Nanolok™ Technology

for high barrier applications

Presentation to AIMCAL October 19, 2005
Outline

• Brief History of InMat
• Target Markets and Applications
• Barrier Coating Performance
• Unique Features of InMat® Technology
• Summary and Conclusions
InMat® NanoLok™ Technology

Aqueous Nanodispersed Suspension

Nanocomposite Barrier

Substrate

Once dry a thin coating provides extremely high barrier

• Reduced Material Costs
• Environmentally Friendly
• Polymer can be chosen to meet the requirements of the market
• Large (2-5 orders of magnitude) improvements in barrier properties over unfilled polymer
InMat History

1996 - Michelin approaches Hoechst to develop coating to displace tire inner liner

1997 – Patents filed on aqueous nanocomposite barrier coating technology – a disruptive technology for the tire and rubber industry

1999 – InMat founded as spin-off from DuPont (after purchase of Herberts from Hoechst)

2001 – First commercialization in Wilson tennis balls.
2002 - DOD awards contract to develop chemical warfare agent gloves

2004 - Technology platform extended to packaging market
Demonstrating potential to revolutionize the entire area of barrier coatings
Target Markets for Nanolok™ Technology

• **Sports Balls**
  – The bounce and feel of natural rubber with the air retention of butyl
    • Commercially used in Wilson’s Double Core™ ball
    • butyl nanocomposite

• **Tires**
  – Improved air retention, lower weight, less rolling resistance and cost vs. butyl
    • Major tire companies testing –
    • butyl nanocomposite

• **Chemical Protection**
  – Improved solvent, oil, and flame resistant protective gloves
    • nitrile rubber and neoprene nanocomposite

• **Packaging**
  – High barrier with see-through clarity which can be applied via roll-coat, dip, or spray coat processing
  – Polyester and acrylic nanocomposite
OTR and WVTR Requirements for Different Applications

- Oxygen Transmission Rate (cc/m²-day-atm)
- Water Vapor Transmission Rate (gm/m²-day)

- Rubber products, tires, Sports Balls
- Flexible packaging, Rigid packaging, Medical packaging
- Organic Semiconductors
- OLED’s

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AFM imaging shows high orientation and Nanodispersion in InMat Nanolok PT coating

Tapping mode height and phase images of the Nanolok PT3575 coating on 500 gauge PET, in cross-section clamped in a plastic vise, 1.5 µm scan size. PET is toward the right-hand side of the image, with Nanolok on the left. Images by PolyInsight
InMat’s Elastomeric Nanocomposites provide a unique combination of flexibility and barrier properties

Relative Oxygen Barrier Effectiveness

Least

Most

Oxygen Permeability (cc-mm/m²-day-atm) at 0% RH and 23°C

Water Vapor Transmission (gm-mm/m²-day) at 23°C

Using Nanolok™ technology in a Butyl Rubber matrix (also available in Nitrile Rubber and Neoprene)
Large oxygen permeability reductions demonstrated with several elastomers

<table>
<thead>
<tr>
<th>Latex Type</th>
<th>% Filled</th>
<th>Permeability (cc-mm/m²-day atm)</th>
<th>X Reduction</th>
<th>% Strain</th>
<th>Key secondary properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyl</td>
<td>50</td>
<td>0.3</td>
<td>300</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Butyl</td>
<td>30</td>
<td>1.2</td>
<td>75</td>
<td>15</td>
<td>Low Temperature flexibility</td>
</tr>
<tr>
<td>Butyl</td>
<td>20</td>
<td>2.5</td>
<td>36</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Butyl</td>
<td>0</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroprene*</td>
<td>30</td>
<td>1.5</td>
<td>83</td>
<td>12</td>
<td>Ozone, UV, oil, and solvent resistance</td>
</tr>
<tr>
<td>Chloroprene</td>
<td>0</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrile*</td>
<td>30</td>
<td>2.3</td>
<td>57</td>
<td>14</td>
<td>Solvent, oil and fuel resistance</td>
</tr>
<tr>
<td>Nitrile</td>
<td>0</td>
<td>130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPDM</td>
<td>20</td>
<td>17</td>
<td>11</td>
<td>15</td>
<td>Ozone, UV, sunlight, steam, brake fluid, and weak acid resistance</td>
</tr>
<tr>
<td>EPDM</td>
<td>0</td>
<td>185</td>
<td></td>
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</table>
A 50 micron InMat coating provides more chemical protection than a butyl rubber glove.
InMat’s Non-Elastomeric Nanocomposites provide the lowest oxygen permeability of any polymeric coating.
Nanolok™ barrier vs. EVOH, Bairocade & PVDC

