Ink Performance Properties of UV, Conventional and Hybrid Sheetfed Inks

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Abstract:

In an attempt to bridge the technological gap between conventional and 100% UV inks for lithography, hybrid inks have been introduced onto the market during the last couple of years. In this paper, commercially available UV, conventional and hybrid sheetfed inks are compared in terms of formulation and performance. Ink properties like pigment wetting, rheology, tack, misting, ink water balance and cure speed were examined in laboratory ink tests. Clear differences in ink water behaviour, cure speed and resistance were observed. The results give a good insight into the advantages and disadvantages of each technology.

Introduction:

UV-radiation curing has become a well accepted technology in the graphic industry. The transformation of the liquid to a solid phase takes place within a fraction of a second on illumination at ambient temperature. In commercial sheetfed printing, UV inks have enabled printers to increase productivity and add improved characteristics such as better gloss and resistance properties.
Because of the difference in nature between UV and conventional inks, modified ink rollers have to be used on offset presses. Generally, rubber rollers for UV inks are based on EPDM, whereas rollers for conventional inks are generally Nitril Butadiene rubber (NBR).
While EPDM is compatible with the more polar UV binders and cleaning agents, NBR is compatible with more apolar materials such as eg. hydrocarbons.
These differences high-light the difficulties which are encountered when printers want to alternate between conventional and UV printing inks.
A possiblity to solve this problem is to equip the press with so called “hybrid” rollers compatible with both technologies.
Recently, “hybrid” inks were brought onto the market, in an attempt to address this in another way. By combining the UV and conventional technology, a printer has the possibility of using a hybrid ink on a conventional press, with only the cost of fitting the press with UV lamps.

Although an established technology, some difference still exist in the runnability on the press of UV versus conventional lithographic inks. UV inks still seem to have less latitude in ink water balance.

Commercial samples of the three ink types, UV, conventional and hybrid inks, were evaluated in our lab. Ink properties like rheology, tack, misting, colour strenght, ink water balance and cure speed were examined.

Offset ink formulations:

In tables 1 to 3 , some general ink formulations of UV, conventional and hybrid inks are described.
These will of course depend on the substrate to be printed.

UV inks for paper and board will mainly contain dimeracid based polyester acrylates for pigment wetting and ink water balance. Epoxy acrylates are added for price reasons and to increase cure speed. In darker colours, high functional urethane acrylates may be used.
Polyesters diluted in monomers such as TMPTA or TMP(EO)TA form the basis of the formulation for UV inks for plastic substrates. Epoxy acrylates and higher functional urethane acrylates are added to increase cure speed, hardness and scratch resistance.

UV offset ink	
Polyester acrylates	0-30%
Diluted polyesters	0-40 %
Epoxyacrylates	10-40%
High funct. urethaneacrylates	0-10%
Pigment	14-24%
Fillers	4-8%
Wax	1-2%
Monomers (GPTA,TMPTA, …)	5-15%
Photoinitiator blend	6-12%
Stabilisors, inhibitors	<1%

Table 1: general UV sheetfed ink composition

Conventional sheetfed ink	
Mineral Oil (280-320°C)	0-30%
(semi) Drying vegetable oil and esters thereof	15-30%
Drying alkyd	10-20%
Hard resin (rosin mod)	20-35%
Pigment	14-24%
Fillers	0-5%
Wax	3-5%
Driers	2%
Anti-oxidants	0-2%

Table 2: general conv. sheetfed ink composition

Hybrid ink composition	
Vegetable oil and esters thereof Semi drying alkyd	5-15%
Polyester acrylates	0-50%
Epoxyacrylates	0-10%
Vegetable oil acrylates	0-50%
Pigment	14-24%
Fillers	4-8%
Wax	1-2%
Monomers (GPTA,TMPTA, etc…)	5-15%
Photoinitiator blend	4-8%
Stabilisors, inhibitors	<1%

Table 3: general hybrid sheetfed ink composition

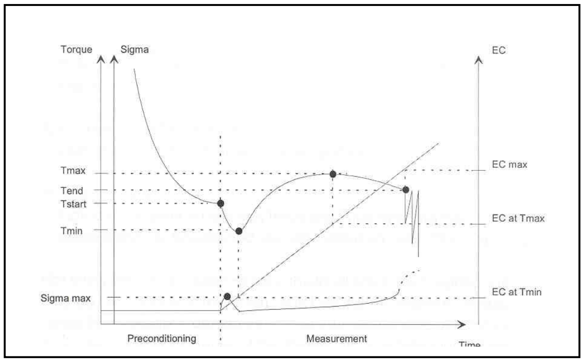
In conventional sheetfed inks for paper and board, low viscosity, low aromatic mineral oils are used to obtain a "quick set" effect. This involves penetration of the low viscosity oils into the substrate to induce a physical drying (setting). The drying of the printed ink film is completed through oxidation over time.
This quick set effect is not applicable when printing is done on non-absorbant substrates like plastics. Here, (drying) vegetable oils and esters thereof are used to dissolve the hard resin and for viscosity reduction. These will also take part in the oxidation reaction.

