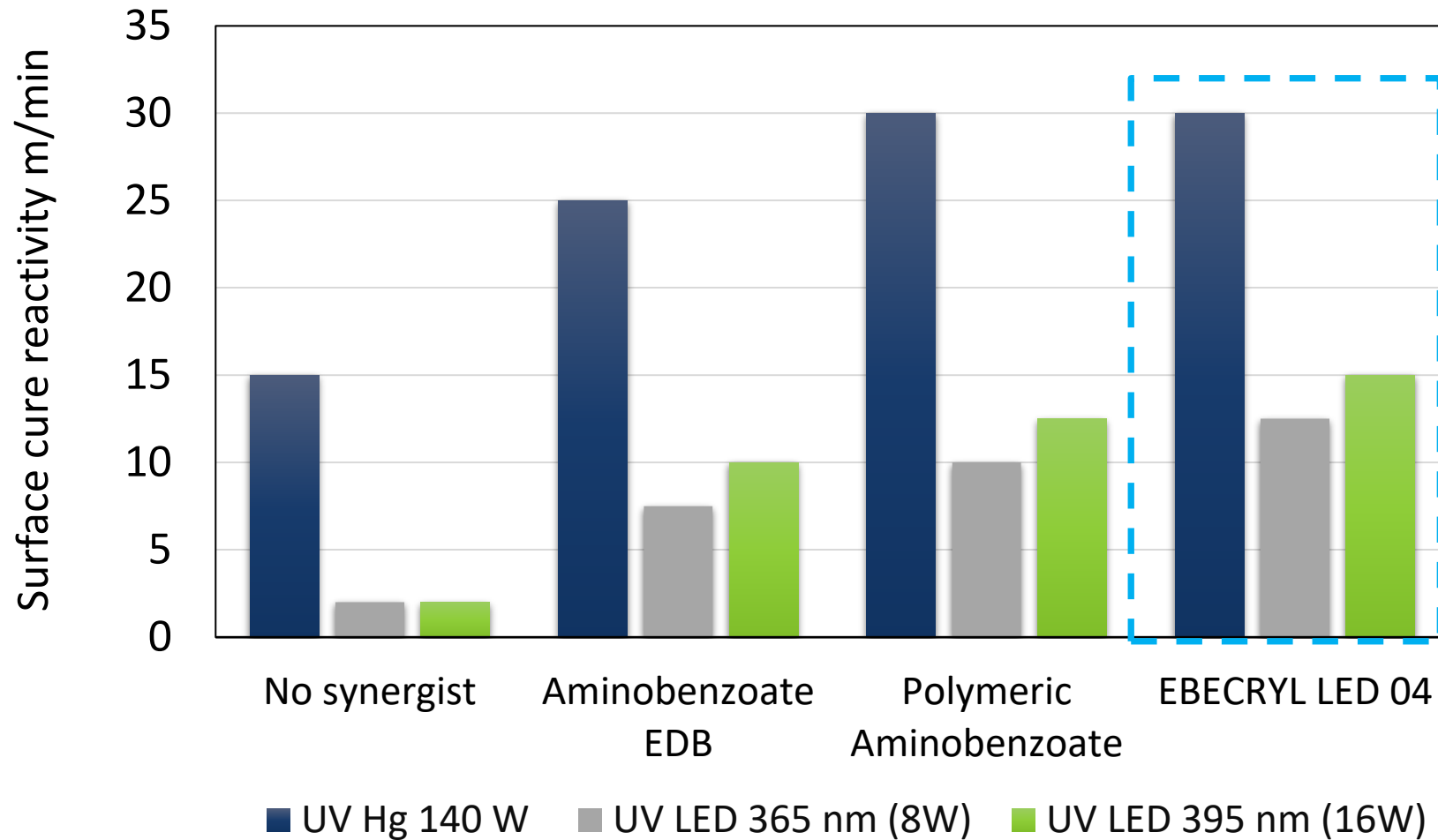
- Aminobenzoates are much more reactive than simple tertiary amines and exhibit lower “bloom”. Aminobenzoates are insoluble in water so are suitable for lithographic applications where water/ ink balance is critical.
- EDB reclassification under REACH registration to reprotoxic 1B
- EBECRYL LED 04 has high acrylate functionality and can be integrated into network
- EBECRYL LED 04 is Nestle/Swiss compliant

