TECHNICAL BULLETIN

EBECRYL® UV/EB Energy Curable Resins

UV/EB INKJET INKS

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allnex
The Coating Resins Company

Introduction

UV/EB inkjet inks can provide significant advantages when compared to non-UV/EB based inkjet inks. Among these are **ultralow volatile organic content (VOC) inks** that are non-flammable, highly durable, one-pack systems with extended pot-life and good adhesion to plastic substrates. UV/EB inkjet inks do not dry unless exposed to UV light or EB energy, minimizing issues with clogged nozzles. Energy cured coatings polymerize in milliseconds upon exposure to ultraviolet light (UV) or electron beam (EB) energy to enable high productivity and energy efficiency.

General Recommendations

The low viscosity of inkjet inks combined with the complexity of the printing head means that pigment particles need to be ground to sub-microns sizes (average size of ≅ 0.1 micron). This fine pigment dispersion is comparable to a nano-particle dispersion and is the highest level of dispersion used in the printing, coating, and materials coloring industries. Bead mills equipped with ceramic beads of ≅ 0.2mm are used to achieve this level of dispersion.

Special pigment grades with specific primary particle size, good dispersant possibility, and light fastness are suggested for use in this area. The use of pigment dispersions prepared in UV resins is recommended.

One of the most important properties of the pigment dispersion is the stability against flocculation during production and storage. This is only achieved when the resin layer containing the dispersing agent is strongly adsorbed to the pigment surface. Therefore, the balance between pigment, dispersing agent, and binder is of primary importance.

UV/EB inkjet inks have several characteristics not found in solvent and water based inkjet inks.

- Inks will not dry by evaporation and/or absorption into the substrate. They must be polymerized by exposure to UV or EB in order to form a cured ink film. The polymerization will not continue after UV/EB exposure. If inks are not properly cured, the residual monomer components could produce a strong odor, or the ink could be tacky or “wet”.

- If the ink penetrates into the substrate, as is possible for some papers and cardboards, the component that has penetrated into the substrate will not be polymerized by the UV lamp. This can generate an unpleasant odor. Printing with UV ink is therefore not possible on some absorbent substrates. EB cure can be used to eliminate this problem, as the electron beams can penetrate the substrate.

- The film thickness of UV/EB inkjet inks is generally higher than those of solvent and water based inks. Indeed, all of the applied UV/EB inkjet ink will form the “dry” ink film, whereas in water and solvent based inks, the solvent or water will be evaporated, leaving a thinner film. Thicknesses between 5 and 40 µm are realistic for UV inkjet prints.

The reactivity or cure speed of UV/EB inkjet inks is linked to the binder composition, the level and quality of the photoinitiator, and the color intensity. See below for binder considerations.

- Mono-acrylated monomers (diluting acrylates) have the lowest viscosity (5 to 10 cP). Unfortunately, their reactivity is also the lowest.
- Di-acrylate monomers have a higher viscosity, but also a higher reactivity than the mono-acrylates. They constitute the major part of the binder.
- Tri-acrylate and higher functionality monomers are highest in reactivity, but will be used in smaller proportions in the formulation, as they also increase shrinkage and brittleness.

Oligomers are used in small amounts to provide important properties, such as toughness and flexibility, which are not achievable with just monomers.

Raw Materials for UV/EB Inkjet Inks

Materials used in UV/EB inkjet inks are usually low viscosity diluting acrylates (monomers) and oligomers because of the low viscosity requirements of inkjet inks. Materials recommended for UV/EB inkjet inks are shown in the following tables.

