New Electron Beam Cured Liquid Inks for the Flexible Packaging Market

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ABSTRACT

While the first generation electron beam curable flexographic inks have recently introduced to the flexible packaging market a new generation of this ink type has extend the application spectrum and the ease of handling on conventional presses. The new EB ink system offers the benefits of UV curable inks—like good print quality, high gloss and product resistance—while eliminating needs in inter-station drying curing. The rheological profile of this system allows simplified conversion of conventional presses.

INTRODUCTION

Today, electron beam technology is aggressively penetrating the flexible packaging market. Several new applications recently introduced to the market include high gloss coatings that replace lamination; cold seal release coatings, and lamination adhesives. EB curable printing inks are the missing piece that would complete the "package" of products required for decoration of most of flexible packages.

Such a system has been recently developed and is currently being introduced on the flexible packaging market. A recent advance in the EB liquid ink technology has shown dramatic improvements in the rheological profile of this ink technology. This improvement allows a simpler transition from conventional liquid ink systems to an EB system on conventional solvent or water-based common impression (CI) presses.

UV FLEXO LESSONS

Ultra violet light flexo printing technology was first introduced to the packaging market by Kobush in the early 90s, suggesting some revolutionary changes in packaging printing. It was immediately noticeable that UV flexo printing inks offered outstanding quality of the gray scale reproduction, well defined dot structure with minimum gain during the printing process, high gloss, and outstanding product resistance properties[1]. While, this highly publicized project ended a few years after its initial introduction, UV flexo printing remains the fastest growing segment of printing technology. Most of the applications of UV flexo are in the areas of label, outdoor bag, and folding carton printing.

Yet, food packaging, the largest segment of the converting industry, is still mostly closed to UV flexo printing. There are two major reasons for this: First, the odor of cured UV flexo inks remains objectionable to many converters. Second, press speeds are still limited to 150-200 m/min—a result of deficiencies in the cure speed of the dark colors that compete with photoinitiators for UV light. The excess of infra-red irradiation (IR) generated by UV lamps requires substantial modifications to the design of the CI (central impression) press; specifically, to improve heat management. This increases both the cost of the press and its maintenance.

EB FLEXO INKS

Understandably, the development of EB curable flexo inks has focused on elimination of inherent deficiencies limiting UV flexo growth. EC curable printing inks would have to abolish the need in inter-station curing, increase printing speeds, and significantly reduce the odor of the cured ink film. Since it is not technically feasible to introduce inter-station EB curing to CI press, the design that dominates printing on flexible packaging, EB curable flexo inks must be wet-trappable without inter-station curing or drying.

The wet trapping of EB flexo printing inks has been accomplished with the design of an ink system that can undergo an instantaneous transition from the liquid to the semi-solid state upon transfer from the plate onto the printed substrate. This transition allows trapping consecutive ink layers on the top of each other without using any source of energy (drying or curing).

This general concept of wet trapping can be used for multi-color flexographic printing and consecutive curing under EB irradiation. Since no heat is generated in this process, additional cooling of CI drum is not required. The EB curable inks are photoinitiator free, which makes them more suitable for food packaging. This wet trapping process can be used in surface printing and in combination with overprint coatings and lamination adhesives.

PERFORMANCE ATTRIBUTES OF EB FLEXO INKS

The potential "targets" of EB flexo printing are solvent and water-based ink technologies. While all these inks are designed for the flexographic printing, physically they are significantly different. Press ready, water and solvent based inks typically do not contain more than 40-45% solid components, including pigment, film forming resins, and additives. Their viscosities range from 50 to 70 cps at about 100 s^{-1}/25C^{o} shear rate and the inks require inter-station drying for multicolor printing. This drying limits speed – without the sufficient removal of water and solvent, acceptable trapping of individual colors cannot be achieved.

The low viscosity of these printing inks is detrimental to both the process print quality and the fidelity of the printed image. Low viscosity inks tend to spread on the printed surface, causing excessive dot gain in the highlights of the image (below 20% dot area) and filling in the dark tone areas (over 75%). It is very difficult, if at all possible, to produce robust solvent or water based inks with a higher viscosity that would have less spreading on the printed surface, as required for a better fidelity of the printed image. Higher viscosity inks require a higher concentration of solids, which usually lead to poor press stability (excessive drying on plate and anilox, limited re-wetting).

