Oil-Based and UV-Curing Inks for Film and Foil Printing

In the past, offset printing on plastic film mainly used inks with mineral-oil based binding vehicles. With printers, converters and end customers having been demanding better performance systems over the past few years, the conclusion has been reached that UV technology is the best alternative to oil-based inks. This article is to present in more detail the status and innovations of the two ink systems•\from the perspective of ink manufacturer Siegwerk. (Reprint from KBA Process No. 5, 2008)

Special requirements for printing on film and foils

Synthetic substrates such as plastic film and other non-absorbent printing substrates are becoming more and more frequent in the printing sector, and particularly in offset printing.

The challenge to find a suitable offset ink system for these applications include

- good printability,
- improved running characteristics on increasingly faster presses,
- secure adhesion and scratch resistance on non-absorbent substrates.

In contrast to most paper and carton substrates, the surface structure of typical plastic film does not allow the ink to set. Drying and adhesion support by filtration into the substrate is not possible. Additionally, the presence of fount solution in oil-based ink offset generally impairs the drying process. Therefore, a good ink-water balance is a key factor in influencing the drying process. Special oil-based inks have been developed for synthetic substrates to accommodate special technical requirements concerning the quality of the printed product. However, a good compromise between fast drying, safe piling, adhesion and abrasion resistance remains a difficult thing to achieve with oil-based inks (see Table 1).

Here the advantages of UV curing technology should be used, including

- immediate hardening of the ink layer,
- low influence of the amount of fount solution, and
- fast readiness for further processing.

Development of modified radiation-curing printing inks

When UV ink systems were first introduced in the printing industry, they were criticised for their problematic printing behaviour in offset presses and for adhesion problems. These problematic characteristics have been successfully overcome by new raw materials and innovative ink formulations.

Printability of UV inks

In non-absorbent substrates such as plastic film, the fount solution cannot filter into the surface. The first generation of UV inks tended to build up on rollers, plates and/or blankets due to excessive fount solution absorption and the resulting loss of tack. Here, an optimized ink-water balance improved printability. New ink generations with optimized absorption and release of fount solution exhibit a much greater margin between over and under-damping.

For some years now, alcohol-free printing has been on the increase. Especially in film and foil printing, however, the use of isopropanol has proved to be the better choice, with reduced surface tension of the fount solution for optimal printing and a good ink-water balance. Instead of IPA, alcohol substitutes might be used depending on press configuration, plates etc.

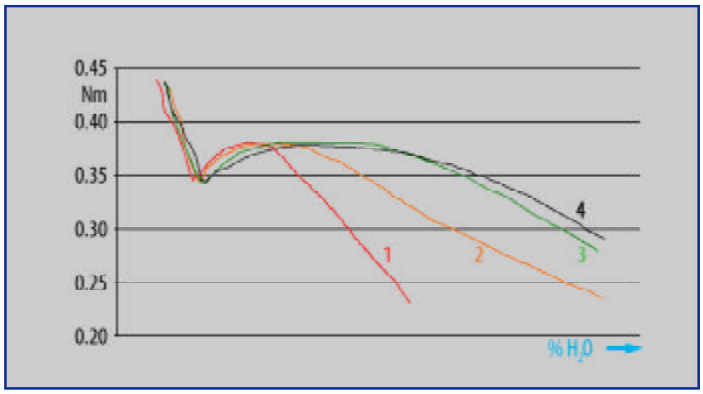
Adhesion of UV inks

In the past, UV inks showed restricted adhesion on foils and films, but these issues have been overcome by newly developed special ingredients and optimized ink formulas.

An essential condition is, however, that the substrate such as PVC does not contain any plasticizers, static inhibitors and other substances that might diminish adhesion.

The recommended surface tension for PVC is 35 mN/m. For substrates made of ABS, PP, PET, PE and PS, a surface tension of over 40 mN/m is essential. These substrates as well should be free of problematic additives like static inhibitors, which might impede uniform ink adhesion due to their separating effects. The correct surface tension in a synthetic substrate lies in the material formulation and thus with the manufacturer of the substrate. Manufacturers also sometimes use so-called corona discharge technology to electrically treat the surface of films. The surface tension might fall during longer storage of the substrate, and the corona pre-treatment must be repeated directly in the web or sheet-fed press. This option is also advisable if non pre-treated substrates are used for economical reasons.