	Viscosity, cP @ 25°C	Key Features & Benefits
MONOFUNCTIONAL DILUTING ACRYLATES		
IBOA	9.5	• Isobornyl acrylate. Provides hardness after cure. • Moderate diluting properties. Flexibility without softening. • High Tg = 75°C
CTFA	14	• Very good adhesion to plastic and metal substrates
EBECRYL® 114	10	• 2-Phenoxyethyl acrylate. • Good reactivity. Lowest shrinkage and favorable adhesion on plastic substrates. • Tg = 7°C.
EBECRYL 113	120	• Hydroxyl functionality. • Very good film flexibilizer. Very good reactivity. Low odor. Improved adhesion. • Low Tg = - 6°C
EBECRYL 117	70	• Hydroxyl functionality • Low Tg = -50°C • Low odor
EBECRYL 118	215	• Phenylglycidyl Ether Acrylate • Increase flexibility of the cure polymer while maintaining strength and toughness • Tg = 26°C
DIFUNCTIONAL DILUTING ACRYLATES		
HDDA	6.3	• 1,6-Hexanediol diacrylate. • High diluting power and excellent adhesion properties. Weatherable.
DPGDA	9.2	• Dipropylene glycol diacrylate. • Good cure speed and better flexibility than HDDA.
TPGDA	11.8	• Tripropylene glycol diacrylate. • Good cure speed and slightly better flexibility than DPGDA and HDDA.
EBECRYL 130	171	• Tricyclodecanediol diacrylate. • Excellent reactivity and good hardness. • Barrier properties. Low shrinkage.
EBECRYL 145 **NPG(PO)$_2$DA**	15.9	• Propoxylated neopentyl glycol diacrylate. • Good pigment wetting and flow. • Low surface tension.
EBECRYL 152	21	• Let down for inkjet inks. • Good flow, leveling, and adhesion to wide range of plastic substrates
MPDDA	8.5	• Low Viscosity and low Odor • Excellent adhesion, good weathering properties

	Viscosity, cP @ 25°C	Key Features & Benefits
HIGHER FUNCTIONALITY DILUTING ACRYLATES		
TMPTA	115	• Trimethylolpropane triacrylate. • Good reactivity and good hardness. Chemical resistance.
TMPEOTA	70	• Ethoxylated trimethylolpropane triacrylate. • Good compatibility with pigment dispersions. Flexibility.
OTA-480	88	• Propoxylated glycerol triacrylate. • Good reactivity, good hardness/flexibility compromise. Low irritancy. • Good pigment wetter.
EBECRYL® 895	7600	• Dipentaerythritol penta/hexa-acrylate. • Low migration resin. • Use to increase cure speed and hardness of inks. High reactivity
EBECRYL 40	148	• Alkoxylated tetra-acrylate. • Good compatibility with pigments (often used in the letdown of liquid inks). • Good hardness/flexibility compromise. • High gloss and high cure speed. • Low irritancy.
EBECRYL 140	979	• Di-trimethylolpropane tetra-acrylate. • Very good compatibility with pigments. • Low irritancy. • Good hardness and solvent resistance. Very high cure speed.
AMINO ACRYLATES		
EBECRYL 81	92	• Amino modified polyether acrylate. • Low viscosity. • High reactivity when used as main binder.
EBECRYL 83	515	• Amino modified polyether acrylate. • High reactivity when used as main binder. • Low irritancy.
EBECRYL 85	150	• Amino modified polyether acrylate. • High reactivity when used as main binder. • Low migration resin.
EBECRYL 7100	1200	• Highly efficient co-initiator, can be used as a resin • Excellent adhesion to plastic substrates
EBECRYL 7110	1150	• Amine functional acrylate. • Use at 10-15% levels to improve the surface cure of the ink. • Film flexibilizer and adhesion promoter. • Possible competition with the dispersing agent with flocculation consequences.
EBECRYL P115	22	• Highly efficient co-initiator used at 5-15% levels to increase surface cure. • Low viscosity
ADHESION PROMOTERS		
EBECRYL 303	900	• Excellent adhesion to a wide range of plastic substrates. Good exterior durability. • 45% HDDA.
EBECRYL 367	1500	• Low acidity, low viscosity, low odor • Suitable for low migration applications • Excellent adhesion to corona treated polyolefin substrates
SELF-CURING RESINS		
EBECRYL 10101	3500	• Use 20-30% in formulation
EBECRYL 10103	6000	• Use 15-20% in formulation • Free choice of synergist
LOW ENERGY BOOSTERS		
EBECRYL LED 03	450	• Suitable for low migration applications • Surface cure booster in low energy/LED cure conditions
EBECRYL LED 04	17,500	• Suitable for low migration applications • Surface cure booster in low energy/LED cure conditions • Has little to no impact on ink-water balance of the formulated ink

