UV Curing Flexo Inks

By David Helsby

The Flexographic Process

Flexography (Flexo) is a process in which the printing image stands up in relief. A liquid ink (generic term for low viscosity inks) is applied, whereby solvent- or water-based inks or UV curing can be used. UV-cured systems have seen rapid growth in certain segments of the flexo world, especially in the area of mid-size presses and narrow web printing for labels. The flexo process has several distinctive features that must be considered when formulating suitable UV curing inks:

Press Configurations

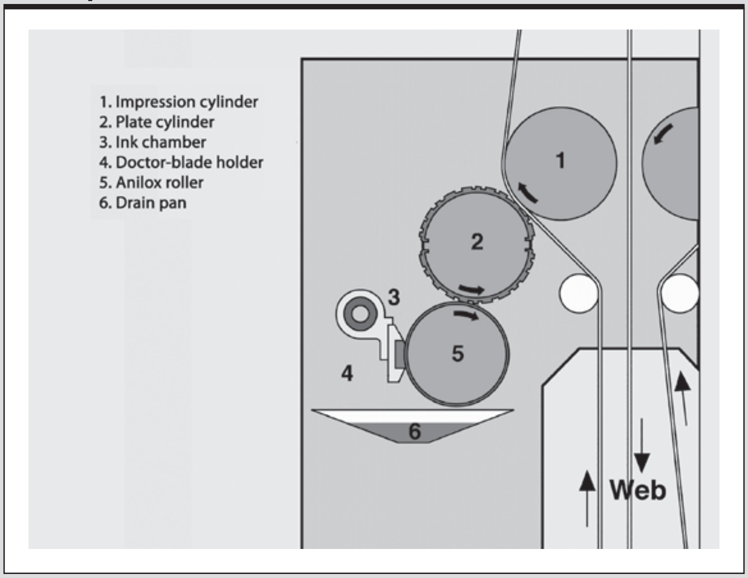
There are three basic configuration types for flexo printing presses:

- stack
- common-impression
- in-line

The first two types more commonly use solvent and water -based systems, but also UV-curing flexo inks are being used. In contrast, in-line press configurations predominantly use UV-curing flexo inks.

Figure A

Flexo process



Printing Unit

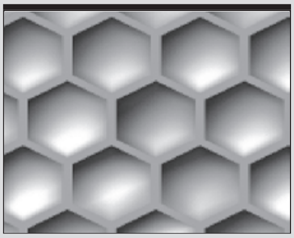
The inking system meters out a fine and controlled film of liquid ink and deposits it upon the surface of the printing plate. It is essential to use low viscosity inks to ensure they transfer rapidly and uniformly, allowing for fast printing speeds on non-absorbent materials such as films and foils. UV-curing flexo inks are usually in the range of 1000 mPas in viscosity. Although some users believe it would be better to have lower viscosities, it is more important to have a balanced series of inks with similar viscosities. Cure or running speeds have increased as press manufacturers have improved their design: 200 m/min are now possible.

Anilox

Ink is applied to the printing plate surface by means of a screened (anilox) roller. The result is a simple ink feed system, especially when compared with Litho presses and their complex water/ink balance. However, the process has its own unique requirements in terms of physical characteristics, rheology and transfer properties. This is especially true for the UV inks now in use. The anilox roller is a crucial factor in achieving good quality flexo printing and there is still much to be learned when it comes to applying UV-curing inks. Ceramic rollers and chrome-plated rollers can carry very different amounts of ink when such factors as cell volume, geometry and screen size are considered. These factors are even more critical to the success of suitable

Figure B

Anilox cells



UV curing inks due to differing surface energies and physical parameters, especially in comparison to conventional solvent-based inks. Thorough testing has been done in order to arrive at the optimum anilox and plate combinations for UV ink applications, and many manufacturers of presses, anilox and plates have specific recommendations for UV inks.

Doctor Blade

The doctor blade scrapes the excess ink from the surface of the anilox as the ink is transferred to the flexoplate. In high-quality printing, reverse angle doctoring (using nylon, polyester or ultrahigh molecular weight polyethylene) has replaced steel and thus cuts down anilox wear significantly.

On a number of UV-curing presses, a double doctor blade forms an ink chamber—creating a totally enclosed inking system—and makes the transfer of UV-curing flexo inks much more efficient.

Flexoplates

These plates consist of light-sensitive photopolymer, which—when exposed to UV radiation through a photographic negative—polymerize and become resistant to the washing-out medium. In some aspects, the chemistry of the plates is similar to the UV inks and care should thus be taken in order to avoid plate damage from the UV ink chemistry. The main areas of concern are with the selection of the low molecular weight content of the ink such as monomers and some additives. As with the anilox, flexoplates should be selected for specific UV curing inks.

