Barrier Coatings for Flexible Substrates

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Product Manager - Coatings
Presentation Content

• What are Nanoparticles
• How are they used
• Properties of Barrier Coatings
• Industrial Applications
• Technical Details
• Value Summary
What is a Nanoparticle?

Nano, a prefix meaning "dwarf" in Greek, also means one billionth. A nanometer is therefore one billionth of a meter. To provide a sense of scale, here are the measurements of some common objects.

Tennis Ball 100,000,000 nm

Bacteria 1000 nm

Virus 100 nm
Nanoparticles in Coatings

• Since the 1990’s, Nanoparticulates have shown promise in coating formulations. In packaging applications they most notably improved barrier to gases, aroma and UV light.

• Early problems with instabilities and poor coverage have been for the most part eliminated with improved formulations and press techniques.
Finely dispersed nanoparticulate (intercalated/ exfoliated) silicate mineral in a polymer solution/ dispersion

Functional oxygen barrier of less than 0.06 cm$^3$/100 inch$^2$/24h at 23°C & 50%RH on PET are routine
Industry Uses for Barrier Coatings

- To replace PVdC and EVOH in flexible food and non-food packaging applications
- To enhance or replace metallized, AlOx and SiOx structures
- Dry and chilled food packaging
- Liquid packaging
- Flexo, gravure or roller coat processes
Industry Uses for Barrier Coatings

Oxygen Barrier: light weighting example

Removal of metal foil and one layer of adhesive
Lighter weight packaging (up to 30% reduction)
Improved laminate integrity (post flexing O₂ barrier improvement)
Industry Uses for Barrier Coatings

Oxygen Barrier: replacement example

Commercial 2-Ply Laminate

- PET Film
- PVdC coated PET
- Ink
- Adhesive
- Polymer Film

New 2-Ply Laminate plus printable barrier coating

- PET Film
- Barrier Coating
- Ink
- Adhesive
- Polymer Film

No chlorine
Increased sales opportunity for converter
Improved O2 barrier
Improved shelf life
Industry Uses for Barrier Coatings

Oxygen Barrier: enhancement example

Commercial 3-Ply Laminate

New 3-Ply Laminate plus printable barrier coating

Lower cost than alternative high performance barriers
Technical Details

• How do they work
• Barrier performance on different substrates
• Improvements in Flexibility
Nanoparticles in Coatings

SEM: Agglomerated Clay

TEM: Nanocomposite Coating

Cast of Dilute Coating on Cu Grid
The Effect of Exfoliation on the Visual Appearance of NanoComposites

Unfilled Polymer

Non-Exfoliated Clay (Tactoid)

Exfoliated Clay Nanocomposite
The generally accepted theory for barrier improvement is that dispersed/exfoliated ‘platy’ minerals increase the diffusion path length through a coating; ‘\textit{TORTUOUS PATH’}. 

\[ d_2 > d_1 \]
Oxygen Transmission Rates of Typical Flexible Packaging Materials

Printable Oxygen Barrier Coatings will offer an alternative to existing High Barrier Options.
# Overview of Gas Barrier Coating Performance on Different Substrates

The graph illustrates the oxygen transmission rate (cm³/m²/day) for different substrates with and without coatings, at 23°C and 50%RH and 23°C and 75%RH.

### Oxygen Transmission Rate

<table>
<thead>
<tr>
<th>Substrate</th>
<th>No Coating</th>
<th>23°C/50%RH</th>
<th>23°C/75%RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>100-110 cm³/m²/day</td>
<td>1250-1350 cm³/m²/day</td>
<td>Value for Commercial PE-EVOH Laminate (23°C &amp; 50%RH)</td>
</tr>
<tr>
<td>OPP</td>
<td>100-110 cm³/m²/day</td>
<td>1250-1350 cm³/m²/day</td>
<td>Value for Commercial PE-EVOH Laminate (23°C &amp; 50%RH)</td>
</tr>
<tr>
<td>OPA</td>
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</tr>
</tbody>
</table>
Overview of Gas Barrier Coating Performance on Different Substrates

The clay composite coatings provide excellent barrier performance on both PET and OPP with dry film weights as low as 0.2 g/m² (dry).