EBECRYL LED 04 - application in litho ink: cyan ink formulation

	No synergist	Aminobenzoate EDB	Polymeric Amino benzoate	EBECRYL LED 04
Resin mix (EBECRYL 870/EBECRYL 1608 50/50)	46.5	46.5	46.5	46.5
Talc	6	6	6	6
Pigment(cyan 15:3)	17	17	17	17
Stabilizer solution	1	1	1	1
TPO-L/ITX (80/20)	10	10	10	10
Amine synergist	-	2.5	7.5	7.5
Resin mix	11	10.5	5	1.5
OTA-480	8.5	6.5	7.0	10.5
Total	100	100	100	100
Viscosity at 2.5 /s (cP)	78,600	88,100	78,000	82,100
Viscosity at 100 /s (cP)	35,800	41,800	35,000	34,600
SI (2.5/100)	2.2	2.1	2.2	2.4

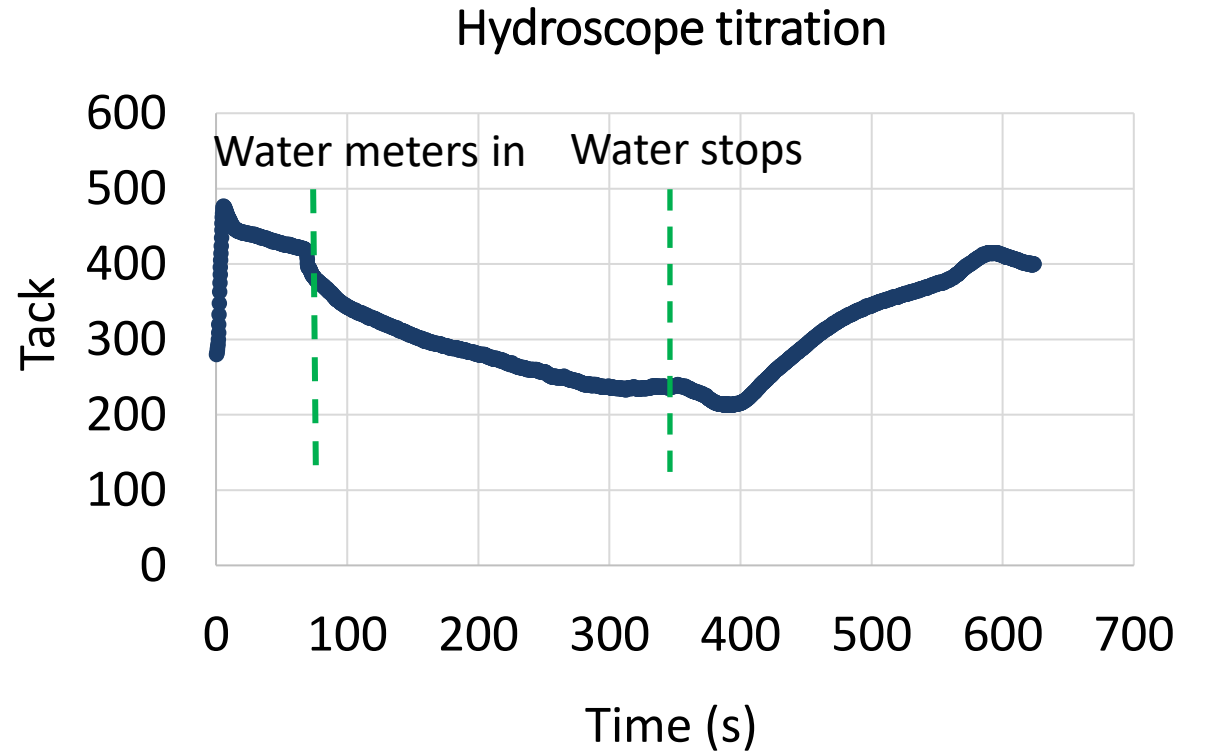
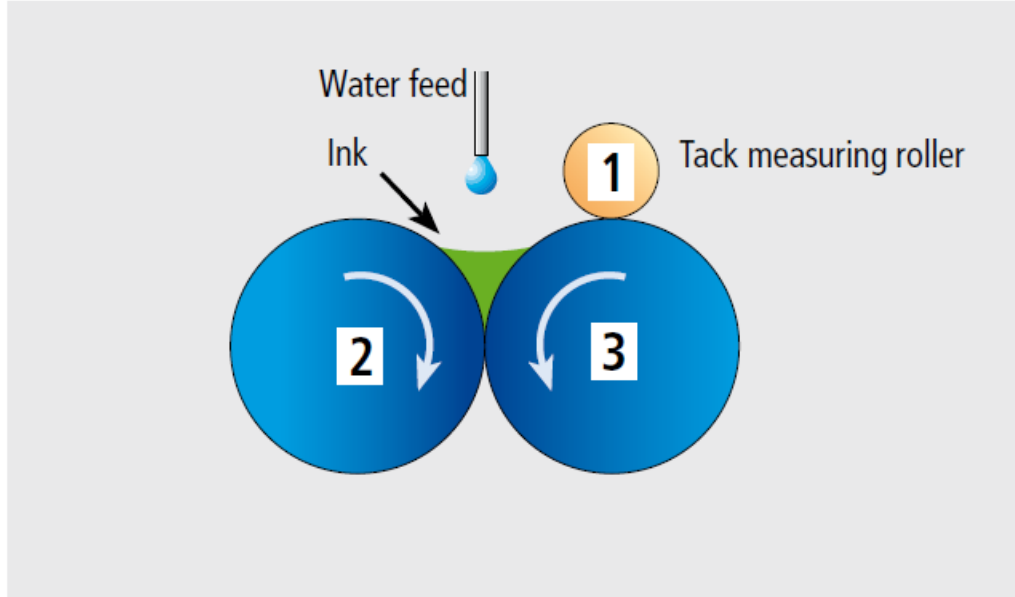
- Incorporation of LED 04 doesn't change the ink rheology

