Aqueous Nanocomposite Barrier Coatings –
A more sustainable option for high barrier flexible packaging

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Outline

- InMat History
- Technology Platform and Approach
- Oxygen Barrier Performance
- Moisture Barrier Performance
- Laminate Barrier Performance
- Screening Results for Retort
- Summary and value proposition
InMat Inc.

- Leader in water based, environmentally friendly high barrier clay-polymer nanocomposite coatings
- Product platform with commercial success & easily scaled to large volumes
- Current product lines use four different polymers and clays
- One component formulations that can be applied using standard coating methods (roll, spray or dip)

<table>
<thead>
<tr>
<th>Elastomeric Coatings</th>
<th>High Barrier Coatings</th>
<th>High Solid Paper Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Chemical protection</td>
<td>• Flexible packaging</td>
<td>• Barrier paperboard for food and juice cartons</td>
</tr>
<tr>
<td>• Sports balls</td>
<td>• Rigid packaging</td>
<td>• Grease resistant paper</td>
</tr>
<tr>
<td>• Specialty industrial</td>
<td>• Medical devices</td>
<td></td>
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<tr>
<td>• Tires</td>
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</table>

**Air D-Fense™ 2000**

**Nanolok™ PT ADV**
- Nanolok™ PT E
- Nanolok™ EXC
- Nanolok™ PT MM
- Nanolok™ WR

**Nanolok™ PT HSC**
Nanocomposite Barrier Coating Platform:
Coating formulations using nanoclay & polymer dispersed in water

• Reduced material costs
• Environmentally friendly / all ingredients have FDA food packaging status
• Polymer can be chosen to meet the requirements of the market
• Large (1-5 orders of magnitude) improvements in barrier properties over unfilled polymer
• Fundamentally different approach to clay–polymer nanocomposites
Clay – Polymer Nanocomposite Barrier: Basic Concepts

- Use clay minerals which are easily exfoliated in water to form 1-3 nm thick silicate sheets
- Impermeable sheets form tortuous path increasing barrier properties of polymer
- As concentration increases, a large fraction of the polymer will be near a clay surface
  - May cause significant changes in permeability of polymer

Key Variables

- Polymer permeability
- Plate aspect ratio
- Clay concentration
- Dispersion and microstructure
- Orientation
Nanocomposite Barrier Coatings

Provide High Barrier in a Water-based, Environmentally Friendly, Coating Formulation
Optical Interference Image provides Surface Topography Map

Field width = 1.2 mm
• Flexible film:
  • Many roll coating processes will work
    » Examples: Slot dye, curtain, flexo, and gravure
  • We have used reverse offset gravure
    – Enables simple thickness control by changing relative speed of film and gravure cylinder
There is a good correlation between the % offset, the coat weight (gsm) and the measured coating thickness.
Nanolok coatings <1 micron thick will replace several microns of competitive materials.
InMat barrier coatings also provide large improvements in moisture barrier.

_Nanolok PT™_

Coating thickness: \( \sim 0.7 \mu \)
Flex Packaging Example

Fewer layers in the final package results in cost reduction.

Current Technology
Total thickness: ~2.6 mils

- 0.5 mil PET
- 0.5 mil EVOH
- 1 mil PE

InMat Technology
Total thickness: ~1.8 mils

- 0.5 mil PET
- 0.5 mil EVOH
- 0.05 mil Nanolok
- 0.3 mil Adhesives
- 1 mil PE

Fewer layers in the final package results in cost reduction.
Performance of Flexible Laminates
There are a large number of critical variables.

- Substrate film
- Barrier coating
- Barrier coating thickness
- Adhesive
- Adhesive thickness
- Laminating film
- Lamination conditions
  - Temperature
  - Pressure
  - Time (rate)
Effect of Lamination
Oxygen transmission rate reduced by a surprising amount.

• Large reductions in OTR after lamination occur on almost all samples – PET, BOPP and variations in adhesives.
• The reductions are more pronounced for thinner coatings that contain more defects.

Barrier coating thickness estimated to be ~ 0.2 microns
Peel Strength:
Barrier coating thickness & adhesive coat weight are both important.

High adhesive coat weights decrease peel strength on the thin barrier coatings.
Feasibility for Retort Packaging
Recent laboratory simulation demonstrated!

1 µm Nanolok

Coated Film
(Reverse gravure roll coated)

Lab Lamination
(with solvent adhesive)

Simulated Retort
(Boiling water, 1 hr)

<table>
<thead>
<tr>
<th></th>
<th>Coated Film</th>
<th>Lab Lamination</th>
<th>Simulated Retort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier (cc/m² day atm)</td>
<td>2</td>
<td>0.3</td>
<td>1</td>
</tr>
<tr>
<td>Clarity</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Adhesion</td>
<td>n/a</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

OTR of uncoated 2 mil BOPP ~1300cc/m²-day atm
Laminate Performance

- Thinner barrier coatings can be used in laminates due to the improvements in OTR after lamination.
- OTR not degraded after boiling in water for 1 hour.
- Peel strengths limited by cohesive strength.
- Large variation in cohesive strength of laminate depending upon:
  - Barrier coating thickness
  - Adhesive coat weight
  - Substrate & surface treatment
  - Type of adhesive
- It is likely that the laminating adhesive and/or the laminating process is reducing the peel strength – further work is needed.
InMat Product Line:
Several high barrier coatings available for flex packaging applications

<table>
<thead>
<tr>
<th>Product</th>
<th>Permeability(^1) (cc um/m(^2) day atm)</th>
<th>MVTR(^2)</th>
<th>Adhesion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0% RH</td>
<td>65% RH</td>
<td>80% RH</td>
</tr>
<tr>
<td>PT ADV-7</td>
<td>0.3</td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>PT ADV E</td>
<td>1.6</td>
<td>3.1</td>
<td>8.8</td>
</tr>
<tr>
<td>EXC 1007V</td>
<td>0.1</td>
<td>3.5</td>
<td>39</td>
</tr>
<tr>
<td>WR 301409</td>
<td>0.4</td>
<td>0.6</td>
<td>15</td>
</tr>
</tbody>
</table>

- All coatings can be applied directly to corona treated films without primer
- Coatings can be used in laminated and/or top coated structures
- Coatings can be used as base coat for ink, or as overcoat
Barrier material cost savings

Reduced package weight – source reductions and disposal costs
- Reduce number of layers as Nanolok™ barrier can usually be applied directly to packaging film without an adhesive

Water based coatings with neutral pH
- Standard application equipment for film
- Low cost spray equipment for rigid parts
- No solvents or hazardous materials

Potential integration into printing and/or lamination process

High oxygen barrier performance along with significant moisture barrier improvements.

Potential for retortable and steam sterilized packaging

Value Proposition Summary
InMat has a line of unique, water based, barrier coatings suitable for flexible packaging and is seeking partners for full commercialization.