![Graph showing OTR vs. Dry film weight for 25μm OPP and 12μm PET](image)
Overview of Gas Barrier Coating Performance on Different Substrates

![Graph showing OTR @ 23°C & 50%RH for different substrates against the number of Gelbo Flexes. The substrates include PET-AIOx, PET-SiOx, PET-PVDC, PET-EVOH, and PET-O2 Barrier. The graph indicates the performance of each material under varying conditions.]
Performance Benchmark – Effect of Humidity

Oxygen Transmission Rate

- SunBar-PET
- PE/EVOH/PE-PET
- PVdC-PET

% Relative Humidity
Humidity Model on PET Single Layer and Lamination

<table>
<thead>
<tr>
<th>External Side</th>
<th>PET</th>
<th>O₂ Barrier Coating</th>
<th>Internal Food Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>65% RH</td>
<td>33.5</td>
<td>1.0</td>
<td>0% RH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12μm PET / coating</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External Side</th>
<th>PET</th>
<th>O₂ Barrier Coating</th>
<th>Adhesive</th>
<th>PP</th>
<th>Internal Food Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>65% RH</td>
<td>55.6</td>
<td>60.3</td>
<td>30.1</td>
<td></td>
<td>0% RH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12μm PET / coating plus adhesive / 50μm PP</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>External Side</th>
<th>PP</th>
<th>Adhesive</th>
<th>O₂ Barrier Coating</th>
<th>PET</th>
<th>Internal Food Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>65% RH</td>
<td>34.9</td>
<td>4.7</td>
<td>2.3</td>
<td>0% RH</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12μm PET / coating plus adhesive / 50μm PP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Humidity Model on OPP Single Layer and Lamination

<table>
<thead>
<tr>
<th>External Side</th>
<th>BOPP</th>
<th>O₂ Barrier Coating</th>
<th>Internal Food Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>65% RH</td>
<td>32.5</td>
<td>0.0</td>
<td>0% RH</td>
</tr>
<tr>
<td></td>
<td>12μm BOPP / coating</td>
<td></td>
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<th>BOPP</th>
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<th>PP</th>
<th>Internal Food Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>65% RH</td>
<td>37.9</td>
<td>10.8</td>
<td>5.4</td>
<td>0% RH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12μm BOPP / coating plus adhesive / 50μm PP</td>
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<th>BOPP</th>
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</tr>
</thead>
<tbody>
<tr>
<td>65% RH</td>
<td>59.6</td>
<td>54.2</td>
<td>27.1</td>
<td>0% RH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12μm BOPP / coating plus adhesive / 50μm PP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Application Data

• Nano clay materials are often supplied in two or more parts that need to be mixed together before use.
  – Newer versions are available as a one part.
• Keep from freezing.
• There is a relationship between the applied coating weight and the level of barrier achieved.
Application Data

• We would expect for approx. 25% of the volume of the anilox to transfer onto the substrate.
• Corona treat films before coating. It will enhance adhesion and improve lamination bond strength.
Value Proposition Summary

• **Market**
  – Chlorine-free
  – Enable light weighting
  – Improve sustainability
  – Remove metal
  – Transparent
  – Improve ability to recycle
  – Alternative to expensive barrier films
Value Proposition Summary

• **Barrier**
  – Excellent O2 barrier
  – Excellent aroma barrier
  – Replace PVdC and EVOH coatings
  – Improve flex crack resistance of oxide/metallized films
  – Extend shelf life
Value Proposition Summary

- **Application**
  - Can be applied at conventional film weights depending on the structure and barrier required
  - Coatings can be applied on existing equipment
  - Enable removal of barrier film and adhesive in 3 ply, and more, laminates
  - Reduction in processing waste
  - Reduction in energy
  - Allow duplex laminates to compete with triplex
Thank You

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