An Overview of the Bioplastics Markets, Applications and Impact to Environment

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Outline

- Driving Forces Behind Bioplastics
- Terminology
- Environmental Impact
- Type of Bioplastics
- Examples of Bioplastics Markets and Applications
- Summary
- Q & A
Driving Force Behind Bioplastics Industry
In 2009 United States generates approximately 230 million tons of "trash" or roughly 4.6 pounds per person per day.

- Less than one-quarter of it is recycled; the rest is incinerated or buried in landfills.

- It is believed 70% of the landfill waste can be recycled.

Source: www.learner.org/garbage/related.html
Break down of Municipal Solid Waste

Total MSW Generation (by Material), 2009
243 Million Tons (Before Recycling)

- Paper and Paperboard 28.2%
- Food Scraps 14.1%
- Yard Trimmings 13.7%
- Plastics 12.3%
- Metals 8.6%
- Rubber, Leather, & Textiles 8.3%
- Wood 6.5%
- Glass 4.8%
- Other 3.5%

Source: epa.gov
Recycling Rates of Selected Products, 2009

<table>
<thead>
<tr>
<th>Products</th>
<th>Recycling Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto Batteries</td>
<td>95.7</td>
</tr>
<tr>
<td>Office-type Papers</td>
<td>74.2</td>
</tr>
<tr>
<td>Steel Cans</td>
<td>66.0</td>
</tr>
<tr>
<td>Yard Trimmings</td>
<td>59.9</td>
</tr>
<tr>
<td>Aluminum Beer &amp; Soda Cans</td>
<td>50.7</td>
</tr>
<tr>
<td>Tires</td>
<td>35.3</td>
</tr>
<tr>
<td>Glass Containers</td>
<td>31.1</td>
</tr>
<tr>
<td>HDPE Natural (white translucent) Bottles</td>
<td>28.9</td>
</tr>
<tr>
<td>PET Bottles &amp; Jars</td>
<td>28.0</td>
</tr>
</tbody>
</table>

Source: epa.gov
Corporate/Consumer Desire to be More Environmental Conscious with Lower Carbon Footprint
1. The Kyoto Protocol: International agreement linked to the United Nations Framework Convention on Climate Change. It sets binding targets for industrialize nations to reduce greenhouse gas (GHG) emissions.

2. Federal Farm Bill Title IX Energy Mandates total funding of $1 million for FY 2008 and $2 million annually for FY2009-12 for testing and labeling of biobased products via USDA Biopreferred Program.
3. Local Municipalities Legislation

Communities such as San Francisco and Los Angeles County have local ordinances in reducing petroleum based plastic bags and foamed PS...
Growing Industry

Freedonia research shows Bioplastics CAGR between 2007-2012 is 17.3%.

According to BCC Multi-client study, Bioplastics grew at a significant pace. The total worldwide use of bioplastics is valued at 571,712 metric tons in 2010.
Terminology
Terminology: Bioplastics

Bioplastics: Plastics that is biodegradable or has biobased content or both.

- **Biodegradable**
  - √

- **Biobased Content**
  - √

[Chemical structures of Starch, Poly(lactic acid) (PLA), and Poly(hydroxybutyrate-co-hydroxyvalerate) (P(HBV)) are shown.]

- Aliphatic copolyester: Poly(butylene succinate adipate) (PBSA)
- Polyesteramide (PEA)
Biobased Content:
Fraction of the carbon content which is new carbon content made up of biological materials or agricultural resources versus fossil carbon content.

Biobased content is measured following the procedures set by ASTM D-6866.
A plastics that undergoes biodegradation, a process in which the degradation results from the action of naturally-occurring micro-organisms such as bacteria, fungi and algae, as per accepted industry standards such as ASTM D6400 (Bioplastics), ASTM D6868 (Papers), ASTM D7081 (Marine) or EN 13432.
Environmental Impact
Compostable vs. Biodegradable

Difference is rate Of Biodegradation
- Time
- Temperature
- Environment (moisture)

Vs.

Biodegradable
Degradation vs Biodegradation

Degradation or Fragmentation:
- Plastics
  - Sun
  - Moisture
  - Soil
  - Polymer Fragments or Residues

Biodegradation:
- Plastics
  - Temperature
  - Moisture
  - Soil
  - CO₂
  - H₂O
  - Humus
  - Microbes

Rate of biodegradation is time, temp & environment dependent

Other visual aesthetics pleasing
No environmental benefits

Positive environmental benefits
Life Cycle Analysis
GHG Reduction for HDPE

Positive Environmental Benefits

(1) GHGenius Feedstocks, Power, Fuels, Fertilizers and Materials p.25 Table 4.10
(2) Canadian Raw Materials Database, University of Waterloo, http://crmd.uwaterloo.ca/
(3) Canada’s National Inventory Report 1990-2004,
(4) Canada’s GHG Verification Center, 2004
Types of Bioplastics