New Presses

The units of modern flexographic printing presses are now engineered to very tight tolerances.

The ability to manufacture to these standards, in combination with the development of higher print quality UV curing inks, has contributed to the growth in flexographic printing, and its use for higher quality products than was previously possible.

Typical UV-Flexo Applications

Originally, UV-curing flexo inks were introduced for the printing of labels and have since become the dominant technology in that field. In the 90s, a number of wide-web machines (>100 cm) were converted to UV curing but the real growth came later in the mid-size printing machines (60 to 100 cm). UV flexo printing inks and varnishes are highly popular and still gaining market share. One good reason is the absence of solvents, which reduces emissions and which was probably one of the main reasons for introducing UV curing technology in the first place. Moreover, these products also offer superior print quality with no solvent replenishment and rapid readiness for use, provide good adhesion on flexible and many other substrates, offer high chemical and product resistance and allow for high running speeds. UV-curing flexo inks are now printing on nearly all ranges of substrates used for finished products such as yogurt tops and cups; sugar, soup and spice sachets; flexible packaging; milk and juice cartons; pet food packaging and even cigarette packs.

Materials for Flexographic Formulations

The materials for UV-curable flexographic formulations include monomers, oligomers, in-can stabilizers and photoinitiators.

Figure C

Flexoplate

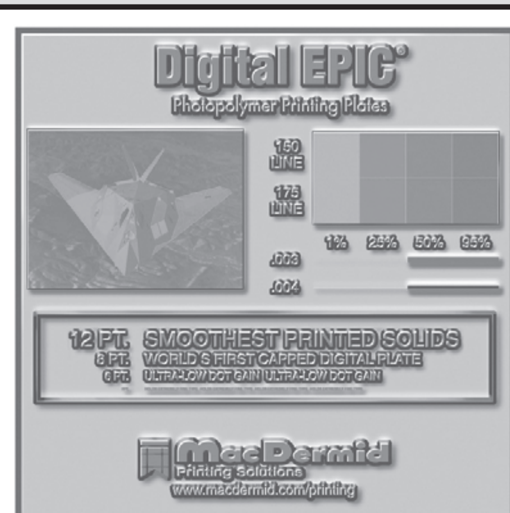


Figure D

Flexo packaging

Monomers

Monomers are typically used in flexographic formulations at 30-60 weight percent of the formulation.

Choosing the right monomers is critical. A wrong type of monomer can lead to plate swell and create registration issues. Monomers provide lower viscosity and can influence rheology, cure rates and adhesion.

Grinding Vehicles

Grinding vehicles are essential in the development of flexographic inks. These vehicles efficiently break down pigment agglomerates and allow for efficient stabilization. Using these vehicles will increase flow, stability and color development of the ink.

Letdown Oligomers

Letdown Oligomers provide enhanced physical properties, unique end properties, cure speed and adhesion.

In-can Stabilizers

In-can stabilizers are an important part of UV-curing flexo inks. They significantly improve shelf life and ink stability during the grinding process. Our stabilizer product range increases the stability of UV-curable flexo ink formulations and has already been in use for many years.

Photoinitiators

A full range of well-established photoinitiators, including polymeric photoinitiators, for radically curing UV systems are commercially available.

Additives

There are many additives used to manufacture UV-curing flexo inks. The huge range of products on the market makes it difficult to give even a rough overview. Successful starting point formulations, however, often contain quite complex additive combinations which customers can sort through given advice from formulators and suppliers. These need to be optimized until the final formulation is meeting the specific requirements.

UV-Curing Ink Formulations

The test inks were formulated by preparing an optimal mill base and then let down to the final finished inks by adding monomers, oligomers, photoinitiators and additives. This method allows for optimum grinding and milling of the pigments—eliminating the risk of reactive photoinitiators and poorly grinding oligomers and additives—that are required in the final ink.

The production of concentrated bases also allows for a number of different ink series to be produced by simply altering the let down formulation. The end formulations listed in this report have been designed as a general purpose series, i.e. as starting point formulations.

Mill Bases

The mill base is the first and most crucial step in the process of making a UV flexo ink from a platform manufacturing system. The mill base contains pigment, oligomer, monomer and a dispersant.

