Maximize performance of gravure inks

Antiblocking, heat resistance and pigment alignment

Eastman **SOLUS**™
performance additives

Application overview

Whether it's due to more discerning consumers worldwide or the rise of the middle class in emerging markets, the demand for quality and variety in food, beverage, personal care and home care products continues to grow. The packaging of these daily commodities plays a critical role in helping brands differentiate themselves to new consumers and establish a premium image. Gravure printing delivers vivid color, distinctive patterns and clear typography. It is widely used for plastic and paper packaging, bottle sleeves and house decorations like wallpaper or PVC flooring. These aesthetic advantages impact consumer choice. The use of a gravure printing process also helps manufacturers print quickly.

Product-in-use details

A specific category of liquid ink, gravure ink is formulated for the gravure printing process and delivers excellent print quality. In these formulations, the high glass transition temperature (T_g) and low surface tension of Eastman Solus™ performance additives provide excellent block and heat resistance. The stable chemistry prevents yellowing during heat sealing, boiling and other processes. The features of Solus™ provide important benefits to this printing process.

Selection considerations

Numerous Solus™ grades are recommended for gravure inks, and many are available in a food contact grade for applications requiring that certification. Properties like viscosity and solubility help determine the suitability of Solus™ for use in a specific formulation. Table 1 shows properties that are critical to quality.

Table 1. Solus™ features

Solus™ function	Ink performance	Ink application
High T_g and low surface tension	Good heat and blocking resistance	Shrink film ink, 2K ink, PU lamination ink, foil OPV
Low surface tension and pigment alignment	Good metallic effect	Metallic ink
Pigment dispersibility	Good color strength	Shrink film ink, PU lamination ink
Alcohol solubility	Alcohol soluble or reducible	Flexographic ink
Nonyellowing	Nonyellowing	Shrink film ink, foil OPV
Water resistance and toughness	Good water resistance and toughness	Surface printing ink
Low odor	Low odor contamination	Food contact ink

Solus™ can be used in various gravure ink types, including lamination, shrink film, decoration film and surface printing.

In addition, Eastman Solus™ is made with cellulose, one of the most abundant natural, renewable resources. Many grades meet requirements for use in certain food contact applications under regulations of the U.S. Food and Drug Administration (Code of Federal Regulations Title 21), European Commission (Regulation 10/2011), and the Swiss Ordinance on Materials and Articles (SR 817.023.21).

Table 2. **Solus™ selection guide for different formulations**

Recommended ink applications
✓ 2K
✓ Decorative film
✓ Lamination
✓ Shrink film
✓ Surface printing

Eastman Solus™ in shrink film ink application

Shrink film packaging is a rapidly growing application for liquid inks. This process allows for the application of durable, distinctive designs onto substrates like Eastman Embrace™ copolyester, polyvinyl chloride (PVC) and oriented polystyrene (OPS) used for bottles and other containers, such as those shown in Figure 1. Solus™ has excellent performance qualities when used as a binder in inks for shrink-sleeve applications.

Figure 1. **Examples of shrink sleeves for bottles**

Solus™ is versatile and can resolve appearance and processing issues across both steam and dry-heat shrinking processes. Benefits are equally achieved on glass and plastic substrates. Solus™ provides excellent print quality, good washup and other performance benefits across a variety of processes and surfaces. Some of the benefits are listed in Table 3.

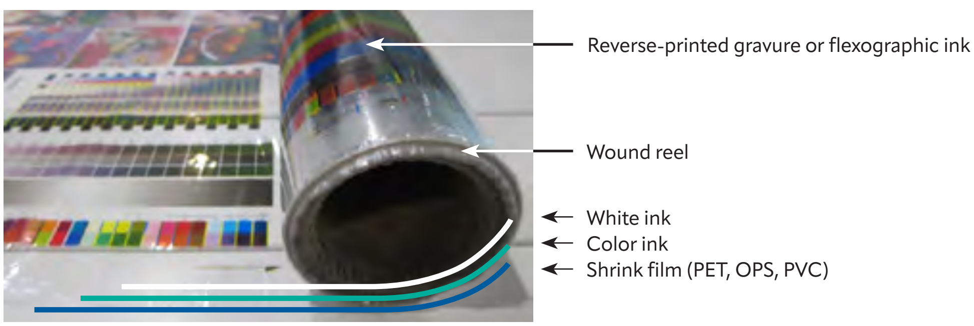
Table 3. Advantages of using Solus™ in shrink film application

Advantage	Result
Temperature resistance	Compared to nitrocellulose (NC) systems, inks formulated with Solus™ have superior heat resistance. This allows steam- or dry-heat shrinking with no adverse effect to the design color or white brilliance.
Blocking	Compared to other systems, inks based on Eastman Solus™ have superior solvent release qualities, preventing issues such as blocking in the printed reel or on the bottle.
Reduction in "wet look"	"Wet look" is a common problem for steam-shrunk sleeves. Compared to NC systems, inks based on Solus™ have shown much less wet look 24 hours after shrinking.
Moisture resistance	A common problem in steam-shrunk applications is ink transfer to the bottle when the sleeve is removed. Inks based on Solus™ have greater moisture resistance and prevent ink transfer onto the plastic or glass bottle.