EBECRYL LED 04 - litho ink application : surface reactivity

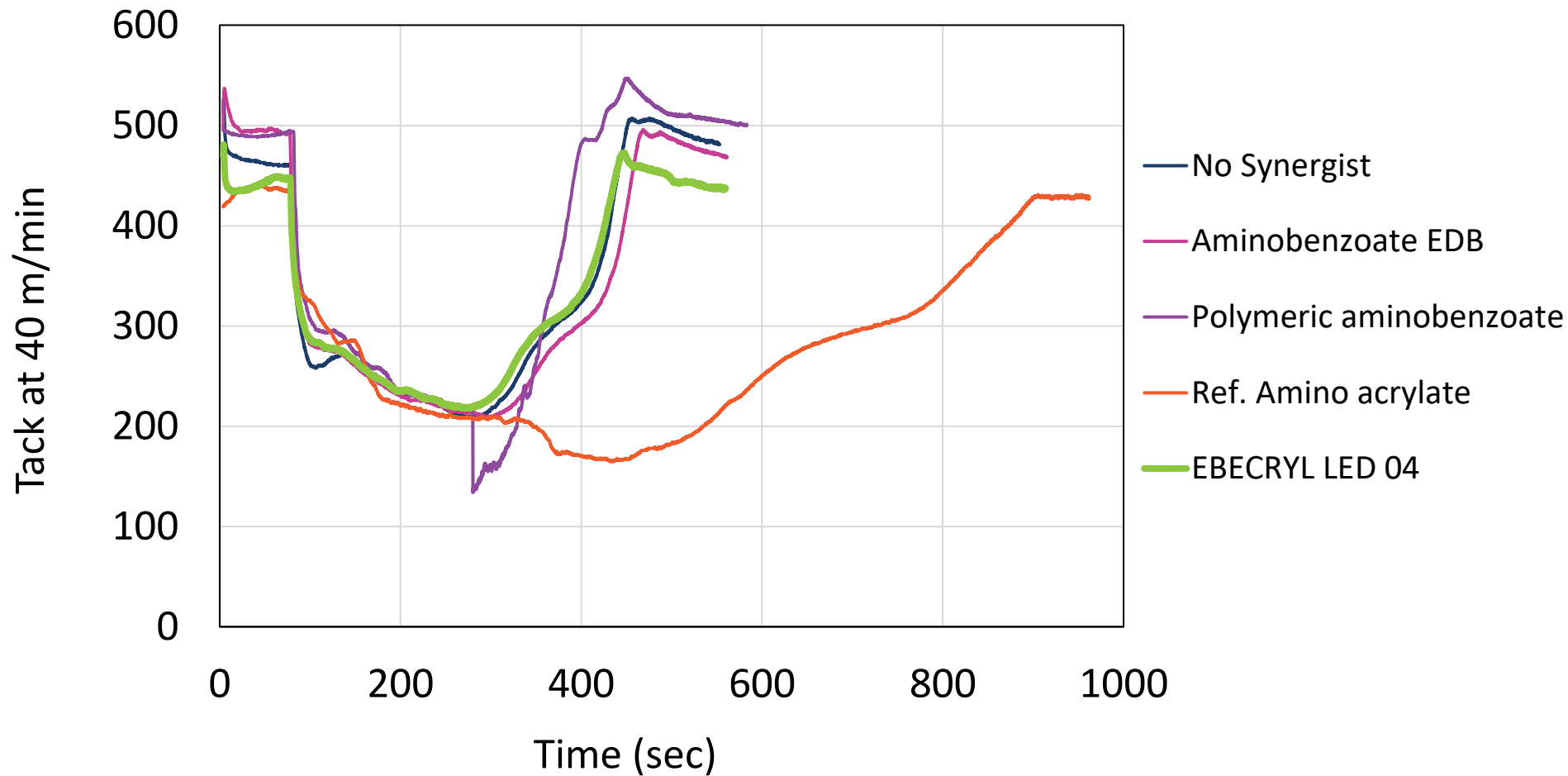


- Excellent surface cure reactivity with EBECRYL LED 04 when cured by LED or Hg lamps.