Hybrid inks are based on binders selected to minimize the attack of ink rollers and blankets. The amount of photoinitiator is reduced for the same reason, resulting in a lower reactivity (see later). The UV binders must of course be compatible with conventional binders. Basically, for this reason, the UV part of hybrid inks generally consists of polyesters acrylates, resulting in inks with lower scratch and chemical resistance. For the above mentioned reasons, hybrid inks are in practise often or almost exclusively used in combination with a UV overprint varnish.

Lithographic ink properties:

Rheology: viscosity measured on a plate and cone rheometer.
High shear viscosity or "print viscosity", influences print parameters like transfer, misting, ink water balance, dot gain etc….Low shear viscosity gives an indication of ink flow behaviour in the ink duct.
The ratio of low shear viscosity versus high shear viscosity is expressed as "shortness index". The lower the shortness index, the more "Newtonian" the ink is.
Tack: measured on a tack-o-scope, 0.3 cc of ink at 350 m/min and 30°C.
Misting: measured on a tack-o-scope, 1 cc of ink at 350 m/min and 50°C. Ink mist collected for 1 minute on white paper. Density measured on different spots and averaged. The higher the density, the more misting.

Remark: misting is measured in the lab on the pure ink. The type of ink water emulsion formed may affect misting on the press, either positively or negatively.
Cure speed is measured by graphite test for coloured inks and chalk test for black inks. Print is considered to be dry when no clear stain can be observed.
Solvent resistance is expressed as aceton dubble rubs (ADR).
Ink water balance: measured on a lithotronic (Novocontrol)



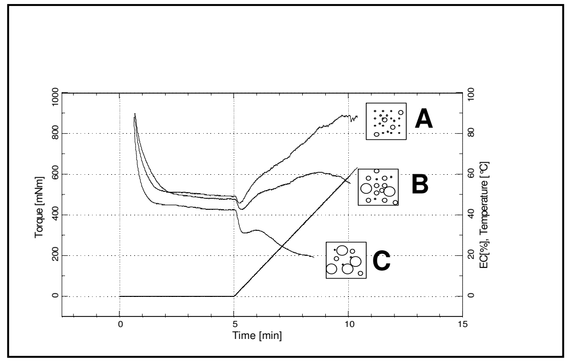


Fig. 1: principle of lithotronic measurement

Fig.2: different types of ink water emulsion

Basically, the Lithotronic measures the torque needed for a certain speed (rpm). The torque gives a measure for viscosity. With the Lithotronic, the change in viscosity of an ink is measured when water is emulsified in it.
The measurement consists of two phases: preconditioning and measurement.(see fig 1)
During preconditioning, the sample is sheared at constant speed and heated at the same time to a certain pre-programmed temperature. At the end of the preconditioning phase, the sample has reached a stable viscosity. At that moment, controlled metering of fount solution is started.
Changes of applied torque (hence viscosity) versus time and emulsion capacity are recorded. When maximum emulsion capacity is reached, a drop in torque is usually experienced because of the free water in the beaker.

The type of ink water emulsion formed has a big impact on the press behaviour and the print result. Ideally, when water is emulsified in the ink, viscosity should only undergo a minor increase. This ensures a good ink transfer on the press (Type B – fig.2). If the emulsion is too fine and too stable, it will lead to a loss of density and possible ink build up (Type A – fig.2). If the emulsion is too coarse (Type C – fig.2), it can lead to unstable press behaviour making regular press control necessary.

Ink properties: UV vs conventional lithographic inks

In table 4, some lab test results of commercially available UV and conventional sheetfed inks can be found. These figures are deduced from an evaluation of inks coming from 5 different suppliers. Inks for paper and board as well as inks for plastics were evaluated.

The most obvious differences are a higher structure (low shear viscosity) and higher tack, especially at higher speeds, for UV inks. UV inks form a coarser less stable emulsion than conventional inks (see fig.3). The higher structure can have a negative impact on the ink flow in the ink duct. This can be attributed to an inferior pigment wetting of the UV binders and the prescence of fillers used to improve misting.

