

UV LED Curing

ADDITOL[®] LED 01

- Introduction
- The ADDITOL® LED 01 Approach
- Application Program
 - Clear Coatings
 - Reactivity
 - LED Line settings (Distance LED to substrate, LED orientation)
 - Coating Thickness
 - Formulation Viscosity & Dilution
 - Dosage ADDITOL® LED 01
 - Gloss
 - Yellowing upon cure
 - Stain resistance
 - Pigmented Coatings
- Conclusions

Value Proposition UV LED

- ✓ Allows coating of heat sensitive surfaces
- ✓ Instant on, instant off
- ✓ Ability to coat small surfaces
- ✓ No ozone generation
- ✓ Others...

Could enable new applications which up to now were not feasible with standard high powered lamps.

The first trials

EBECRYL® 8465	85	85
DPGDA	10	10
ADDITOL® TPO	5	5
Inert Atmosphere	Yes	No
Reactivity at Finger Nail Resistance (m/min)	> 80	4x5 NOK

Application : 30μ by Barcoater on Leneta paper

*Curing : LED 8W/cm² 395 nm, 1cm distance from substrate to LED
(perpendicular orientation)*

Surface curing is an issue !

- Transform a UV curable formulation into a UV LED curable formulation by replacing part of the oligomer by a « **booster** » resin.
- This led to the development of **ADDITOL[®] LED 01**.
- The approach is also valid for other low energy curing UV technologies (e.g. UV-A curing).

Example

EBECRYL® 8465	85	65
DPGDA	10	10
ADDITOL® LED 01		20
ADDITOL® TPO	5	5
Reactivity Finger Nail Resistance (m/min)	4x 5 NOK	1x 5

Application: 30µm by Barcoater on Leneta paper

*Curing: LED 8W/cm² 395 nm, 1cm distance from substrate to LED
(**perpendicular** orientation)*

ADDITOL® LED 01 is a co-resin,
used as booster for surface cure.

ADDITOL[®] LED 01 – Physical Data

• Appearance	Liquid
• Viscosity, 25°C, mPa.s	210
• Colour	pale, pinkish
• Boiling point	> 200°C
• Vapour Pressure	< 1.33 hPa @ 20°C
• Flash Point	> 100°C Cleveland Open Cup
• Stability	> 10d @ 60°C

ADDITOL[®] LED 01 - Compatibility

EBECRYL [®] 8254 (6 f)	75	55			
EBECRYL [®] 8405 (4 f)			45		
EBECRYL [®] 8465 (3 f)				45	
EBECRYL [®] 8807 (2 f)					45
HDDA			10	10	10
ADDITOL [®] LED 01	20	40	40	40	40
ADDITOL [®] TPO	5	5	5	5	5
ADDITOL [®] ITX	0,1	0,1	0,1	0,1	0,1
Fingernail resistant (m/min)	1 x 5	1 x 10	1 x 25	1 x 15	1 x 20

Application : 10 μ m on Leneta

Cured with 8W /cm² 395nm LED at 2cm substrate lamp distance

Good Compatibility with selected Urethane Acrylates

ADDITOL[®] LED 01 - Compatibility

EBECRYL [®] 3700	65	45		
EBECRYL [®] 800			75	55
HDDA	10	10	10	10
ADDITOL [®] LED 01	20	40	20	40
ADDITOL [®] TPO	5	5	5	5
ADDITOL [®] ITX	0,1	0,1	0,1	0,1
Fingernail resistant (m/min)	1 x 35	1 x 50	< 1 x 5	1 x 10

Application : 10 μ m on Leneta

Cured with 8W /cm² 395nm LED at 2cm substrate lamp distance

Good Compatibility with selected Epoxy and Polyester
Acrylates

ADDITOL[®] LED 01 - Compatibility

EBECRYL [®] 892	34
EBECRYL [®] 837	10
Pigment Paste	36
ADDITOL [®] LED 01	20
EBECRYL [®] 168	4
ADDITOL [®] TPO	4
ADDITOL [®] ITX	0.5
Viscosity (mPa.s)	390

