Expanding the Use of Compostable Plastics: A Novel Approach to Corrosion Inhibiting Films

Ivana Radic Borsic

Cortec Corporation/EcoCortec

25 October 2011
Outline

- Introduction
- Cost of Corrosion
- Corrosion Defined
- VpCI Explained
- Issues Surrounding Plastic
- Eco-Corr\textsuperscript{®} Biodegradable VpCI Film
- Experimental Procedures
- Results & Conclusion
- Product Line Review – Compostable Packaging
Cortec’s Manufacturing & Global Presence

Headquarters: Saint Paul, MN

World’s Largest & Most Vertically-Integrated VpCI Facilities

Cortec Advanced Films: Cambridge, MN

Cortec Coated Products: Eau Claire, WI

Cortec Cros Warehouse: Split, Croatia

Cortec Spray Technologies: Spooner, WI

Parkway Technology Campus: Saint Paul, MN
EcoCortec - Croatia
Corrosion Cost

• Indirect costs total approximately $300 billion annually
  • 3.1% of GDP
  • Of this total the manufacturing & production sector experiences $17.6 billion per year
• $121 billion spent annually to prevent & control corrosion

• Direct costs of corrosion total $137.9 billion annually

- $47.9 billion Utilities 34.7%
- $17.6 billion Production 12.8%
- $20.1 billion Business 14.6%
- $22.6 billion Infrastructure 16.4%
- $29.7 billion Transportation 21.5%
Defining Corrosion

- **Dictionary Definition:**
  
  “Destruction, deterioration or degradation of a material due to a reaction with its environment.”

- For metals, this is a natural process by which a metal attempts to revert back to its original state by releasing energy.

  - Natural iron is oxidized, we add energy when we mine it - iron wants to return to a natural, low energy state

- **Examples of Corrosion:**
  
  - Cavities in teeth
  - Batteries
  - Red rust
  - White rust on Aluminum
Corrosion Prevention

- Methods:
  - Protective Coatings
  - Cathodic or Anodic Protection
  - Corrosion Inhibitors
  - Material Selection, Alloys
  - Structural Design
Vapor-phase Corrosion Inhibitors

- Condition an enclosed atmosphere with a protective vapor that condenses on all metal surfaces.

- Multi-metal corrosion inhibitor that protects and prevents corrosion even if not in direct contact.
How VpClIs work
VpCI® Packaging

- VpCI® Packaging combines protective packaging with corrosion inhibitors all in one
- Applications: asset preservation
- Industry Standard Products
  - Polyethylene-based films
  - Disposal: Recyclable, but not accepted at all facilities; most enters landfill
Issues Surrounding Plastics

- Contributor of:
  - increased waste production due to overuse
  - consumption of non-renewable resources
  - overflowing landfills
  - pollution and litter

- 1 trillion plastic bags consumed annually
  - ~1% recycled
  - ~80% of litter collected from waterways and roadways is from plastic material
Plastics Diversion

- Recycling:
  - Not all plastics are accepted
  - Incorporated into non-recyclable goods
  - Consumes fossil fuels
  - Some processes cost more than producing product from virgin resin

- Incineration:
  - Generates and contributes to greenhouse gas emissions
  - Unsightly
  - Doesn’t reduce consumption of non-renewable resources, but can be used as a source of energy
BioPlastics in the Market

- Most prevalent bioplastics in the market today include:
  - Starch-based Polymers
  - Polylactic Acid (PLA)
  - Polyhydroxyalkanoates (PHA, PHB)
  - Polyamides (PA)
  - Biobased PE
Biodegradable Plastics

- Plastics designed for their “end of life”
- Naturally degrade by aerobic microorganisms
- Common misconceptions:
  - All biobased materials are biodegradable
  - Petrochemical plastics are not
  - All degradable plastics are compostable and certified
Eco-Corr® Biodegradable VpCl Film

- Designed to:
  - Aid in the fight against corrosion
  - Reduce plastic waste
  - Provide an environmentally conscious end of life
  - Reduce fossil fuel consumption
Experimental Procedures

- Corrosion Inhibition
  - Razorblade Test
  - SO$_2$ Test
  - VIA Test
- ASTM D6400
- Laboratory Biodegradation Test
- Mechanical Properties
Razorblade Test Method