EBECRYL LED 04 - Hydroscope-ink water balance



EBECRYL LED 04 - litho ink application: ink-water balance

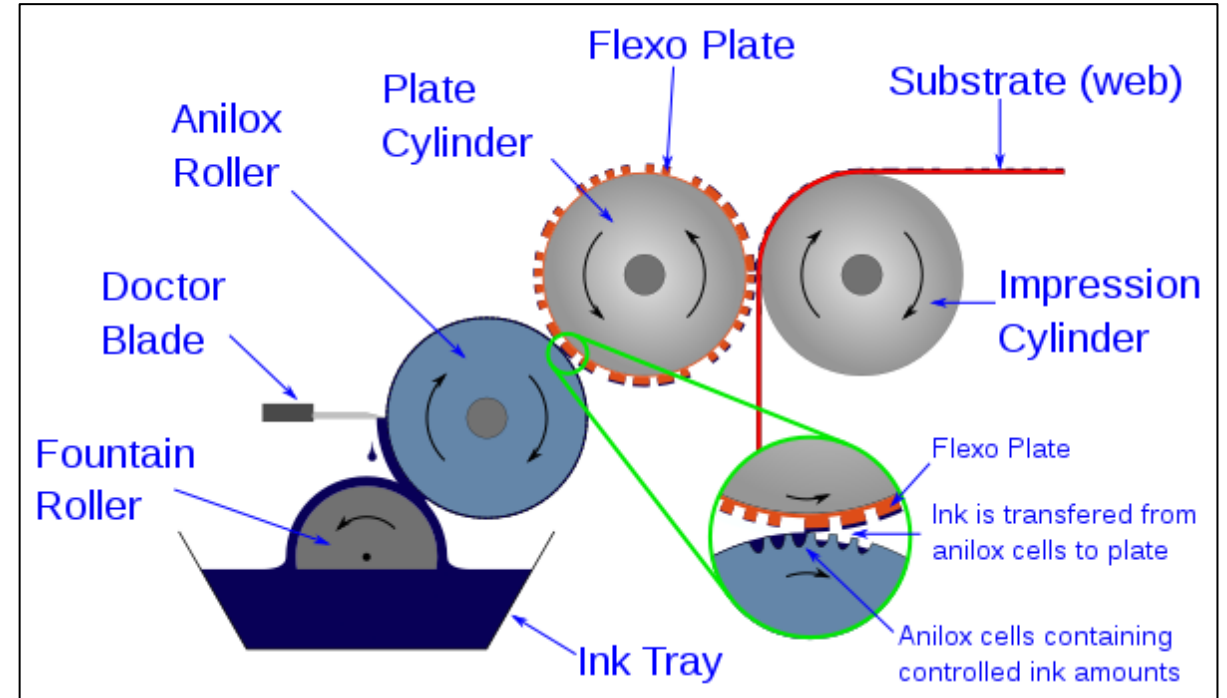


- The amine synergist has a big impact on ink-water balance
- The hydrophobic nature makes EBECRYL LED 04 a good choice for litho inks

Part 3: EBECRYL LED 05 – improved storage stability

- Medium Viscosity amino acrylate
- High Amine content – leading to a strong boosting effect
- Good pigment storage stability

Properties	EBECRYL LED 05
Acrylate Functionality	6
Appearance	Clear Liquid
Viscosity at 25°C (mPa.s)	~7500
Amine Content (mg KOH/g)	95