Application : 20 µm by barcoater on sanded untreated steel

Cured with Panacol 254 UV-H (UVA-lamp) at 15 cm substrate lamp distance

Good Compatibility with acidic adhesion promoters

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LED Equipment



8W/cm² LED 395 nm (2.5cm x 22.0cm)

Clear Coating - Starting Point Formulation

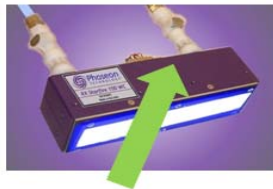

EBECRYL® 8465 (3-functional UA)	65
DPGDA	10
ADDITOL® LED 01	20
IRGACURE® 2100	5
Viscosity (mPa.s)	4000

Application : Barcoater on Leneta paper, thickness as mentioned

Curing : LED 8W/cm² 395 nm, geometry LED and distance LED to substrate as mentioned

EBECRYL® 8465 is a 3-functional urethane acrylate with balanced properties.

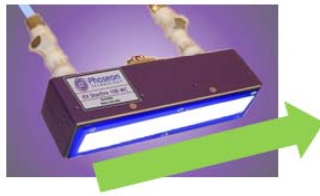
Reactivity – Distance to Substrate & Lamp Orientation

	<i>“perpendicular”</i>	<i>“in-line”</i>
		
Distance LED to substrate (cm)		
0.5	1X 5	1x 15
1	1x 5	1x 15
2	2X 5	1x 15

*Starting point formulation, 30 μ on Leneta paper
 Reactivity (m/min) - fingernail resistance*

Lower influence of distance to substrate with
 “in-line” orientation

Reactivity – Coating thickness



	10µm	30µm
Distance LED to substrate (cm)		
0.5	3x 5	1x 15
1	3x 5	1x 15
2	4x 5	1x 15

*SPF, on Leneta, thickness as mentioned
 LED orientation : "in length"
 Reactivity (m/min) - fingernail resistant*

Significant lower reactivity for thin coatings (<20µ)

Reactivity - Viscosity & Dilution

SPF

EBECRYL® 8465	49	57	65
DPGDA	26	18	10
ADDITOL® LED 01	20	20	20
IRGACURE® 2100	5	5	5
Viscosity (25°C, mPa.s)	1000	2000	4000
Fingernail resistant (m/min)	1x5	1x10	1x15
Gloss at 60° (%)	90	90	90

Application : 30 µm on Leneta paper

*Cured with 8W /cm² 395nm LED at 1cm substrate lamp distance,
LED "in-line" with the substrate (22cm).*

Cure speeds drops with increasing DPGDA dilution.

Reactivity – Dosage ADDITOL® LED 01 at iso formulation viscosity

EBECRYL® 8465	65	65	65
DPGDA	10	10	10
ADDITOL® LED 01		20	40
EBECRYL® 892	40	20	0
IRGACURE® 2100	5	5	5
Viscosity (25°C, mPa.s)	2300	2400	2500
Fingernail resistant (m/min)	4 x 5 NOK	1 x 5	> 1 x 40

Application : 30 μ on Leneta

Cured with 8W /cm² 395nm LED at 1cm substrate lamp distance,

LED “in-line” with the substrate (22cm)

> 40m/min with 40 parts ADDITOL® LED 01

Reactivity – Oligomer Functionality


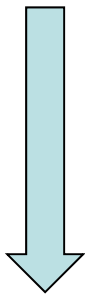






EBECRYL® 8465 (3-functional UA)	57	
DPGDA	18	
EBECRYL® 8254 (6-functional UA)		75
ADDITOL® LED 01	20	20
IRGACURE® 2100	5	5
Viscosity (25°C, mPa.s)	2000	1400
Fingernail resistant (m/min)	1x 10	1x 40

Application : 30 μ on Leneta

*Cured with 8W /cm² 395nm LED at 1cm substrate lamp distance,
LED “in-line” with the substrate (22cm)*

Higher surface reactivity is obtained with higher functional oligomers.