	Viscosity, cP @ 25°C	Oligomer Class	Acrylate Functionality	Key Features & Benefits
LOW VISCOSITY OLIGOMERS				
EBECRYL® 810	453	Polyester Acrylate	4	• Low irritancy. • Hardness and Chemical resistance.
EBECRYL 5781	450	Polyester Acrylate	2	• Outstanding reactivity. • Bio-based. (57%) • High Tg (162°C).
EBECRYL 5850	5000	Polyester Acrylate	2	• High reactivity. • Bio-based. (56%)
EBECRYL 4100	6800 (23°C)	Aliphatic Urethane Acrylate	3	• Tough and flexible. • Good chemical and wear resistance.
EBECRYL 4857	2000	Aliphatic Urethane Acrylate	2	• Low Tg (4°C) • Flexible
EBECRYL 4858	7170	Aliphatic Urethane Acrylate	2	• Toughness and impact resistance. • Exterior durability.
EBECRYL 4859	9300	Aliphatic Urethane Methacrylate	2	• Toughness and impact resistance. • High Tg (124°C).
EBECRYL 5130	9500	Aliphatic Urethane Acrylate	6	• Low Viscosity version of EBECRYL 5129 • Fast cure. • Chemical, scratch, and abrasion resistance.
EBECRYL 8210	3750	Aliphatic Urethane Acrylate	3.5	• Hydroxyl functionality. • Excellent reactivity. Good scratch and abrasion resistance.
EBECRYL 8313	6000	Aliphatic Urethane Acrylate	2	• Flexible • Low Color
EBECRYL 8409	12500	Aliphatic Urethane Acrylate	2	• Outstanding exterior durability. • Good adhesion. • Tin-free version of EBECRYL 8402
EBECRYL 4500	6000 (23°C)	Aromatic Urethane Acrylate	4	• Outstanding abrasion resistance. • Good chemical and mechanical resistance

	Viscosity, cP @ 25°C	% Solids	pH	Particle size	Key Features & Benefits
WATER BASED PUDS FOR INKJET					
UCECOAT® 2801	15	38	6.7	90	• Versatile binder with good reactivity and resolubility before cure
UCECOAT 2802	200	38	7.3	80	• Versatile binder especially designed for application onto PVC with barrier to plasticizers
UCECOAT 2803	300	40	7.5	75	• Versatile binder with excellent pigment wetting properties
UCECOAT 2804	75	35	7.5	100	• Very reactive binder especially designed for low migration and excellent adhesion to plastics
UCECOAT 2805	100	35	8.0	20	• Very low particle size binder especially designed for superior stability and unlabeled inks
UCECOAT 2806	10	35	6.7	75	• Very low viscosity binder especially designed to combine low migration with good flexibility
UCECOAT 2807	<200	34	8.0	100	• Versatile binder designed to combine good adhesion with flexibility and low migration

Starting Point Formulations for UV/EB Inkjet Inks

Pigment Paste	Yellow	Cyan	Magenta	Black
Grinding resin*	68.4	67.8	69	69
Stabilizer **	1.0	1.0	1.0	1.0
Solsperse 22000	0.6 – 1.0			
Solsperse 5000		1.0 – 1.5		
Solsperse 39000	5.0	5.0	5.0	5.0
Yellow pigment	25.0			
Blue pigment		25.0		
Red pigment			25.0	
Black pigment: SB 250				25.0
Total	100	100	100	100

* EBECRYL® 151, 452, 3203.

** The use of a stabilizer is required in order to avoid the in-can polymerization of pigmented radiation curing materials caused by the complex interaction of pigment and acrylates.
Example of commercial products: Florstab UV-1 from Kromachem.

Ink	Yellow	Cyan	Magenta	Black
Pigment paste	ca. 20	ca. 20	ca. 20	ca. 20
Diluent	60 -70	60 -70	60 -70	60 -70
PI system (UV cure only)	10 - 16	10 - 16	10 - 16	10 - 16

Note: The quantity of pigment depends on the type of pigment and the degree of dispersion.

PI System for UV Curing	
TPO or TPO-L	15%
ITX	35%
EDB	40%
Omnirad 369 or 379	10%

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