	UV	Conv.
Visco 0,1s^{-1}@ 25℃	500-1000 Pa.s	100-700 Pa.s
Visco 100 s^{-1} @ 25℃	35-50 Pa.s	30-40 Pa.s
SI	15-30	3-15
Tack 50 m/min	100-200	100-120
Tack 350 m/min	400-700	200-250
Misting 1.0 cc 50℃	0.40-0.60	0.30-0.60
Density – 1,5 g/m²	1.5(Y)-2.1(B)	1.5(Y)-2.1(B)
Gloss – 1,5 g/m² 60°	20-30	20-30
Solvent resist. (ADR)	>50	1-2

Table 4: lab results commercial UV and conventional sheetfed inks.

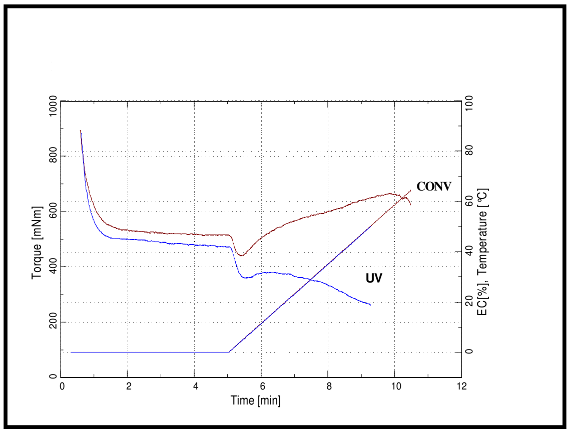


Fig.3: typical lithotronic curves of a UV and conventional sheetfed ink.

If tack is too high, it may lead to picking of fibers or coating when printing on paper or board. In conventional inks, tack can be modified by adapting the solubility of the resin-oil system. This is less the case in UV inks.

Hybrid inks

Two european hybrid inks were evaluated (results table 5). The main difference with “standard” UV inks is the lower reactivity. Ink water balance is fairly comparable to UV inks, meaning an ink water emulsion less stable than conventional oil based inks (fig. 4).

	UV	Hybrid
Visco 0,1s^{-1}@ 25℃	500-1000 Pa.s	400-800 Pa.s
Visco 100 s^{-1} @ 25℃	35-50 Pa.s	30-45 Pa.s
SI	15-30	12-28
Tack 50 m/min	100-200	100-120
Tack 350 m/min	400-700	400-600
Misting 1.0 cc 50℃	0.40-0.60	0.30-0.50
Density – 1,5 g/m²	1.5(Y)-2.1(B)	1.7(Y)-2.2(B)
Gloss – 1,5 g/m² 60°	20-30	20-30
Cure speed @ 120 W/cm	70-120 m/min	10-30 m/min
Solvent resist. (ADR)	>50	1-2

Table 5: lab results commercial hybrid sheetfed inks.

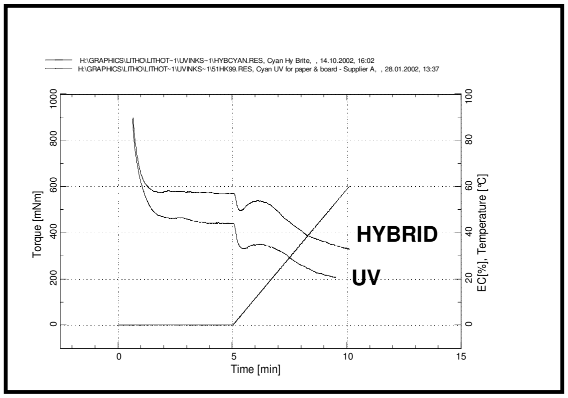


Fig. 4: lithotronic curve of a UV and hybrid sheetfed ink

The lower reactivity may be explained by the fact that only very low amounts of epoxy acrylates can be used because of limited compatibility with conventional materials such as eg. alkyds. Furthermore, a lower photoinitiator concentration is used to improve compatibility with conventional ink rollers. The low solvent resistance is confirmed by aceton double rubs (ADR).

Conclusion:

Post press productivity is improved due to the immediate drying of UV inks. Press behaviour, however, now needs to be improved. Comparison, in the laboratory, of commercial UV sheet-fed inks, conventional sheet-fed inks and hybrid sheet-fed inks highlighted differences.
Our results indicate different areas requiring improvement. It is essential to improve the ink water balance (type of emulsion) of the UV inks. An ink water emulsion that is more stable will have a positive impact on tack and misting (amongst other characteristics), these two properties need to be improved as press speeds increase. Together with pigment wetting, the above mentioned parameters are and will be the subject of research programs.