Table 1

Starting point formulations

	Yellow	Magenta	Cyan	Black	White
Pigment	PY 13	PR 57:1	PB 15:3	PB 7	PW 6
Supplier Code	Irgalithyellow LBG	Irgalithrubin L4BD	Irgalithblue GLO	Special black 250	Titan 2310
Supplier	Ciba	Ciba	Ciba	Degussa	Kronos
Pigment	35.00	35.00	35.00	35.00	50.00
Grinding Oligomer	60.00	60.00	64.00	60.00	49.00
BYK 168	4.00	4.00	-	4.00	-
Stabilizer	1.00	1.00	1.00	1.00	1.00
Totals	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 2

Properties of finished Flexo Inks

	SPF 524	SPF 526	SPF 530	SPF 528	SPF 532
Mill base [%]	40.0	42.0	40.0	3.0 7.0 30.0	52.0
Stabilizer	0.5	0.5	0.5	0.5	0.5
Modified Epoxy Acrylate	9.5	9.5	13.5	10.0	10.0
Modifed Urethane Acrylate	5.0	5.0	5.0	5.0	
Reactive diluent (4 functional)					9.0
Reactive diluent (3 functional)	15.0	15.0	11.0	18.5	7.0
Reactive diluent (2 functional)	21.4	19.4	19.5	15.0	12.9
Uvitex OB					0.1
WAX OR SLIP ADDITIVE	1.0	1.0	1.0	1.0	1.0
Photoinitiator 1	1.9	1.9	2.4	2.5	2.0
Photoinitiator 2					3.0
Photoinitiator 3	0.8	0.8	0.9	1.0	
Photoinitiator 4	1.9	1.9	2.4	2.5	1.0
Photoinitiator 5					1.5
Photoinitiator 6	3.0	3.0	3.8	4.0	
Total	**100**	**100**	**100**	**100**	**100**
Reactivity in m/min at 1 pass 240W/cm mpHg lamp	approx. 100				

* toned with cyan and magenta mill bases

The pigment selection is the first and some say most important step in the manufacturing of UV curing inks. The pigments used here should only serve as a starting point, and we strongly recommend that thorough tests be done to arrive at the optimum pigments for each individual product requirement. The mill base formulations shown here can be used as benchmark formulations to evaluate alternative pigments.

The dispersant used in the mill base has been chosen to compliment the grinding oligomer and provides pigment wetting and improved grinding properties. The dispersant additive is not required in the Blue and White.

The mill bases were produced on a Bühler SDY- 200 mill, with one loose pass at 15 bar, followed by up to 3 passes at 20 bar, achieving a fineness of less than 5 micron with no peppers.

Viscosity and Flow Properties

The viscosity and flow of a mill base or a finished ink can be determined by

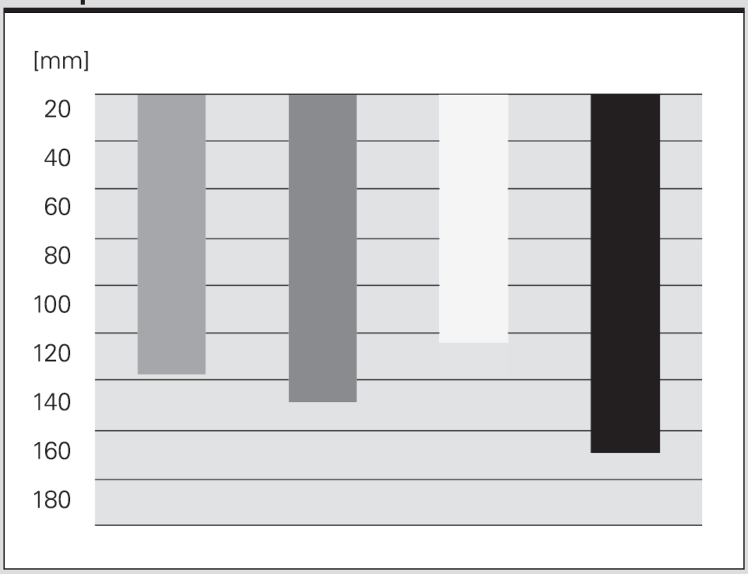
Table 3

Viscosity of inks measured on the Mettler RM260

	SPF 524	SPF 526	SPF 530	SPF 528	SPF 532
Viscosity [Pa*s @ 25°C]	1.01	1.03	1.03	0.9	0.7

