Cellulose esters and Eastman Solus™ 2100 performance additive in ink jet applications

Introduction

Cellulose esters have been used in gravure, flexographic and screen printing processes for many decades offering unique benefits to the ink formulator. Recently Eastman Chemical Company has introduced a new product initially targeted at automotive refinish applications. This new product, Eastman Solus™ 2100 performance additive, is based on proprietary technology and offers similar performance enhancements to cellulose ester materials but with considerably lower solvent demand. This paper explores the use of cellulose ester products in traditional ink processes but also shows detailed work performed at a UK University where cellulose esters have been evaluated alongside Solus™ 2100 for performance attributes in the rapidly growing nonimpact ink jet application area.

Mixed esters of cellulose such as cellulose acetate butyrate (CAB) and cellulose acetate propionate (CAP) have been important ingredients in liquid ink formulations for many decades.

Photo 1 Shrink film labels

These materials bring performance attributes such as high heat resistance, excellent solvent release, blocking resistance and outstanding pigment wetting.

Major printing ink applications for cellulose esters include inks for shrink film labels (Photo 1), lamination inks and inks for coated flexible packaging substrates such as acrylic and polyvinylidene chloride (PVDC) coated films.

The adhesion characteristics of inks based on cellulose esters can be modified using a variety of adhesion promoting additives such as titanates and zirconates as well as polyethylene imine (PEI) which offers the ink formulator unparalleled formulating options in the ink recipe.

A typical shrink film ink formulation based on cellulose acetate propionate is illustrated in Table 1.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Wt %</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-Propanol</td>
<td>35.0</td>
</tr>
<tr>
<td>n-Propyl acetate</td>
<td>15.0</td>
</tr>
<tr>
<td>Eastman™ cellulose acetate propionate (CAP-504-0.2)</td>
<td>5.0</td>
</tr>
<tr>
<td>Acrylic resin*</td>
<td>10.0</td>
</tr>
<tr>
<td>Wetting aid</td>
<td>1–3</td>
</tr>
<tr>
<td>Antifoam</td>
<td>2–5</td>
</tr>
<tr>
<td>TiO₂ pigment</td>
<td>25.0</td>
</tr>
<tr>
<td>PE wax</td>
<td>1–5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*Paraloid™ B-44 Rhom & Haas or suitable acrylic

This formulation exhibits many of the benefits cellulose esters provide, such as high heat resistance and excellent anti-block characteristics resulting from rapid solvent release.
Coding and marking print systems are required to have trouble free low/zero maintenance for considerable time periods exceeding 5,000 hours and often under varying conditions of temperature and humidity. By far the most common resin type for such coding and marking inks is nitrocellulose (NC), but experience has shown that such inks can be problematic under severe application conditions. The main problem encountered involves the reduction in viscosity with time of such inks believed to be due to hydrolysis of the NC resin system particularly under conditions of high temperature and humidity. Graph 1 shows the relative stability of a CAB resin solution in methyl ethyl ketone (MEK) solvent compared to an NC solution over a four week storage period at both room temperature and 40°C.

The results indicate that CAB has improved high temperature storage stability compared to NC. This has been a key consideration in the choice of CAB resins by some of the leading ink jet ink manufacturers for coding and marking applications.

In order to better understand the role of cellulose esters in ink jet applications, Eastman has been working closely with the Organic Materials Innovation Centre (OMIC) at the University of Manchester in the UK to evaluate the performance of several of its products in both solvent borne and UV curable ink jet formulations.

The work at Manchester University focused on the effect of varying concentrations of cellulose esters in suitable solvent systems including MEK and gamma butyrolactone and captured images of ink drop formation with varying print head waveform inputs.
Ink viscosities and surface tensions were determined at 25°C using an Anton Paar AMVn automated microviscometer and a Kruss 100 Tensiometer respectively.

The trial ink jetting was carried out using an Optica X visualization system, equipped with an IJT ID 64 printhead. This was chosen as it is a robust head suited to a wide range of solvent types. It delivers 240 (+/- 10%) µl drops (single pulse waveform) through a 64 nozzle array having 677.7 µm nozzle pitch capable of operating at 8KHz. Standard fluid properties are viscosity 5–20 cps and surface tension 30–45 mN/m at 25°C.

For each product, the selected dilution (30 ml) was filtered using a glass microfibre filter (ø 47mm, 0.26 mm thick, 1.2 µm retention and filtration speed of 100/100ml). The printhead was flushed with an ethanol-based cleaner (IMS 99) and with MEK before and after ink jetting each dilution. Trial ink jetting of each dilution was observed at 22ºC over 5 minutes. The waveform was adjusted to give optimal performance.