Formulation recommendation

Inks for shrink film applications containing Solus™ are commonly based on combinations of a cellulose ester and a co-binder, usually acrylic resin. Such inks are reverse printed, as shown in Figure 2, where the outer surface of the substrate provides the gloss and protection. The performance requirements for each application can vary.

Figure 2. Diagram of reverse printing



In shrink film applications, a backing ink is typically applied as the final ink (commonly referred to as "flood coat" in the U.S.). Using a Solus™ grade in the backing ink with higher alcohol solubility, allows you to use less aggressive solvent blends that will not redissolve the previously applied ink layers.

Since these printing inks must adhere to the shrink film, adhesion-promoting additives are often incorporated. Polyethyleneimine (PEI) is most often used for these types of inks, but rosin esters, titanates and zirconates may be also suitable adhesion promoters.

Technical evaluation of Solus™ vs. nitrocellulose (NC) in shrink film ink

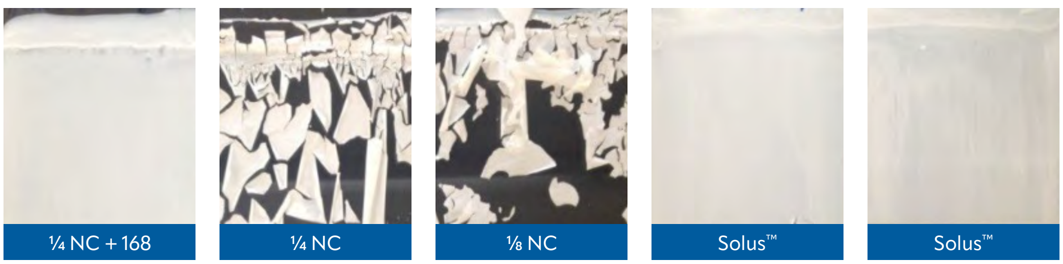
To demonstrate the superior performance of Solus™, a white ink formulation was evaluated against a NC-based shrink film ink. The inks were printed onto glass and PVC film substrates and evaluated for toughness, clogging, settling, adhesion, blocking resistance and scratch resistance.

Toughness

Toughness is a critical quality in shrink film, which will shrink to 40%–80% of its original size when treated by hot steam or air. The shrinking process can cause cracks or even detachment of the ink layer.

White inks with two Solus grades, ¼ NC, ⅛ NC, or ¼ NC plus 2% Eastman 168™ non-phthalate plasticizer were prepared. The inks were applied on glass by a RK No. 2 bar to a 12 µm wet film thickness and dried at room temperature. As shown in Figure 3, the Solus™-based inks are tough without plasticizer. The inks based on ¼ NC and ⅛ NC without plasticizer are both brittle. The additional 2% Eastman 168 must be added to the NC-based ink to make it tougher.

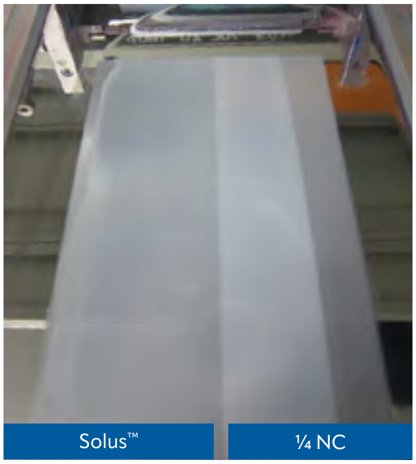
Figure 3. Ink film toughness of Solus™-based and NC-based shrink film inks



Clogging

Clogging refers to ink drying in the cells of a rotogravure cylinder and never redissolving in the solvent. The clogged cells will cause missing dots on the printed image. As a result, clogging during the printing process should be prevented. The white backing ink formulation was printed on a RK proofer, followed by washing with a blend of *n*-propyl acetate/ethanol/*i*-propanol at a 3:4:3 ratio. The result, shown in Figure 4, is that the Solus™-based ink has almost no dried residue, while the NC-based ink has dried, white, solid residue in cells.