Reactivity - Summary

Effect of Increasing... on formulation reactivity		Coating thickness	DPGDA dilution (*)	ADDITOL® LED 01	Oligomer Funct.
Formulation reactivity	Higher				
	Lower				

(*) Higher functional diluting oligomers might have different impact on the formulation reactivity.

A 30µm hard coating will be easier to cure than
a 5µm flexible coating

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EBECRYL [®] 8465	60
DPGDA	40
ADDITOL [®] LED 01	20
IRGACURE [®] 2100	5
Syloid 162C	8
Acematt TS100	2
Lancowax PP1362	2
Viscosity, 25°C, mPa.s	2150
Fingernail resistant (m/min)	2 x 5
Gloss at 60° (%)	65

*Application : 30-35 μ on Leneta
 Cured with 8W /cm² 395nm LED at 1cm substrate lamp distance,
 LED "in-line" with the substrate (22cm)*

Difficult to achieve low gloss given the low T cure

	Hg (80W/cm)	LED	LED
EBECRYL® 8465	85	85	65
DPGDA	10	10	10
ADDITOL® LED 01			20
ADDITOL® BCPK	5		
ADDITOL® TPO		5	5
Yellowing, b-value 24 h (initial)	0 (1.4)	/	0.5 (2.8)
Fingernail resistant (m/min)	1x 25	4x5 NOK	1x 5

Application : 30μ by Barcoater on Leneta paper

*Curing : LED 8W/cm² 395 nm, 1cm distance from substrate to LED
(**perpendicular** orientation)*

Yellowing after UV LED curing is higher compared to standard curing due to the required photo-initiator.

	Hg (80W/cm)	LED
EBECRYL® 8465	85	65
DPGDA	10	10
ADDITOL® LED 01		20
ADDITOL® BCPK	5	
ADDITOL® TPO		5
Viscosity (mPa.s)	10,100	4,020
Solvent Resistance (ADR)	>100	>100
Eosine (16 hours)	4	1
NH ₃ 10% (16 hours)	5	5
Mustard (16 hours)	1	1
Ethanol 50% (16 hours)	5	5

Application : 30μ by Barcoater on Leneta paper

*Curing : LED 8W/cm² 395 nm, 1cm distance from substrate to LED (**perpendicular orientation**)*

Apart of the eosine resistance, stain resistance is very similar for UV LED and standard formulation.

EBECRYL® 8465 (3-functional UA)	45	35	25
DPGDA	10	10	10
ADDITOL® LED 01	20	20	20
TiO ₂ Hombitan R210 (F55-2)	20	30	40
IRGACURE® 2100	5	5	5
Viscosity (mPa.s)	3620	3520	3540
30-35 μ, Finger Nail resistance (m/min)	1 x 5	1 x 10	1 x 15
Yellowing, after cure, b-value	2.7	2.5	2.2

Application : 30-35 μ on Leneta

Cured with 8W /cm² 395nm LED at 1cm substrate lamp distance, LED “in-line” with the substrate (22cm)

Good surface & deep curing possible in
white pigmented systems

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- ✓ The ADDITOL[®] LED 01 approach is about transforming UV formulations into UV LED curable formulations.
- ✓ This approach is also valid for other low energy curing UV technologies (e.g. UV-A curing).
- ✓ ADDITOL[®] LED 01 is a co-resin and replaces part of the UV oligomers in the formulation.
- ✓ Application results have shown that ADDITOL[®] LED 01 is very effective in increasing reactivity of UV LED curing systems.
- ✓ UV LED technology opens opportunities for new applications.
- ✓ Further development are necessary to achieve specific application requirements.