UV and EB flexo printing inks are much higher in viscosity, typically ranging from 300 to 1000 cps at 100 s^{-1} shear rate, 25^{o}C. This leads to exceptionally good reproduction of the process dots in the gray scale regions. It is not uncommon for commercial UV flexo printers to print 1% and 2% dots, while keeping open 95% and even 98% dot areas. Since no drying takes place, press stability of UV flexo inks is not affected by the higher viscosity. Similar print quality has been achieved with EB flexo inks.

Recent developments of the wet trapping EB liquid ink technology show significant improvement of the rheological profile. Still at generally higher viscosity than conventional solvent and water-based inks show these inks viscosities at the lower end of the energy curable liquid ink spectrum. With a viscosity of around 300 cps at 100s-1 shear rate, 25^{o}C, these inks show almost Newtonian behavior similar to new generation UV inks used on modern CI presses with print speed up to 500 m/min (Graph 1). This rheological profile also allows the printer a simpler transition from conventional liquid ink systems to an EB system on conventional solvent or water-based CI presses, since the ink handles very similar to conventional liquid inks.

COMPARATIVE STUDY OF THE PRESS PERFORMANCE AND INK CONSUMPTION

A transition to EB curable flexo printing inks requires a capital investment in EB curing equipment. This decision should be based on the comparison of the comprehensive cost and performance analysis of the technology to existing solvent and water based ink technologies. Press performance is an important element of the transitional model. Since EB chemistry is more expensive than conventional systems, it is highly recommended to always attempt the printing with the lowest anilox volume possible. If this is done, a converter will be able to reduce the total ink consumption while achieving higher print quality. Thus, the testing of all three types of the ink systems on the same press under the same application conditions is important to understanding of potential benefits and deficiencies of the new EB flexo process.

A printing study was undertaken on the 14" wide Chesnut flexo press equipped with dryers for drying conventional inks and an electron beam unit. A banded anilox roller (Table 1) was used to simulate four different engravings typically used to print process and line colors. The goal of the study was to estimate total ink consumption and determine the print density and gloss that could be achieved with each ink system. Cyan color ink was selected for all three ink systems. The inks were printed on corona treated polypropylene/polystyrene blend film using a solid photopolymer plate. Both the water and solvent-based inks were adjusted to the press ready viscosities of about 30 sec/Zahn#2 cup. Percent solids for both conventional inks were 42% and 38% respectively.

As Graph 1 indicates, the total applied weight of conventional inks was substantially higher than for EB flexo inks, especially for the low volume anilox engravings. The consumption of conventional inks was determined to be about 33% higher than EB ink at 250 lpi anilox count. With lower volume anilox, this difference was lower, but still around 23 %.

While the total (wet) applied film weight was lower for EB flexo inks, it was higher than the dry weight of the water and solvent based inks (Graph 2), leading to much higher print density (Graph 3) and gloss (Graph 4) within entire range of anilox volumes. EB cyan color ink was 45 - 65 % higher in density and much higher gloss than the water and solvent cyan color inks.

Using density data, we can calculate the theoretical anilox requirements needed to achieve the target process print density of 1.43 for the cyan color ink. In order to get 1.43 process print density on corona treated PE film, one would have to use 566 lines per inch (lpi), 604 lpi and 751 lpi anilox rollers for water based, solvent based and EB flexo inks respectively (Graph 5). In terms of the ink consumption, one would have to use about 34% more of conventional inks than EB flexo ink (Graph 6). Obviously, this is just an indicator of the trend, since actual anilox selection depends on cell volume, depth to opening ratio and some other factors.

CONCLUSION

EB flexo inks offer the flexible packaging and converting market a new process, free from the deficiencies of UV flexo printing, yet superior in print quality and the physical properties of the finished package to conventional water and solvent based ink technologies. The total cost of such EB flexo printing systems still need to be evaluated, but they are expected to provide lower ink consumption then conventional inks.