Each of the cellulose esters evaluated by OMIC exhibited excellent viscosity stability with respect to temperature with minor variations which would be well within the tolerances of typical ink jet printing equipment. Graph 2 shows the Anton Parr viscosity profile of CAB-551-0.01 in MEK.

Graph 2  Viscosity profile 16% solution of CAB-551-0.01 in MEK

Photo 2 shows the ink jetting photographs of drop forms produced for CAB-551-0.2. Firstly, a pronounced ligament connecting the drop to the printhead was observed from waveform 30/10/17/68V at 22°C; this is a product of the unoptimized waveform used. Through adjusting the waveform, the perfect drop without visible ligament was obtained from waveform 07/10/11/63V at 22°C which is the optimized waveform. This excellent ink droplet formation was exhibited by each cellulose ester product evaluated by OMIC.

One other important attribute in addition to excellent ink drop formation is the stability of the droplet formation with respect to time. Photo 3 illustrates the excellent stability of droplet formation for CAB-551-0.2 with the left image showing droplet formation at 1 minute into the print run and the right image capturing droplet formation after 5 minutes continuous printing. The lack of variation is indicative of excellent stability.

Photo 3  Ink droplet stability for CAB-551-0.2 with time
The conclusions of the OMIC study were that each of the cellulose acetate butyrate resins evaluated showed excellent ink droplet formation characteristics and stability with respect to time and temperature. This behaviour and the performance attributes of cellulose ester resins in traditional printing ink applications make cellulose ester resins ideal ink vehicles and modifying resins for digital printing applications. The products find use in both CIJ coding and marking and also wide format printing of vinyl banners and tarpaulins, etc. In addition to these desirable application characteristics, it is prudent to note that the benefits of CEs in the ink once applied, such as anti-block, flow and levelling and adhesion are also important.

**Eastman Solus™ 2100 performance additive in ink jet applications**

The implementation of legislation aimed at reducing the emission of volatile organic compounds (VOCs) has had a profound affect on many industries not least of which is the automotive refinish sector. Eastman cellulose esters have, for many years, found widespread use in automotive clear coat applications where they provide rapid hardness development, reduced drying time and excellent flow and levelling characteristics. However, for some grades of cellulose ester, the relatively high molecular weight of the product led to increased viscosity and thus a VOC content in excess of the legislated maximum value.

In 2007, Eastman introduced a new product, Eastman Solus™ 2100 performance additive, aimed at the automotive industry. This product is based on proprietary technology and provides the same benefits as the cellulose ester products but with the added advantage of significantly reduced viscosity and therefore VOC content.

As part of our evaluation of the traditional cellulose ester products in ink jet printing, Eastman requested that OMIC evaluate Eastman Solus™ 2100 to determine its suitability for ink jet printing.

Not unexpectedly, Eastman Solus™ 2100 exhibited excellent viscosity and temperature stability but OMIC found that it was possible to jet this material at 33% solids content in MEK and at 16% solids in a slower evaporating solvent gamma butyrolactone (see Photos 4 and 5).
Conclusion

Cellulose ester resins CAB and CAP have a proven track record in traditional printing processes and systems going back over several decades.

Work performed on Eastman’s behalf by OMIC at the University of Manchester in the UK demonstrated that traditional cellulose esters and Eastman Solus™ 2100 performance additive possess attributes which make them ideally suited for use in ink jet printing inks where they achieve excellent and predictable ink droplet formation. Furthermore the stability of cellulose esters and Solus™ 2100 with respect to time and temperature was observed to be outstanding and in this respect superior to other binder systems used for such applications.

Reference publications


Material Safety Data Sheets providing safety precautions, that should be observed when handling and storing Eastman products, are available online or by request. You should obtain and review the available material safety information before handling any of these products. If any materials mentioned are not Eastman products, appropriate industrial hygiene and other safety precautions recommended by their manufacturers should be observed.

Neither Eastman Chemical Company nor its marketing affiliates shall be responsible for the use of this information, or of any product, method or apparatus mentioned, and you must make your own determination of its suitability and completeness for your own use, for the protection of the environment and for the health and safety of your employees and purchasers of your products. NO WARRANTY IS MADE OF THE MERCHANTABILITY OR FITNESS OF ANY PRODUCT, AND NOTHING HEREBIN WAIVES ANY OF THE SELLER’S CONDITIONS OF SALE.

Eastman and Solus are trademarks of Eastman Chemical Company.

All other brands are the property of their respective owners.