Figure 4. Comparison of clogging of Solus™-based and NC-based inks

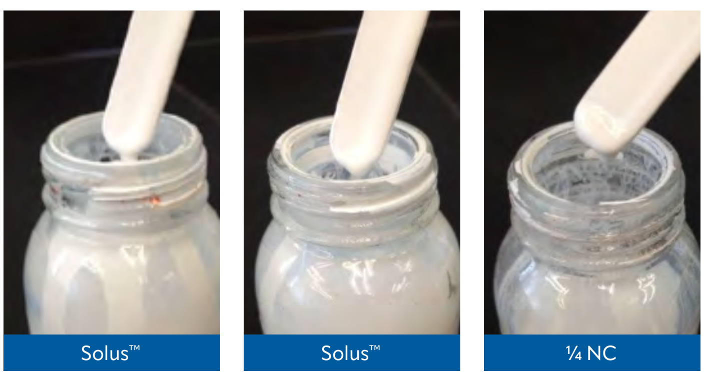


Settling

Settling refers to the pigment depositing or layering from the ink dispersion. The ink quality becomes unstable when pigment settling occurs.

White inks with two Solus™ grades and ¼ NC were prepared and then the inks were stored in a 50°C oven for seven days. The results in Figure 5 show the Solus™-based ink has less pigment settling than the NC-based ink.

Figure 5. Comparison of settling between Solus™-based and NC-based ink



Adhesion

Adhesion is the bonding strength of the ink layer to the substrate. The white inks with Solus™, ¼ NC, ⅛ NC, and ¼ NC plus 2% Eastman 168 were applied to shrink PVC film using a RK No. 2 bar. Adhesion was tested using 3M 600 Scotch Tape and scored by peeled-off area. The tape adhesion test was run under three conditions: at room temperature, after shrinking by hot air and after shrinking by hot water. The results were evaluated on a scale of five to one. A rating of five represents no peel off and best adhesion, and a rating of one represents all peeled off and worst adhesion. The results in Table 4 show that the Solus™-based ink has good adhesion under all conditions, while the NC-based ink has poor adhesion in steam- or hot-water shrinking processes.

Table 4. **Tape adhesion test of Solus™-based and NC-based shrink film inks[a]**

Condition	Binder			
	Solus™	¼ NC	⅛ NC	¼ NC plus Eastman 168
Ambient temperature	5	5	5	5
After shrinking by hot air	5	5	5	5
After shrinking by hot water	5	2	2	2

[a]5 = no peeling, best adhesion; 1 = peeling, worst adhesion

Blocking resistance

In the gravure printing process, the ink layer is in tight contact with the backside of the film substrate. In the shrinking process, the ink layer comes into contact with the bottle. The thermoplastic binder of the ink system will stick and transfer to the backside of the substrate under certain processing conditions such as winding pressure and steam or dry heating. This issue is called blocking. It leads to poor appearance and possible contamination of the package. Binders with a high glass transition temperature (T_g), like Solus™, NC, silica and wax, are widely used to improve blocking resistance.

Compared to other binders, Solus™ provide inks with superior heat resistance, low surface tension and solvent release qualities that can prevent blocking in the printed reel or on the bottle. To test blocking of shrink film ink, we placed the shrink sleeve around the glass beverage bottle and shrunk around the bottle via steam. The assembled bottle was stored at ambient temperature for seven days before removing the film and evaluating the appearance of the inked film and bottle surface. No ink transfer was observed from the Solus™-based ink, which indicates that it provided better block resistance than the NC-based ink.

Scratch resistance

Scratch resistance is the performance of an ink layer against physical scrub. White inks with two Solus™ grades, ¼ NC, ⅛ NC, and ¼ NC plus 2% Eastman 168 were applied to shrink PVC film using a RK No. 2 bar. The nail scratch, pencil hardness and pendulum hardness methods were run on the coated PVC film supported by a glass plate. The results show that Solus™-based inks have a higher nail scratch score, higher pencil hardness and pendulum hardness than the NC-based inks, which means Solus™ has better scratch resistance as shown in Table 5 and Figure 6.