Moreover, the molecular structure of the cured ink layer widely influences adhesive characteristics, flexibility and scratch resistance.



1 The torque (y axis) of a rotation viscosimeter mapped against the water content (x axis) of the ink permits conclusions on how the ink-water balance influences the printability of inks. The more water an ink can absorb, the greater the margin for problem-free printing of films and foils. Here a higher torque denotes a lower influence of the dampening ratio. Older types of UV inks (1 and 2) did not absorb enough water. Latest-generation UV inks (3) exhibit an equally suitable behaviour as oil-based inks (4)

Flexibility of UV-cured layers

UV inks and coatings generally tend to shrink during curing. The thicker the layer of the ink, and especially of the UV coating, the more volume is there to shrink. One result is reduced adhesion.

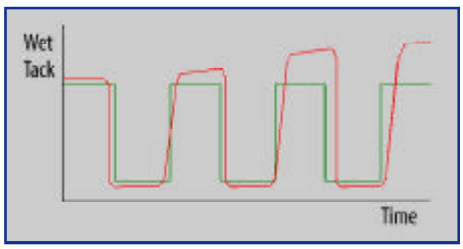
Especially in the crosscut test, the adhesive force of the adhesive tape can exceed the bonding force between the ink/coating and the printing substrate, causing the ink-coating layer to lift off from the substrate. Adhesion quality also depends strongly on the use of highly flexible ink/coating/binding vehicle systems that reduce shrinking.

Curing of UV inks

Differing curing characteristics can also influence the adhesion of the ink/coating layer. If the ink does not cure completely, adhesion might be diminished by insufficient cross-linking of the ink/coating layer. In rare cases, an overcured ink/coating layer might shrink strongly and become brittle, which results in lower flexibility and adhesion.

Versatility of UV inks

In the early days of UV technology, it was rarely possible to use inks specially formulated for film and foil printing also for printing on paper and carton due to the high tackiness of the oligomers, which ensure adhesion. Today, optimized qualities allow the use

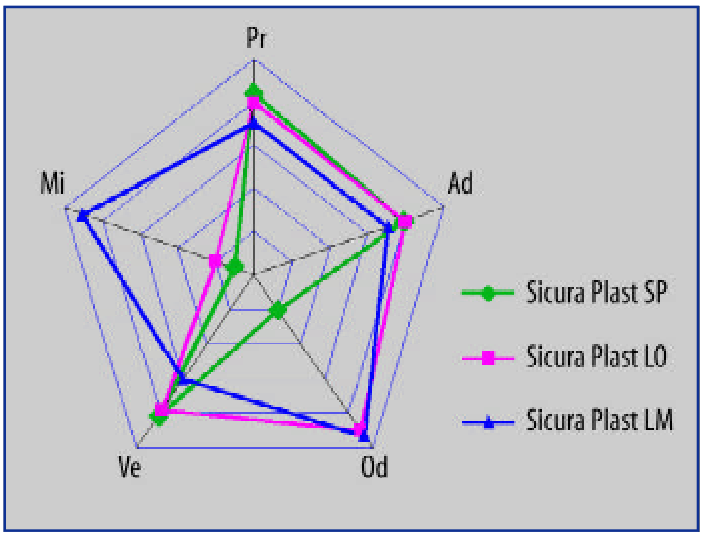


2 Ink-water balance profile in the production run. The wet tack of the ink changes over time because of alternating downtimes (make-ready, pile change, intermediate washing) and optimum production speed. Recent UV inks (green) retain the set ink-water balance while former-generation UV inks get increasingly out of control

Table 1: Criteria in film printing with oil-based inks

Criterion	Parameter	Level
Fount solution	pH value	> 5 *
	IPA content	3 … 12% **
	Water feed	As low as possible
Piling	Pile height	restricted ***
	Pile temperature	< 40 °C ***
Powder	Powder quantity	specified
Waiting time ****	Period between printing and post-press	< 48 h

*) Higher fount solution acidity slows drying down; **) Up to 12% recommended for printing with smallest possible amount of fount solution; ***) To prevent blocking and set-off; ****) Do not over-ink, coating if scratch resistance is too low



3 Characteristics of the UV offset ink series developed by Siegwerk for printing on plastics: Pr = printability, Mi = low migration, Ad = adhesion, Ve = versatility, Od = low odour

of UV film printing inks on paper-based substrates in many cases.

