Benefits of Controlling the Interfacial Chemistry of Paper
A global specialty chemicals player with leading positions in demanding specialty markets
Our Core Strengths

Modification and Control of interfacial chemistry

Supplying specialty additives for the Paint, Plastics and Ink markets

Focusing on the paper coatings market, we apply our knowledge and capability to modify paper coatings and the surface characteristics of coated paper for improving printability and convertibility.
Paper Surface improvement Processes

- Surface sizing
- Single coating
- Precoat
- Topcoat
- Metalized and embossed
Paper is a Non Homogeneous Substrate for Many Printing and Converting Processes

Paper remains porous

Base paper

Coating layer
Modeling Paper as a porous system

Darcys Law

\[ Q = \frac{K \Delta P}{\eta \Delta L} \]

- \( Q \) = flow rate
- \( K \) = permeability coefficient
- \( \Delta P \) = pressure drop
- \( \Delta L \) = Flow length
- \( \eta \) = fluid viscosity
- \( \Delta \) = Area of cross sectional Area to flow

\[ \gamma_{sl} = \gamma_{sg} - \gamma_{lg} \cdot \cos \Theta \]

- \( \gamma_{sl} \) = cohesion
- \( \gamma_{sg} \) = Adhesion
- \( \gamma_{lg} \) = surface tension

Permeability of a Membrane

Surface wetting

Coating paper

Coating and surface sizing to increase uniformity
Modeling the Physics of Capillary Rise and Pore Fill

Bosanquet = $\mathcal{E} f \left( \frac{1}{R}, \gamma \rho t^2 \right)$; Lukas Washburn = $\mathcal{E} f \left( R; \gamma \eta t \right)$ (t<<1^-)

$\mathcal{E}$ = Void Area of Surface

Bosanquet  Lukas- Washburn

- Bosanquet small pores = fastest liquid uptake $\sim R = 0,05 \mu$m
- Lukas-Washburn = most liquid uptake $R > 0,25\mu$m

$\gamma$ = Wetting
$\eta$ = Viscosity (T)
$\rho$ = Material
$t$ = Time
Paper substrate during Coating

- Penetration of liquid into the base paper
- Dependent on Water retention, Viscosity, Application type, Dry content, Speed, Paper sizing

Timeframe 0,01 - 0,2 s

Penetration

Leveling element

Drying

Porous Dry Coating

Immobilization of pigments
Paper substrate during Printing

Drying

Wetting of surface

Dot gain

Drying Adhesion

Penetration

Real speed printing
Unit ~ 0.2 - 0.4 sec

System compatibility of Wetting and Penetration of Paper Substrate Regarding Printing system and Printing Ink
Missing dots
(gravure printing <25% of coverage)

- Topography
- Wetting problems
- Penetration – local
  Mottling – negative dot gain/ positive dot gain
Scratch resistance/Rub resistance

- Changing local surface
  Due to handling

- Gloss mottling on paper

- Surface scratches
  from conversion* processes

- Printing on these surfaces,
  due to non uniformity of
  liquid penetration, gives
  a mottling impression

- Converting temperature and moisture*
Mottling = non uniformity of Printing appearance

- Mottling is in a difference in Color density within 50 - 100 µm
- Different types of Mottling can be traced to different paper substrate issues
  - Backtrap mottling = Non uniformity of paper
  - Color splitting = Adhesion of Color
  - Gloss mottling = Non uniformity of gloss surface due to penetration and wetting differences
  - Non uniformity in penetration of fountain water
  - Non uniformity of binder – binder migration due to heating and drying
Paper Surface Characterization*

Dynamic Penetration (Porosity, Capillarity)

Dynamic Topography (Smoothness)

Dynamic Wetability

*Based on four university studies in cooperation with BYK
Topography of Paper surface

Printability – no color acceptance
In areas of no contact

Leveling of Varnish before the next conversion step
Dynamic Penetration (Capillarity, Pores)
Dynamic Wetability

Reduction of polar part – still acceptable
Reduction of polar and disperse part – no adhesion

Dynamic Tension

[Dynamic – time related]

Static – liquid related

[mN/m]

Dispers

Polar

Good adhesion

Still acceptable

no adhesion with foil
Characterization of Paper surface

Develop Test Method

Improve Surface

Characterization of paper surface to predict printability and convertibility and to improve conversion steps
Case study: Topcoat uniformity control

Dynamic Penetration PDA Measurement: 1 MHz, cell: 35 mm, 30 sec, test liquid: water

Additive in Topcoat

- Increased wetting phase
- Increased uniformity
- Lower penetration speed
Changing liquid Penetration speed

Different additives

Special modified system

Increase surface Adhesion
Reduce Penetration – binder migration topcoat
Good printability combined with improved paper uniformity
Dynamic Wetting - Drop Measurement

**Drop base**

<table>
<thead>
<tr>
<th>Time [s]</th>
<th>Control</th>
<th>With surface Additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,1</td>
<td>1,5</td>
<td>2</td>
</tr>
<tr>
<td>0,5</td>
<td>1,5</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
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</tr>
</tbody>
</table>

**Contact angle**

<table>
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</tr>
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<tbody>
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<td>60</td>
</tr>
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Increased wetability
Larger drop base
Lower contact angle
Rapid Indication of Paper surface characteristic

Different paper surfaces and Effect Pigment in
• Gravure Printing
• Flexographic Printing

Impression of Printing in
• Color
• Mottling
• Gloss
are related to paper surface characteristic
Laboratory and Pilot print device

- Paper surface
- The metallic flakes are oriented above the surface
- Ink and binder penetrates into the capillary system
Pigment orientation at the surface

Topography related gloss development
Light reflection increases with oriented mirror like surface
Color Impression

Metallic pigment

Color match metallic print dot

Perfect color

Increasing Color absorption enlarges print dot

Color mottling Color Separation

Total Binder absorption metallic pigment flocs

No Print dot
Our method for characterizing Paper is a fingerprint of the surface for predicting runability during converting processes.

Dynamic Penetration of Liquids

Dynamic Topography

Dynamic Wetability

Metallic Ink Color
Using and understanding Interfacial Chemistry to explain and control material behavior

Most application, performance and appearance defects are caused by undesirable differences in surface tensions.

Surface tension modifying additives can be used to control and modify material interactions.

• Material flow is always from areas of low surface tension towards areas of higher surface tension
Surface defects from wrong defoamer choice

A defoamer with balanced incompatibility destroys the bubble; a defoamer that is too strong can create surface defects.
Influence of Components in converting process
Printing & Converting combines material in a machine

Material (Ink, Coating, Foil)

Additives
Surface Wetting
Paper surface

Compatibility
Machine

Runability
Test Color for Paper Surface Characteristics

Highly sensitive Printing Ink
For magnifying paper characteristics

Impression of Printing in
• Color
• Mottling
• Gloss
lead to the related paper surface characteristic
Supporting the value chain via Interfacial Chemistry Control

- Cost optimization
- Added value
  Improve the surface
- Product Development
Questions?