Table 5. Scratch resistance test

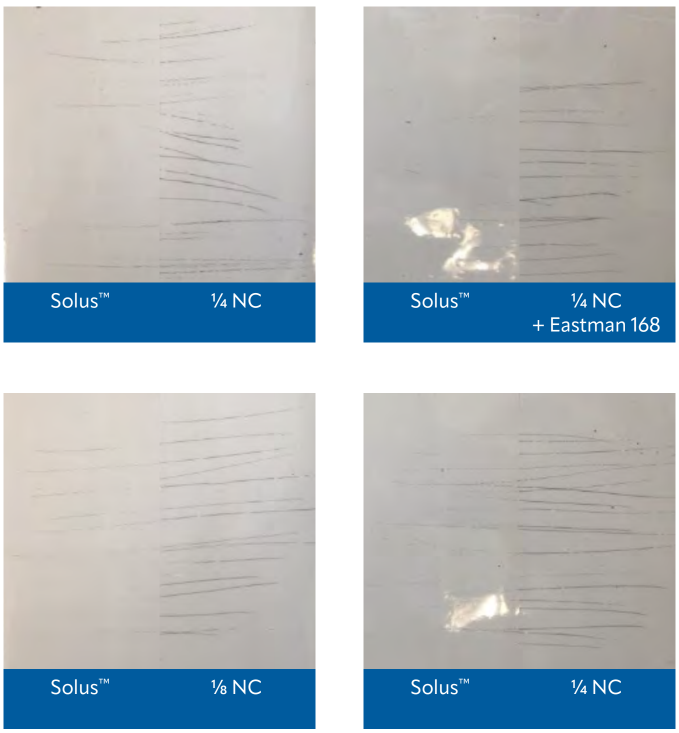
Condition	Binder				
	Solus™ grades	Solus™ grades	¼ NC	⅛ NC	¼ NC plus Eastman 168
Nail scratching[a]	2	2	1	1	1
Pencil hardness[b]	3–4H	3–4H	3H	3H	3H
Pendulum hardness[b, c]	113/113	106/107	101/106	102/99	106/104

[a] *In the nail scratch test, 5 = best nail scratch resistance and 1 = worst nail scratch resistance.*

[b] *Pencil hardness is run on PVC film supported by a glass plate. The cylindrical pencil lead is maintained at a constant angle of 45° and exerts a force of 7.5 N (1.68 lbf). The hardness of the pencil lead is gradually increased until the ink layer is broken more than two times in five repeated tests. The pencil hardness is the hardness of the ink layer at this point.*

[c] *Pendulum hardness indicates the number of times it takes for the König pendulum to stop. Softer films cause the pendulum to stop more quickly than harder films.*

Figure 6. Nail scratch resistance of Solus™-based and NC-based shrink film ink



Solus™ in lamination ink application

Lamination packaging is one of the largest applications for liquid inks. It provides a barrier function for the content and is widely used for packaged food and daily consumables. Lamination ink enables easy-to-read typography and appealing appearance, both of which are important to consumers. It is reverse printed on the barrier film and laminated with hot-sealing film or another barrier film. Common barrier films used as printing substrates include biaxially oriented polypropylene (BOPP), biaxially oriented polyethylene terephthalate (BOPET) and biaxially oriented polyamide (BOPA). Examples of commercial lamination packages are shown in Figure 7.

Figure 7. Commercial lamination packages

Polyurethane (PU) lamination ink is the most popular binder system of lamination ink because of its good adhesion, flexibility and printing quality, all of which contribute to more attractive packaging valued by consumers. However, the good adhesion and flexibility of PU can cause the ink layer to transfer to the reverse side of the film substrate in the printed reel. This leads to poor appearance and risk of contamination of the package. In lamination ink, Solus™ provides better antiblocking compared with PVC/vinyl chloride-vinyl acetate or silica. The low-odor property of several Solus™ grades makes them suitable for food lamination packaging.

Formulation recommendation

In ink applications, it is easier for the operator to add a Solus™ solution into the ink formulation than a Solus™ powder. Solus™ solutions can be prepared with ester or alcohol cosolvents, depending on the Solus™ grade, with 20% solid content.

Typical PU lamination ink formulations are prepared to test antiblocking performance based on a set of magenta and cyan formulations. Solus™ is added easily by stirring it into the PU ink. This improves the antiblocking performance.

The critical qualities of PU lamination ink were checked to determine the influence of Solus™ on the ink. The test results are shown in Table 6 and Figure 8. In Table 6, formulations with the Solus™-based inks showed superior antiblocking performance compared to the conventional PU lamination ink. The Solus™-based inks do not have negative impact on critical qualities of PU lamination ink like ink viscosity, dilution rate, color strength and bonding strength.

The results show the conventional PU lamination ink does not have a sufficient antiblocking property. Blending a Solus™ additive solution with the PU lamination ink can significantly improve the antiblocking performance. The unique function of Solus™ can allow the printer to use higher drying temperatures and winding tension, which can increase printing speed.