Assesses the corrosion inhibition of packaging materials while in direct contact with a metal surface.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Solution</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Steel</td>
<td>DI water</td>
<td>2 hours</td>
</tr>
<tr>
<td>*Galvanized Steel</td>
<td>3.5% CH₃CO₂Na</td>
<td>4 hours</td>
</tr>
<tr>
<td>Copper</td>
<td>0.005% NaCl</td>
<td>4 hours</td>
</tr>
<tr>
<td>Aluminum</td>
<td>3.5% NaCl</td>
<td>24 hours</td>
</tr>
</tbody>
</table>
## Razorblade Test Results

### Carbon steel Razor Blade Test Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Panel 1</th>
<th>Panel 2</th>
<th>Panel 3</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco-Corr®</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Fail</td>
</tr>
<tr>
<td>VpCI®-126</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Fail</td>
</tr>
</tbody>
</table>

### Copper Razor Blade Test Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Panel 1</th>
<th>Panel 2</th>
<th>Panel 3</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco-Corr®</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Fail</td>
</tr>
<tr>
<td>VpCI®-126</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Fail</td>
</tr>
</tbody>
</table>
SO$_2$ Test Method

Tests a material’s performance as a barrier to corrosive gases, such as sulfur dioxide.

Humid sulfur dioxide gas environment produced inside the test jar. SO$_2$ generated through reaction between sodium thiosulfate and sulfuric acid:

\[
\text{Na}_2\text{S}_2\text{O}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{SO}_2 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O} + \text{S}
\]
## SO$_2$ Test Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Panel 1</th>
<th>Panel 2</th>
<th>Panel 3</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco-Corr®</td>
<td>Grade 4</td>
<td>Grade 4</td>
<td>Grade 4</td>
<td>Grade 0</td>
</tr>
<tr>
<td>VpCI®-126</td>
<td>Grade 4</td>
<td>Grade 4</td>
<td>Grade 4</td>
<td>Grade 0</td>
</tr>
</tbody>
</table>
Vapor Inhibiting Ability (VIA)

Test Method

- Assesses the product’s ability to provide corrosion prevention when not in direct contact
- Samples arranged such that they cannot come into contact with the test substrate
- Relies solely on vapor-phase deposition for protection
## VIA Test Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Plug 1</th>
<th>Plug 2</th>
<th>Plug 3</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco-Corr®</td>
<td>Grade 3</td>
<td>Grade 3</td>
<td>Grade 3</td>
<td>Grade 0</td>
</tr>
<tr>
<td>VpCI®-126</td>
<td>Grade 3</td>
<td>Grade 3</td>
<td>Grade 3</td>
<td>Grade 0</td>
</tr>
</tbody>
</table>
ASTM D6400

- Standard specification for compostable plastics:
  - Satisfactory rate of biodegradation and subsequent conversion to carbon dioxide
  - Biodegradation does not result in the production of toxic materials and does not adversely impact the ability of the resultant compost to support plant growth
## Metals Analysis

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Test Method</th>
<th>Units</th>
<th>Results</th>
<th>BPI Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;0.50</td>
<td>21.5</td>
</tr>
<tr>
<td>Cadmium</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;0.25</td>
<td>19.5</td>
</tr>
<tr>
<td>Calcium</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>2100</td>
<td>NA</td>
</tr>
<tr>
<td>Chromium</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;0.50</td>
<td>NA</td>
</tr>
<tr>
<td>Cobalt</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;0.25</td>
<td>NA</td>
</tr>
<tr>
<td>Copper</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;1.0</td>
<td>750</td>
</tr>
<tr>
<td>Iron</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>20</td>
<td>NA</td>
</tr>
<tr>
<td>Lead</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;1.0</td>
<td>150</td>
</tr>
<tr>
<td>Mercury</td>
<td>EPA 7471A</td>
<td>mg/kg</td>
<td>&lt;0.10</td>
<td>8.5</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;2.5</td>
<td>NA</td>
</tr>
<tr>
<td>Nickel</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;0.50</td>
<td>210</td>
</tr>
<tr>
<td>Selenium</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>&lt;1.0</td>
<td>50</td>
</tr>
<tr>
<td>Zinc</td>
<td>EPA 6010B</td>
<td>mg/kg</td>
<td>2.4</td>
<td>1400</td>
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</tbody>
</table>
Laboratory Biodegradation Study