ACKNOWLEDGMENTS

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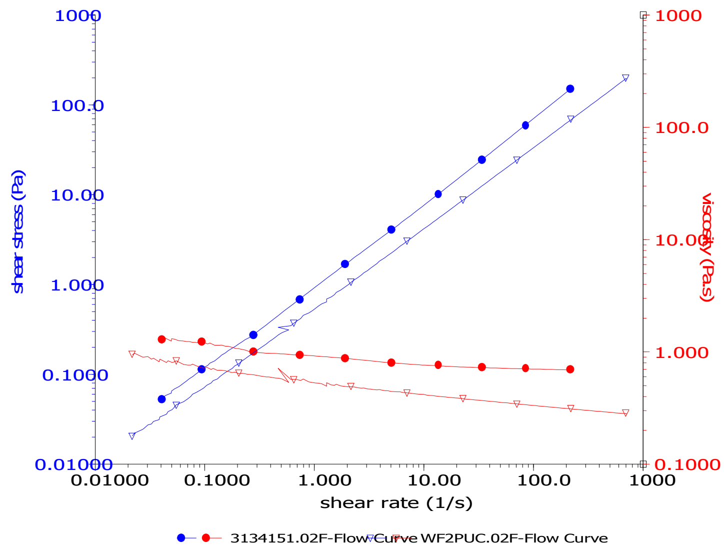
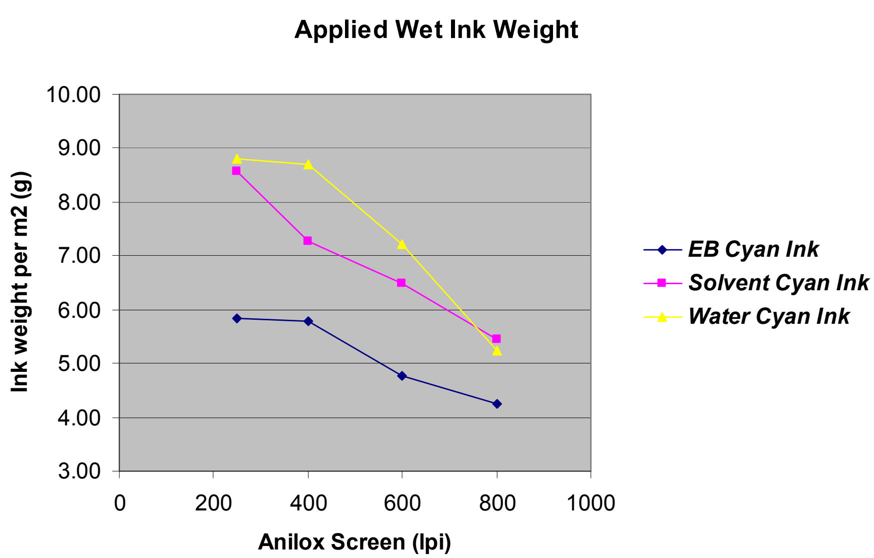
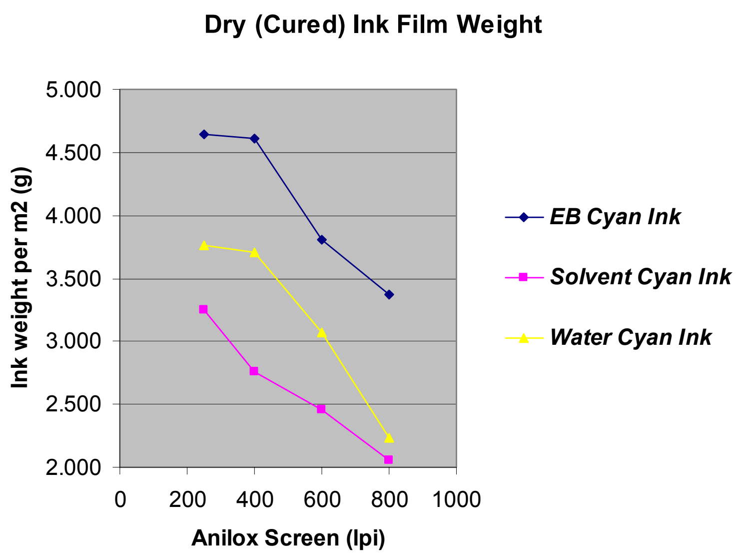


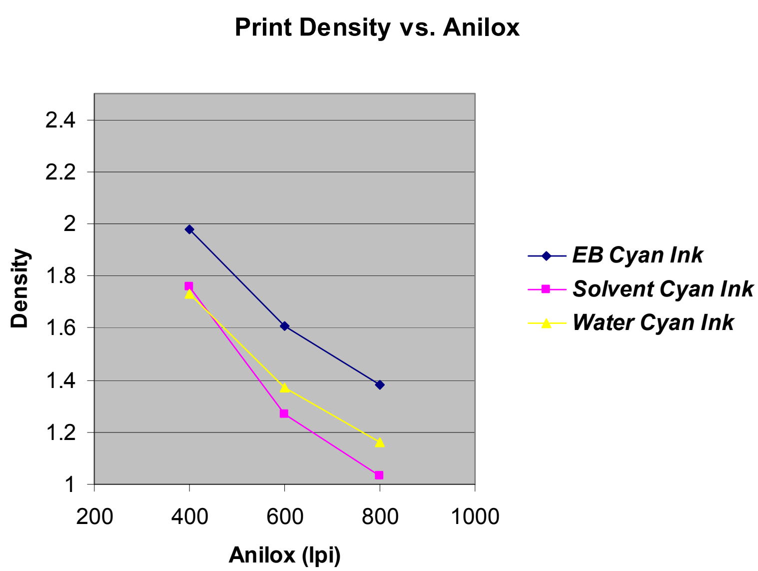
Graph 1: ***Rheological profile of the new generation EB flexo ink in comparison to a modern conventional UV flexo ink.***
Solid dot: Profile of a UV flexo cyan ink; Outlined Triangle: Profile of the new generation EB ink. The inks were measure with an TA Instruments AR1000 cone and plate rheometer. Shear stress and viscosity were recorded over declining shear rates.