Table 6. Results of PU lamination ink formulation testing

Test		Sample					
		Magenta PU ink (control)	Magenta PU ink with 0.5% Solus™		Cyan PU ink (control)	Cyan PU ink with 0.5% Solus™	
Ink viscosity, sec[a]		23.1	25.3	23.8	28.3	30.0	29.9
Dilution rate, g[b]		18.0	18.2	18.3	18.8	20.0	19.3
Color strength, %[c]		100.0	100.0	100.2	100.0	100.1	99.8
Bonding strength, N[d]	BOPP/PE	0.77	0.69	0.60	0.66	0.78	0.73
	BOPET/PE	1.88	1.75	1.68	1.76	1.65	1.69
Antiblocking[e]		3	4.5	4.5	2	4	4

[a] *Ink viscosity is measured with a Sheen 405/2 cup.*

[b] *100-gram finished ink is diluted with NPAc/EAc/IPA with a ratio of 6:3:1 to printing viscosity 18 sec in Sheen 405/2 cup; the solvent amount is the dilution rate.*

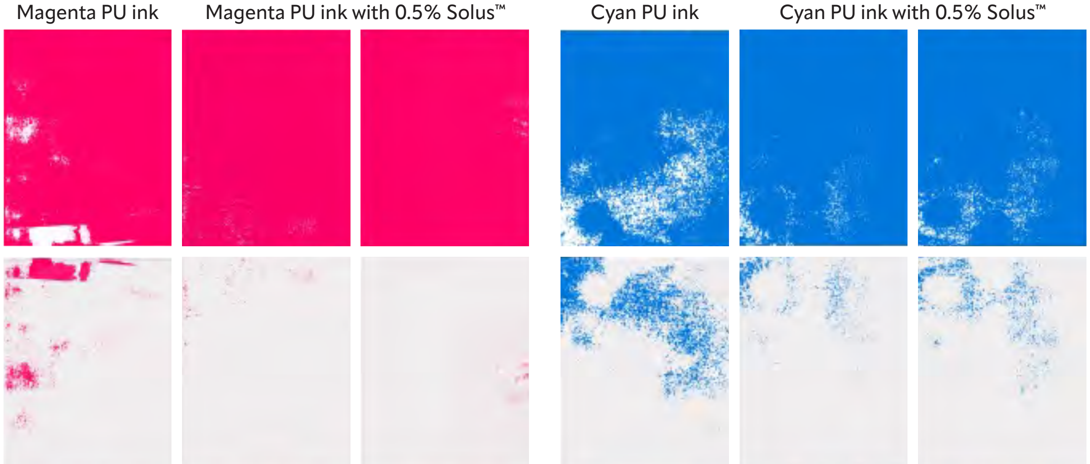
[c] *Color strength is the comparative value between the color saturation of sample and reference on 32 µm gravure depth.*

[d] *BOPP/PE and PET/PE lamination structures are tested. Films are laminated with 2K PU adhesive, cut into 15-mm wide strips, and peeled. Unit is in Newton.*

[e] *Antiblocking tests are run on ink to PET (not corona-treated side) under 3 kg/cm² and 50°C for 24 hr. The result is scored using a 0 to 5 scale, with 5 given to a sample that has no area of blocking observed and 0 given to a sample that has most of the area blocked.*

Figure 8. Blocking resistance of PU lamination ink with and without Solus™

Magenta PU ink | Magenta PU ink with 0.5% Solus™ | Cyan PU ink | Cyan PU ink with 0.5% Solus™



58 µm (50 L/cm) | 58 µm (50 L/cm) | 58 µm (50 L/cm) | 58 µm (50 L/cm) | 58 µm (50 L/cm) | 58 µm (50 L/cm)

Conclusion

In the gravure ink market, ink makers are constantly striving to improve final print quality and minimize defects. The versatility of Solus™ cellulose esters can help improve the efficiency and performance of gravure inks. They contribute excellent block and heat resistance, which can add efficiency to printing processes. They also improve the final appearance of printed products because their toughness prevents cracking and their stability prevents yellowing. That's why Solus™ are widely used in gravure ink applications, especially for shrink film ink and lamination ink, to achieve better printing performance.

Contact your Eastman technical representative or authorized Eastman distributor for help selecting the best Solus™ grade for your specific application. Starting point formulations used are available on request.

For nearly a century, Eastman has been the world leader in manufacturing specialty cellulose esters and has developed deep application expertise. Eastman Solus™ can help formulators achieve high performance, enduring beauty, sustainability and regulatory compliance. Because of the breadth of possibilities, this naturally derived cellulosic is ideal for many applications. It offers the consistency and quality that formulators require and brand owners rely on. Eastman Solus™ — the natural choice.

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