Unique High Oxygen Barrier Coatings for Food Packaging
Two very different oxygen barrier coatings will be presented

– Coatings onto BOPET film
– Coatings onto AlOx coated BOPET film
Coatings onto BOPET Film
Objective

• Reduce oxygen transmission through thin, transparent packaging film to retard oxidative spoilage and prolong product freshness, extend shelf life

• Demonstrate a very thin layer of coating on film can have a high impact on barrier, without adding significant cost or weight to a package structure.
In Line Barrier Coating Application

- Used in line in the film production process
- BOPET substrate
  - Substrate selection is critical, smoother is better
- Better properties achieved through the stretching process – e.g. adhesion
- Coat weight range 0.04 – 0.07 dry gsm
- Enhance barrier properties by metalizing on top of the coating
- Work done at Bruckner
Michem® Flex Barrier 3510

- Applied in-line with BOPET line
- Applied between machine direction and transverse stretching
- Used either
  - As a pre coating prior to metallization
  - Or as a transparent barrier for dry conditions
- Applying in-line gives low coat weight and better properties. <0.1 microns

<table>
<thead>
<tr>
<th>Typical Parameter</th>
<th>Unit</th>
<th>BOPET</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD stretching ratio</td>
<td>-</td>
<td>3 - 5</td>
</tr>
<tr>
<td>TD stretching ratio</td>
<td>-</td>
<td>4 - 5</td>
</tr>
<tr>
<td>MDO stretching temperature</td>
<td>°C</td>
<td>90 - 120</td>
</tr>
<tr>
<td>TDO stretching temperature</td>
<td>°C</td>
<td>90 - 105</td>
</tr>
<tr>
<td>Annealing temperature</td>
<td>°C</td>
<td>180 - 240</td>
</tr>
<tr>
<td>Coating weight (wet)</td>
<td>g/m²</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Solid content</td>
<td>%</td>
<td>5 - 15</td>
</tr>
<tr>
<td>Coating thickness (after orientation)</td>
<td>nm</td>
<td>50 – 150</td>
</tr>
</tbody>
</table>

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Inline Film Coating

Gravure Coating Head
Barrier Coating Characteristics

- 10% solids in water
- Single component
- Excellent shelf life
- No mineral nano-particulate content
- No chlorine
- Food compliant
- Adhesion
  - To film substrates
  - To vacuum deposited metal, AlOx and SiOx
- Promising water resistance
- >500 g/in metal adhesion between film and metal
Barrier Coating - Effect of Humidity

12μ BOPET/MFB3510 @ 0% RH

12μ BOPET/MFB3510/2.7 OD metallizing @ 90% RH

12μ BOPET/MFB3510 @ 90% RH
Summary: Coating for BOPET

- **Transparent Oxygen Barrier**
  - New Building Block Structure for higher performance and/or lower cost
  - Can we eliminate lamination?
  - Can we eliminate PVDC?
  - Where are alu foil structures over-engineered?

- **Functional Inline PET Coating**
  - Aqueous
  - 0.05 – 0.10 microns
  - Recyclable
  - Sustainable
  - Strong O2 Barrier
  - Easy to coat – one component
  - Food Compliant
  - Excellent adhesion
  - Converter Friendly
  - Metalizable

- **Primer for Metallization**
  - Multi-functional
Improving AlOx Coatings
Experiment

• In cooperation with BOBST
• Objective - Improve the performance of AlOx coating especially in durability and retention of barrier properties through converting operations
Ceramic Clear Barrier Coatings

Advantages over polymer based transparent barrier films (PVDC, EVOH)
- No barrier loss at high relative humidity
- Thickness in nanometer range – other technologies in the micron range
- Economical raw materials consumption and cost
- Chlorine free

Advantages of metalized polymer films
- Product Visibility
- Microwavable
- Suitable for met detection
Barrier retention on elongation

EXPERIMENTAL
- Characterisation of stretch durability
- Stretching of $\text{AlO}_x$ coated film to a predefined elongation using tensile tester
- Assess capability of coated film to withstand downstream processing

RESULTS
- $\text{AlO}_x$ coated PET

$\Rightarrow$ WVTR deteriorates beyond 1 to 1.5 % elongation
$\Rightarrow$ OTR withstands higher strain than WVTR (up to 3 % elongation)
Barrier Retention