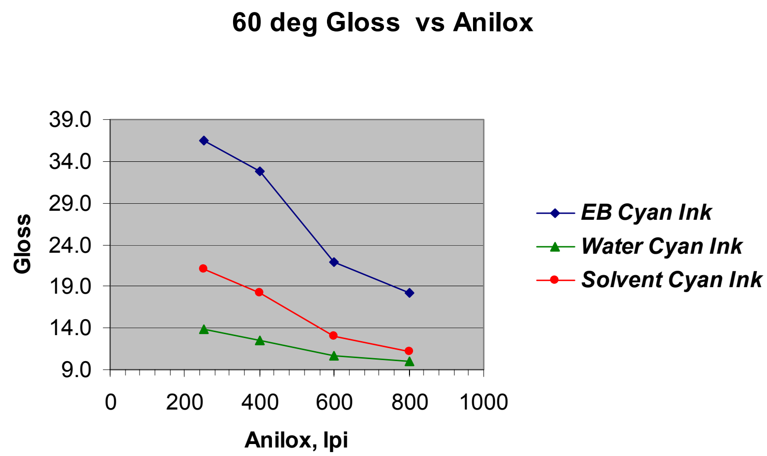
Graph 2: ***Applied (wet) film weight of EB, solvent and water based cyan inks with different volume of anilox engravings.***
Test conditions: 14” Chesnut flex press, Cyrel photopolymer plate, 100 fpm press speed; EB – ESI 125 kV, 3 Mrad; 200 ppm O_2.



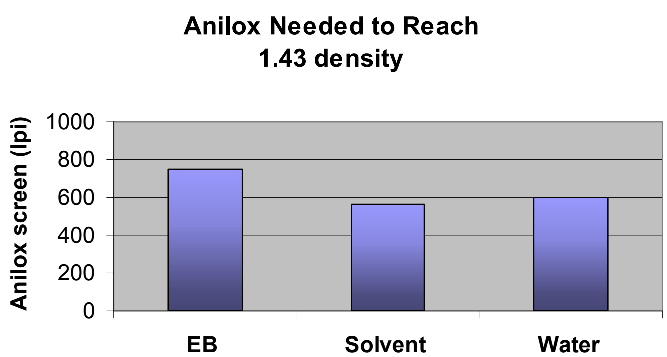
Graph 3: ***Applied dry film weight of EB, solvent and water based cyan inks with different volume of anilox engravings.***



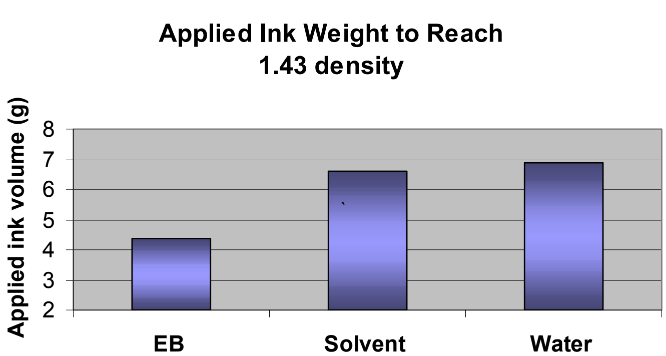
Graph 4: ***Print density of EB, solvent and water based cyan inks with different volume of anilox engravings.***



Graph 5: ***Gloss of EB, solvent and water based cyan inks with different volume of anilox engravings.***



Graph 6: ***Calculated anilox requirements for EB, solvent and water based cyan inks to reach 1.43 print density.***



Graph 7: Calculated consumption of EB, solvent and water based cyan inks to reach 1.43 print density.

Table 1: Banded anilox roller for Chesnut press

250 lpi	400 lpi	600 lpi	800 lpi
5.8 bcm	3.7 bcm	2.5 bcm	1.8 bcm