Source: PPG, Nippon-Gohsei, Solvin and InMat, 25°C
InMat coatings use nanoclays in a thin coating to provide barrier improvements.

Oxygen transmission rate is reduced by a factor of >100 on PET and >1000 on PP.
Thin coatings of Nanolok PT can provide large reductions in oxygen transmission rate

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Substrate Thickness (microns)</th>
<th>Substrate OTR (cc/m2-day-atm)</th>
<th>Coated Substrate OTR (1 micron Nanolok PT)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>12</td>
<td>120</td>
<td>0.8-2.0</td>
</tr>
<tr>
<td>BOPP</td>
<td>20</td>
<td>3000</td>
<td>1.5-2.0</td>
</tr>
</tbody>
</table>

*The range of OTR is due to variations in substrate surface and coating uniformity due to non-optimized coating process.*
Secondary Properties can be controlled by formulation and choice of polymer matrix

<table>
<thead>
<tr>
<th>Aqueous Dispersed Polymer</th>
<th>Oxygen Permeability unfilled (cc-mm/m²-day-atm)</th>
<th>Oxygen Permeability (30-40% filled) (cc-mm/m²-day-atm)</th>
<th>Times reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanolok PT</td>
<td>2</td>
<td>0.002</td>
<td>1000</td>
</tr>
<tr>
<td>Nanolok Ac 1*</td>
<td>9</td>
<td>0.0003</td>
<td>30,000</td>
</tr>
<tr>
<td>Nanolok Ac 2*</td>
<td>30</td>
<td>0.0002</td>
<td>150,000</td>
</tr>
<tr>
<td>Nanolok PVDC*</td>
<td>0.4</td>
<td>0.008</td>
<td>50</td>
</tr>
</tbody>
</table>

* Formulations still under development
Processing

• Nanolok PT has been coated on PET film using a standard roll coating process.
  • 0.2-0.5 micron in a single pass, multiple passes used to increase thickness
  • PE adhesion lamination demonstrated

• High speed roll coating under development.
• Dip coating and spray coating have been demonstrated with both elastomeric and non-elastomeric formulations.
• InMat optimizes formulations to meet the processing needs of its customers.
InMat Coatings Adhere to PET and PP Packaging Film

• Nanolok PT was designed for adhesion to PET film.
  • Adhesion is excellent on corona and/or chemical treated PET.
  • Good adhesion has also been demonstrated on BOPP films

• Nanolok AC formulations have excellent adhesion to PP film.
InMat strategy

- Large (>> 10x) changes in permeability
- Aqueous coating formulations
- Use commercially available nano-clays
- Choose polymer for both barrier and required secondary properties
- Provide cost advantage by material reduction (i.e. replace thick film with much thinner film)
InMat’s Barrier Coating technology is a disruptive innovation for all products requiring gas, vapor, or chemical barriers.
Summary and Conclusions

• InMat has demonstrated its capability to make high barrier nanocomposite coatings with a wide variety of polymers chosen to meet market needs.

• Its technology platform has the clear potential to revolutionize the barrier coating industry.

• Its non-elastomeric barrier coatings provide the most cost effective oxygen barrier coating technology for packaging and other markets.
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• InMat® is a registered trademark of InMat, Inc.
• Double Core™ is a trademark of Wilson Sporting Goods.
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