Conventional AlOx/SiOx coated film

AlOx/SiOx coated Films without Overcoating

| PET 12µm | SiOx or AlOx |

GL Film

AlOx/SiOx coated Film with Overcoating

| PET 12µm | AlOx or SiOx |
|          | Overcoating |

PET 12µm | AlOx or SiOx |
|          | Overcoating |

Toppan’s patented overcoating layer minimizes flex cracking.
AlOx Coated PET-Vacuum Metallization

- Bobst K5000 Vacuum Metallizer
- AlOx deposition (10nm) onto 12µm BOPET film
- Speed 720m/min
- Widths 1250mm to 3650mm
- OTR <1cc & WVTR < 2gm
Topcoating – AlOx Coated PET Film

Experimental
- Bobst CL 850D coater/laminator - modified for AlOx suitability
- 12 micron AlOx coated BOPET
- 10 nm AlOx coating
- Rotogravure coating application
- Coating speed 250 m/min

- Water based topcoats
- Coat weights between 0.5 to 1.5 grams/m2 DRY
- Three different coating chemistries
Topcoating – AlO$_x$ coated PET

Bobst – CL 850D

RESULTS

• Topcoats successfully applied without damaging AlO$_x$
• Barrier performance post-topcoating depends on topcoat chemistry
• Barrier topcoat C improves OTR and WVTR significantly
• Barrier properties of topcoat material are important for barrier enhancement

\[
\begin{align*}
\text{WVTR}\, [\text{g/(m}^2\text{ d)}] \\
\text{OTR}\, [\text{cm}^3/(\text{m}^2 \text{ d})]
\end{align*}
\]

- AlO$_x$ PET + Topcoat A
- AlO$_x$ PET + Topcoat B
- AlO$_x$ PET + Topcoat C
- AlO$_x$ PET (no topcoat)

*OTR 23 °C, 50 % RH
**WVTR 37.8 °C, 90 % RH
## Barrier Through Converting Processes

<table>
<thead>
<tr>
<th>Conversion Process</th>
<th>Structure</th>
<th>OTR cm³/(m² d)</th>
<th>WVTR g/(m² d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TopCoating B</td>
<td>PET/AlOx/topcoat</td>
<td>0.65 ± 0.09</td>
<td>0.56 ± 0.10</td>
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<tr>
<td>Printing</td>
<td>PET/AlOx/topcoat/ink</td>
<td>0.78 ± 0.10</td>
<td>0.70 ± 0.05</td>
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<tr>
<td>Lamination</td>
<td>PET/AlOx/topcoat/ink/ad/PE</td>
<td>0.77 ± 0.10</td>
<td>0.69 ± 0.06</td>
</tr>
<tr>
<td>Slitting</td>
<td>PET/AlOx/topcoat/ink/ad/PE</td>
<td>0.59 ± 0.02</td>
<td>0.69 ± 0.01</td>
</tr>
<tr>
<td>TopCoating C</td>
<td>PET/AlOx/topcoat</td>
<td>0.09 ± 0.04</td>
<td>0.42 ± 0.03</td>
</tr>
<tr>
<td>Printing</td>
<td>PET/AlOx/topcoat/ink</td>
<td>0.12 ± 0.08</td>
<td>0.45 ± 0.06</td>
</tr>
<tr>
<td>Lamination</td>
<td>PET/AlOx/topcoat/ink/ad/PE</td>
<td>0.11 ± 0.07</td>
<td>0.44 ± 0.13</td>
</tr>
<tr>
<td>Slitting</td>
<td>PET/AlOx/topcoat/ink/ad/PE</td>
<td>0.11 ± 0.09</td>
<td>0.41 ± 0.01</td>
</tr>
</tbody>
</table>
Acknowledgments

• To BOBST
  – Nick Copeland – R&D Director
  – Dr. Carolin Struller – Research Associate

• To Michelman
  – Robin Cooper – Strategic Program Manager
Next Steps – Whole Program
BOPET Coatings and AlOx Coatings

- Build Prototypes – film/convert/fill/shelf life
- Offline comparison to inline coating
- Work with BOPP film
- Retort Testing
THANK YOU!

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