Figure E

Flow plate results

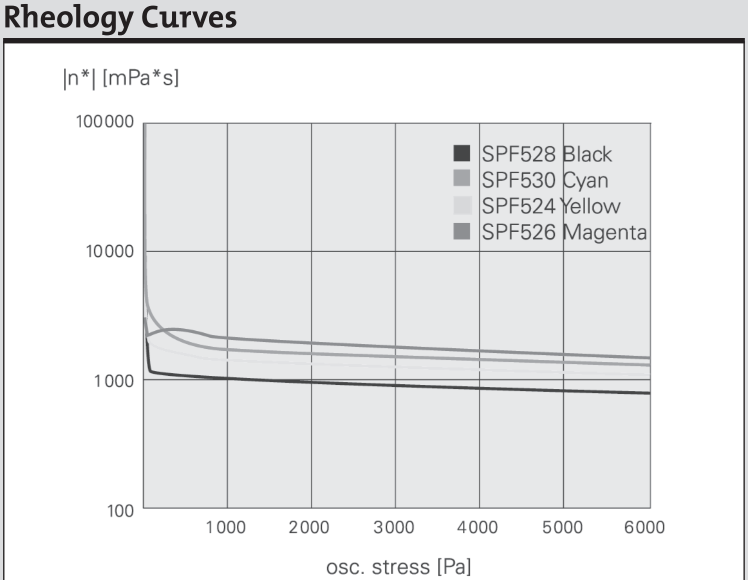


sophisticated measurement on a variety of rheology testers, quickly checked by a cone and plate viscometer or simply and visually compared by the flow plate method. In this particular study we have used:

- an AR 550 Rheomat from TA Instruments to determine the rheology curves and viscosity of the bases.
- a RM 260 Rheomat from Mettler for a QC viscosity check of the inks.
- a flow plate method to observe the flow characteristics.

Figure F

Rheology Curves



The flow plate method is a simplistic and comparative method. Depending on the product, 5 to 10 g are placed on a glass plate, allowed to settle for 30 seconds and then the plate is positioned upright at 80°[TBC1]. Depending on the products being compared (i.e. finished ink or millbase), the flow length is measured in mm after 1 or 3 minutes. The flow, viscosity and rheology curves of the bases have been compared to bases made from our standard epoxy acrylate, reduced with trimethylol propane tri(ethylene oxide) triacrylate.

Flexo Inks

The mill bases are let down with monomers, oligomers, photoinitiators and additives to produce the finished ink. By varying the letdowns, many different inks can be made from the same mill base. The letdown oligomers and monomers have been selected to give the finished ink properties. The photoinitiators are shown in breakback quantities but are added to the letdown as an eutectic mix. A breakback of the final ink formulation can also be produced as an in-situ formulation run on a pearl mill such as Bühler K8 but special care is required with regard to the correct cooling of the mill and/or the eutectic photoinitiators mix left out of the grinding stage and added in the final potting stages.

Please note that the viscosities achieved are part of an ink series with balanced properties. Lower viscosities can be achieved with some colors but are often counter productive when run on a press configuration if not in balance with the rest of the colors.

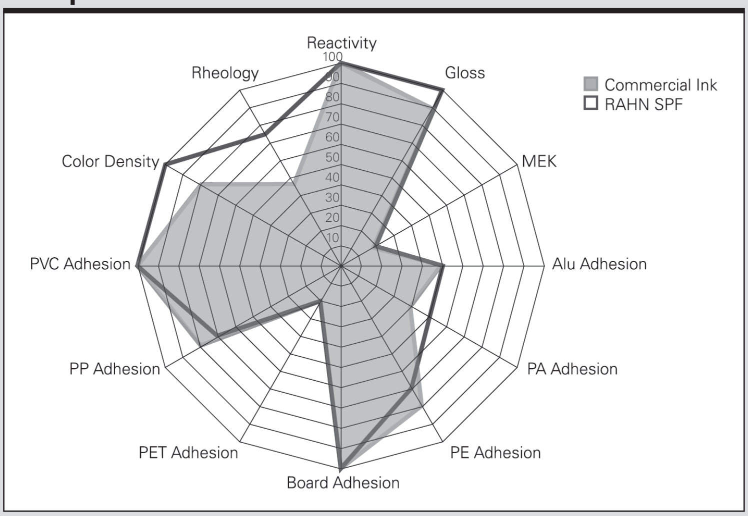
Glass Plate Flow Measurements

The results shown in the flow and rheology measurements are an indication of how the inks will perform on the press. Different presses will have different shear characteristics in the ink train but also in the ink delivery. Some presses may have an enclosed recirculation of ink or may have a simple gravity-fed flow pan.

Usually, the better the flow (especially at low stress), the better the performance of the inks on the printing press. The finished inks were compared to a commercially available series of UV curing flexo inks. The spider diagram below compares some of the properties compared.

Figure G

Comparison



Conclusions

This was an overview of the flexo ink printing process and the requirements needed to develop a UV curing ink series for state-of-the-art flexographic presses. RAHN's starting point formulations for UV-curing flexo inks give robust all-round inks with an excellent reactivity, well-balanced rheological properties and good color strength. They can be used as a base to create ink series with various specific properties. ◗

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