Typical Markets and Applications
## Classification of Bioplastics

<table>
<thead>
<tr>
<th>Non-biodegradable</th>
<th>Fossil-based</th>
<th>Bio-based = Renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PVC</td>
<td>Starch/Polyolefin (Teknor, Cereplast)</td>
</tr>
<tr>
<td></td>
<td>Commodity Plastics</td>
<td>Bio-PE (Braskem)</td>
</tr>
<tr>
<td></td>
<td>Engineering Thermoplastic</td>
<td>Bio-PVC (Solvay)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bio-Polyurethane (Merquinsa)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polyamide 11 (Arkema)</td>
</tr>
<tr>
<td></td>
<td><strong>Terraloy™ Compounds</strong></td>
<td></td>
</tr>
<tr>
<td>Biodegradable</td>
<td>PBAT (BASF)</td>
<td>Starch based/PLA blend (Teknor)</td>
</tr>
<tr>
<td></td>
<td>Starch/PBAT (Teknor, Novamont)</td>
<td>PLA (NatureWorks)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PHA (Metabolix/Telles)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PLA Blend (Teknor, FKuR)</td>
</tr>
</tbody>
</table>
Automotive Market

Products Used
• Soya based
• Wheat Straw
• Bio-filled PP
• PLA
• PLA reinforced
• Bio-based TPU
• PA11

The 2010 Ford Fusion Hybrid
A soy-based foam seat.
(Ford Motor )

Source: Ford
Consumer Durable market
- Electronics

Products Used
- PLA
- PLA/Kenaf reinforced
- PLA/PC
- PA11

Typical Applications:
- Mobil Phone
- Laptop
- Camera components

Fujitsu's bioplastic
FMV-BIBLO
PLA Based

Source: Samsung
PLA
### Consumer Market

<table>
<thead>
<tr>
<th>Products Used</th>
<th>Typical Applications:</th>
</tr>
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<tbody>
<tr>
<td>• PLA</td>
<td>• Toys</td>
</tr>
<tr>
<td>• PLA Kenaf reinforced</td>
<td>• Writing Instruments</td>
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<tr>
<td>• Starch blends</td>
<td>• Beauty Products</td>
</tr>
<tr>
<td>• PHA, PHB, PHBV</td>
<td>• Baby Products</td>
</tr>
<tr>
<td>• PBS</td>
<td>• Containers/Buckets</td>
</tr>
<tr>
<td>• PBAT blend</td>
<td></td>
</tr>
</tbody>
</table>

**Products Used:**
- PLA
- PLA Kenaf reinforced
- Starch blends
- PHA, PHB, PHBV
- PBS
- PBAT blend

**Typical Applications:**
- Toys
- Writing Instruments
- Beauty Products
- Baby Products
- Containers/Buckets

- Papermate biodegradable Pen made from Mirel
- Teknor Apex
- Green Toys Brand Toys made from Starch blend
  
  Source: www.babble.com/
Agriculture/Horticulture Market

**Products Used**
- PLA blend
- PBS
- PBAT
- Starch/PBAT
- PHA

**Typical Applications:**
- Mulch Film

- Mirel PHA Mulch film
- PLA based Mulch Film
- Novamont Starch/PBAT Mulch film
Bottle Market

Products Used
• PLA
• PLA Blend

Typical Applications:
• Water Bottle
• Soda bottle

NatureWorks PLA

PLA Bottles
Source: www.petrecycling.cz/

Source: www.packaging-int.com
Food Service Market

**Products Used**
- PLA
- Starch based blend
- PLA blend
- PHA, PHB, PHBV
- PBS

**Typical Applications:**
- Cups
- Lids
- Containers
- Caps
- Straws
- Clamshell
- Cutlery

http://www.buygreen.com

NatureWorks PLA
Film Market

Products Used
• PLA
• TPS blends
• PBAT
• PBAT Blend
• Cellulose Acetate
• PHA blend

Typical Applications:
• T-Shirt bag
• Can liners
• Organic waste bag
• Carrier bag

Teknor Apex
Starch based Trash bag

Teknor Apex

Organic waste bag
Source: BASF
Packaging Market

Products Used
• PLA
• TPS blends
• PBAT
• PBAT blends
• PBS
• Cellulose Acetate

Typical Applications:
• Food Packaging
• Rigid Packaging

Cellulose Acetate
PBAT
NatureWorks PLA
NatureWorks PLA
Fibers Market

**Products Used**
- PLA

**Typical Applications:**
- Clothes/Apparel
- Carpet
- Furnishings
- Non-woven
- Industrial

This comforter is part of a new, environmentally friendly bedding collection, comprised of corn-derived NatureWorks™ fibers and developed by Pacific Coast Feather Company. Source: Textile News
Summary

• Bioplastics is a growing industry and continue to gain ground in numerous markets and applications
• Bioplastics can be bio-based or petroleum based and may or may not be biodegradable
• Environmental benefits for using Bioplastics include
  – Reducing dependency of petroleum based products
  – Some Bioplastics are biodegradable or compostable thus adding environmental benefits
  – Bioplastics products has “less” GHG than petroleum based products
• Teknor Apex has a diverse Bioplastics product portfolio that will balance price, performance and processing to meet your sustainability goals
Photo for the parts are taken from public websites, they include companies such as BASF, Biobags, Ford Motors, Frito Lay, Fujitsu, Metabolix, NatureWorks, Novamont, Samsung etc. The parts shown in these photos are not made from Teknor Apex Company’s resins, if you want to know more about their products, please contact these companies directly.
Questions and Comments

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