t = 0
t = 15 days

t = 30 days

t = 43 days

t = 62 days

t = 76 days

t = 93 days

t = 112 days
# Mechanical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Units</th>
<th>Eco-Corr 40°</th>
<th>Eco-Corr 0°</th>
<th>VpCI-126</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caliper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASTM D6988</td>
<td>mil</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
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<tr>
<td>Breaking Factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>MD</td>
<td>ASTM D882-02</td>
<td>lbs/in</td>
<td>11.77</td>
<td>10.40</td>
<td>18.88</td>
</tr>
<tr>
<td>CD</td>
<td></td>
<td></td>
<td>9.32</td>
<td>10.81</td>
<td>18.25</td>
</tr>
<tr>
<td>Tensile Strength at Break</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>MD</td>
<td>ASTM D882-02</td>
<td>psi</td>
<td>5774.65</td>
<td>4728.20</td>
<td>3184.35</td>
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<tr>
<td>CD</td>
<td></td>
<td></td>
<td>4451.90</td>
<td>4699.10</td>
<td>3109.60</td>
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<tr>
<td>Elongation at Break</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD</td>
<td>ASTM D882-02</td>
<td>%</td>
<td>300.21</td>
<td>759.38</td>
<td>770.37</td>
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<tr>
<td>CD</td>
<td></td>
<td></td>
<td>340.68</td>
<td>795.89</td>
<td>833.65</td>
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<tr>
<td>Yield Strength</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD</td>
<td>ASTM D882-02</td>
<td>psi</td>
<td>2321.62</td>
<td>991.44</td>
<td>793.85</td>
</tr>
<tr>
<td>CD</td>
<td></td>
<td></td>
<td>2285.99</td>
<td>1093.1</td>
<td>1425.18</td>
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<tr>
<td>Tear Resistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD</td>
<td>ASTM D1922-06a</td>
<td>mN</td>
<td>156.96</td>
<td>3719.95</td>
<td>15852.96</td>
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<tr>
<td>CD</td>
<td></td>
<td></td>
<td>470.88</td>
<td>4959.94</td>
<td>20279.24</td>
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<tr>
<td>Dart Drop Impact Resistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASTM D1709-04, A</td>
<td>grams</td>
<td>573.30</td>
<td>&gt;1300</td>
<td>753.28</td>
</tr>
</tbody>
</table>
CERTIFICATE
For Products

THIS IS TO CERTIFY that the following PRODUCTS have been found to comply with the specifications established in the American Society for Testing and Materials standard ASTM D6400, "Standard Specifications for Compostable Plastics", in accordance with the terms and conditions of the Biodegradable Products Institute and The United States Composting Council Certification Program for Products Made of Compostable Plastics - Program Rules:  

Product
- Eco Film™ and Eco Works™ films and bags manufactured by Cortec Corporation to a maximum thickness of 6.0 mils (per Cortec formula Bio-1000)
- EcoCore™ compostable films and bags with a maximum thickness of 6.0 mils (per Cortec formulas Bio-1950, Bio-1900, Bio-1800, Bio-1750, Bio-1600)

as further described in the application and related information submitted to the Biodegradable Products Institute by Cortec Corporation (the "Licensor") of St. Paul, MN.

This Certificate authorizes the Licensor to use the Certification Program Logo depicted below in relation to such Product, subject to all conditions and terms of the Program Rules and the License Agreement between the Biodegradable Products Institute and the Licensor.

By,  
BPI Executive Director

Valid Until: October 1, 2012
Conclusion

A certified biodegradable/compostable corrosion inhibiting film has been developed. Eco-Corr provides an alternative to traditional polyethylene-based films without compromising mechanical properties. Eco-Corr film demonstrates excellent corrosion inhibition in contact, through vapor-phase and as a barrier to corrosive gases.
Product Line Review: Compostable Packaging
- EcoOcean™
  - 100% anaerobically digestable
- EcoWorks® Film
  - 5-45% biobased content (derived from corn)
  - Certified 100% compostable
- EcoWorks® Resin
  - Certified compostable resin for film extrusion
- EcoFilm®
  - Certified 100% compostable film & bags
  - Non biobased, 100% synthetic
- EcoCorr® / EcoCorr® ESD
  - Certified compostable VpCI Film
  - Available with combination Antistat
- EcoWrap®
  - Biodegradable/Compostable cling film
- BioCushion®
  - Biodegradable/Compostable void fill
EcoOcean™

- High renewable content: 77% biobased content
- Designed to biodegrade in marine environments, anaerobic digestion, natural soil and water environments, backyard composting systems and municipal composting facilities
- BPI certified to meet ASTM D6400 for compostable plastic
- Marine biodegradable per ASTM D 7081 standard specification
- 100% anaerobically digestable per ASTM D5511 standard test method
- USDA BioPreferred™ certified material
Potential applications

- Community composting programs
- Anaerobic digestion programs
- Organic waste disposal
- Lawn & leaf bags
- Retail packaging
- T-shirt bags
- Agricultural films
Eco Film®

- Certified compostable per ASTM D 6400
- High and Low Temperature Stable
- Heat-Sealable, Convertible, Laminations
- Biodegrades within 45 days of composting
- Biodegrades rapidly in soil (varies on region)
- Elastic and visually attractive material
Minnesota Zoo Composting Program - launched with Cortec's Eco Film®!