Requirements on UV systems in film printing

The filming quality of UV inks can be markedly improved by the use of doped lamps or in a nitrogen atmosphere (inert UV). So-called cold UV systems reduce the emitted heat and the pile temperature, preventing dimensional changes in the films and foils; however, it also slows down the polymerization of the UV inks and coatings. If the molecular cross-linking process takes place in the presence of nitrogen, polymerization is faster, permitting higher printing speeds. It is essential to test the adhesion of inks and coatings on the substrate in all jobs. Unlike scratch resistance, generally adhesion does not improve any further after 12 hours from printing.

Sensory and migration properties

Printed films are used as wraps, shrink film, cosmetics packaging, labels and much more. Some of these applications require particular specifications in UV inks and coatings, such as

- low odour,
- no influence on the taste of the packages goods,
- no migration into the packaged goods.

Against the background of constantly increasing demands by consumers, legislation and better analytics, ink manufacturers must satisfy new requirements every day. Ink qualities are formulated with special materials that minimize the organoleptic effects, e.g., the excitation of sensitive receptors such as olfactory and gustatory nerves in the mucous membranes, and reduce molecular migration. Optimized photo initiator systems, the use of ultra-pure monomers and oligomers of high molecular weights and adapted formulations result in very low migration and thus help to meet new demands.

With all the high purity of materials and sophisticated manufacturing technology, users still should check and coordinate the qualities recommended by the ink supplier with the technical environment in the printing shop (press, UV system, printing speed, etc.) according to the legal regulations. Apart from ink and coating, organoleptic and migration data can be influenced by many other parameters beyond the influence of the ink manufacturer. This applies in particular to suitable cleaners and dampening additives. Printing substrates also might develop an inherent odour after UV radiation. Careful handling and storage of the printed run are another important factor.

For questions or special jobs, especially in the sensitive area of food packaging, it is always advisable to contact the local representative of the ink and coating manufacturer in order to receive the best possible technical support and advice.

Resume

Printing on increasingly demanding substrates with impenetrable surfaces—from plastic films to metalized substrates to sheet metal boards• \requires ink manufacturers to constantly develop their products. Increasing press speeds and the resulting shorter drying times present a particular challenge.

Due to their absence of shrinking, oil-based systems continue to be used for special applications. However, UV technology will continue to occupy an ever increasing place in the graphic industry, with constantly improving ink formulations and manufacture (in particular with regard to organoleptic qualities), tonal value control in pre-press and physical properties of radiation equipment.

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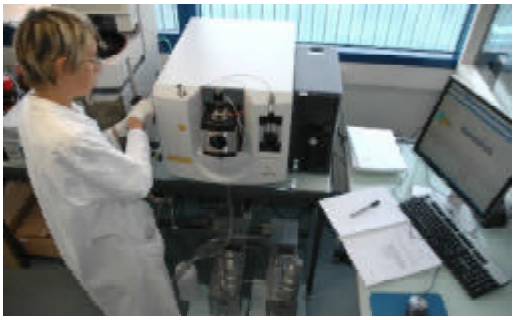

4 For the testing of printing inks, a liquid chromatograph/mass spectrometer (LC/MS) system may be used to measure impurities, which might migrate in very small amounts

Table 2: UV litho printing inks of Siegwerk Druckfarben AG for film printing

Substrates	Non-absorbent			Paper/Board	
Printing ink series	Sicura Plast SP	Sicura Plast LO	Sicura Plast LM	Sicura Litho	Sicura LM
Folding boxes for primary food packagings	X	X	***	X	***
Folding boxes for secondary food packagings	**	***	**	**	***
Fold. b. for cosmetics, pharmaceuticals, tobacco	***	**	*	***	*
Folding boxes for chemicals	***	*	*	***	*
Labels & tags	***	**	*	***	*
IML	X	*	***	X	***
Display	***	*	*	***	*
Brochures, leaflets	***	*	*	***	*
Metal Dec 3P	***	***	*	X	X

*) Not fit to purpose but can be used; **) Recommended; ***) Highly recommended; X) No possible use