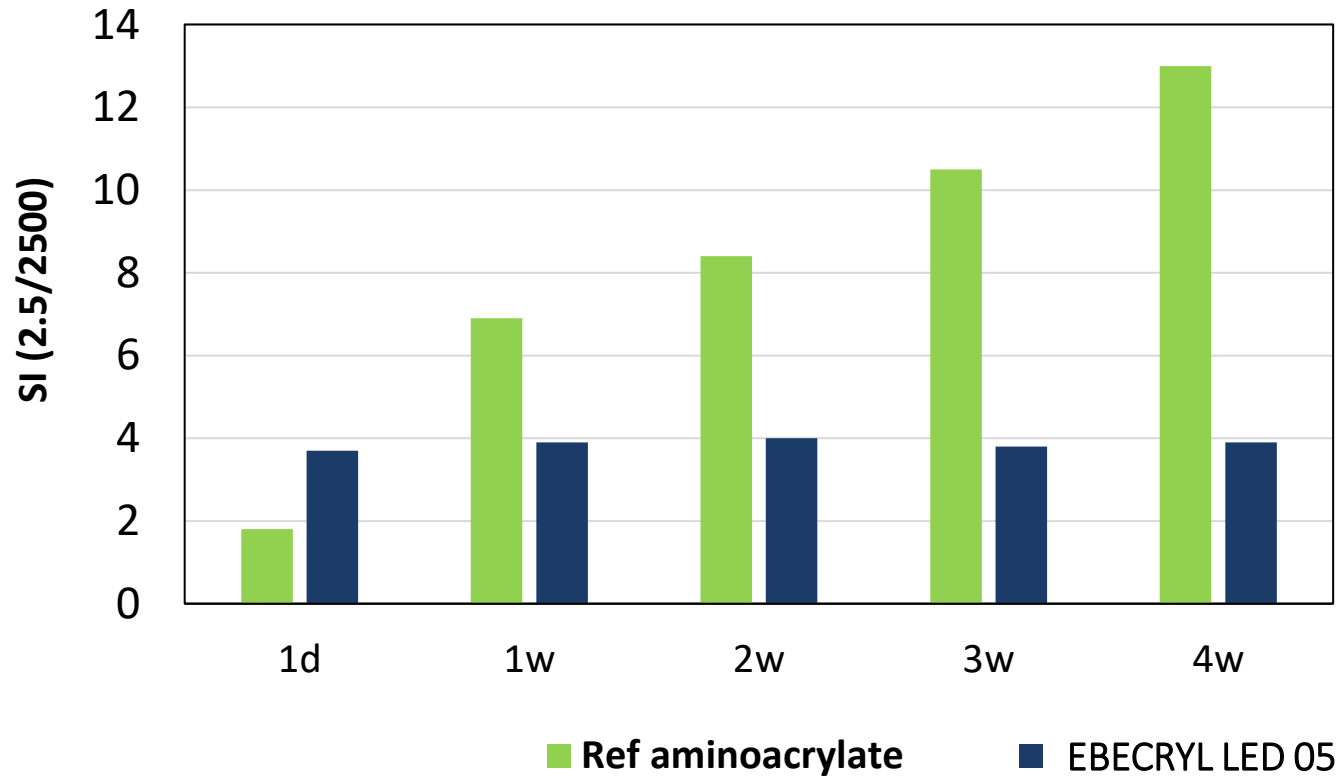
Flexo Ink with EBECRYL LED 05	
Pigment Paste*	46
NPG(PO)2DA	18
PETIA	18
PI (DETX/TPO-L) (50/50)	8
Amine Synergist	10

Cure speed – LED 395 nm 16 W/min	7
Viscosity at 2.5 s ⁻¹ (mPa.s)	4070
Viscosity at 2500 s ⁻¹ (mPa.s)	1100
SI (2.5/2500)	3.7

Pigment Paste	
Polyester Acrylate (4f)	60
Stabilizer	1
Pigment red 57:1	35
Dispersing Agent	4
Total	100

EBECRYL LED 05 - Pigment Storage Stability

- Combinations of some pigments with amino acrylates can lead to a decrease of flow properties upon storage



EBECRYL LED 05 shows an improved pigment storage stability maintaining good ink flow

Summary: EBECRYL LED Boosters for Graphic Applications

Products	Acrylate Functionality	Viscosity (mPa.s) @25°C	Amine Value mg KOH/g	Key features	Target market
EBECRYL LED 03	2	450	165	<ul style="list-style-type: none"> <input type="checkbox"/> Excellent reactivity booster <input type="checkbox"/> Low viscosity <input type="checkbox"/> Low yellowing upon cure <input type="checkbox"/> LM profile 	<input type="checkbox"/> OPV, INKJET, FLEXO
EBECRYL LED 04	6	17 500	108	<ul style="list-style-type: none"> <input type="checkbox"/> No impact on IW balance (litho) <input type="checkbox"/> Strong reactivity booster <input type="checkbox"/> LM profile 	<input type="checkbox"/> LITHO
EBECRYL LED 05	6	7500	95	<ul style="list-style-type: none"> <input type="checkbox"/> Excellent pigment storage stability <input type="checkbox"/> Strong reactivity booster <input type="checkbox"/> LM profile 	<input type="checkbox"/> FLEXO

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THANK YOU FOR YOUR ATTENTION!

Questions?



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