The Minnesota Zoo belongs to a top ten zoo in North America and is home to more than 3,000 animals.

Cortec® Corporation, a leader in green and environmentally responsible technologies is very proud of its contribution to the Minnesota Zoo Green Program, which focuses on conservation and sustainability of natural resources. In an effort to conserve these resources and minimize waste, the Minnesota Zoo is incorporating “green” practices into its design and every day operations.

The Zoo recently formed a Green Team, whose main goal is promoting activities aimed at sustainability. One of the initiatives lead to development of a composting program that greatly reduces the amount of waste generated. The program was implemented in the spring of 2011, using Cortec's Eco Film®, a 100% biodegradable and compostable film, designed specifically for the unique demands of compost programs. Eco Film® replaces non-degradable starch and polyethylene-based films, and is up to 300% stronger than polyethylene.

As part of their Green team initiative, the Zoo recycled 370 tons of material, and composted about 600 tons of waste just last year! The program generates a great quantity of finished compost which is then used as a soil mix additive and as mulch on existing turf areas. Its goal is to divert food waste at the zoo, and reduce the trash that is taken into area landfills.

The zoo will be selling finished compost in the bulk to the public, which will be used as fertilizer for coops, farms and gardens.

This concept of using composting and recycling of materials is applicable to all kinds of large gathering places. Venues where large volumes of food is consumed lead to large quantities of organic waste. This includes stadiums, national parks, amusement parks, clubs, fairs, large resorts, hotels and many more.

Before starting the composting program, the zoo tested all certified commercially available compostable plastics from various manufacturers. According to Brenda Teske (Director of Corporate Giving, Minnesota Zoo), “Staff tested a number of different compostable bags, and the ones from Cortec performed by far the best”.

Now, Eco Film® bags are used for food waste created by employees, staff, their catering service, as well as during summer Zoo Camp – with plans to expand to common areas soon.

“When the Zoo contacted us to participate in their composting program, there was no doubt we were more than happy to help”, says Cliff Cincicer (Vice President of Sales, Cortec Corporation). “They are considered one of the ten best Zoo’s in the nation, so it should be a surprise they are taking innovative steps to be Green. The Minnesota Zoo should be commended for their work. It sends a powerful message to the community about sustainability.”

It is more important than ever that people make prompt decisions which will help to avoid the effects of plastic pollution. As a company determined to make a positive impact on the environment, we hope that the Minnesota Zoo Green Program will positively influence many other communities throughout the world to take actions and encourage this kind of green projects.

Need a High Resolution Photo? Please Visit www.cortecemitting.com

Cortec® Corporation is a world leader in innovative, environmentally responsible VCI® and MC® corrosion control technologies for Plating, Metalworking, Construction, Electronics, Water Treatment, Oil & Gas, and other industries. Our relentless dedication to sustainability, quality, service, and support is unmatched in the industry. Headquartered in St. Paul, Minnesota, Cortec® manufactures over 400 products distributed worldwide. ISO 9001 & ISO 14001 Certified.

Cortec Website: http://www.cortecemitting.com Phone: 1-800-426-7802 FAX: (651) 429-1122

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Attention: Editor
October 10, 2011
PRESS RELEASE

The Minnesota Zoo is incorporating “green” practices into its design and every day operations.
Eco Works® Premium Films & Bags

- Certified compostable per ASTM 6400 and DIN CERTCO
- Meet proposed USDA definition of Biobased
  - A minimum of 25% of the formulation must contain material that is derived from an annually-renewable source
- Certified and approved for Food Contact (Faculty of Food Technology and Biotechnology Zagreb, Croatia)
- More rigid than Eco Film (allows handle bags)
- Longer curb life in some areas (UK)
- More marketable to some customers
- Formulation derived, in part, from corn
Eco Wrap® Compostable Stretch Film

- Applied with the same stretch equipment
  - Hand or machine, can withstand 400% prestretch
- Agricultural markets initially
  - Typically do not use pallets, so twine (also biodegradable) and stretch film are only packaging materials
- Accepts printing
  - For marketing and identification
References

References: Test Procedures

- Legend Technical Services, Inc. St. Paul, MN 55103
GRAZIE

THANK YOU