BIOCYCLE – Sustainable polymer from sugar cane

PHB INDUSTRIAL S/A

BIOENERGY II
08 - 13 March, 2009
Rio de Janeiro - Brazil
Petro based Products – Life Cycle Assessment

Global Warming

Oil Extraction

Plastics Production
BIObased Products – Life Cycle Assessment

Rescue – 4.400 kg CO2/ton of PHB - Biocycle

Bioplastic Production

Biomass Growth
BIObased Products – Life Cycle Assessment

Positive Environment Impact

Biomass Growth
Biorefinery Concept

- Sugar Cane
  - Energy
  - Compost
  - Discharge

- Sugar Mill
  - Boilers
  - Bagasse

- PHB Production
  - Solvent
  - Sugar
  - Compost

- Final Product
  - Polímero
  - Energy

- Ethanol
  - CO
  - CO₂

- Destilaria
- Molasses
## GHG (GreenHouse Gas) in the sugar cane, sugar and ethanol production

- **Activities 1: Production, harvest and sugar cane transport**
  - $+425.2$ kg CO$_2$/Ton of Sugar Cane

- **Activities 2: Industrialization of Sugar Cane: Production of Sugar and Ethanol (45% Sugar, 55% Ethanol)**
  - $-169.0$ kg CO$_2$/Ton of Sugar Cane

- **Activities 3: Final Products utilization (Sugar and Ethanol)**
  - $-49.4$ kg CO$_2$/Ton of Sugar Cane

**Total Avoided Emissions**

- $+206.8$ kg CO$_2$/Ton of Sugar Cane

**Average production of sugar cane (ton) per hectare**

- $85.00$ ton

**Total Avoided Emissions (kg CO$_2$) per hectare**

- $+17.578$ kg CO$_2$

**Source:** Unicamp / CTC - Copersucar
Biocycle is a net CO2 consumer / cleaner, when considered the entire lifecycle

<table>
<thead>
<tr>
<th>Product</th>
<th>CO2 (kg) per Ton of Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHB – Biocycle (from sugar cane)</td>
<td>4.400</td>
</tr>
<tr>
<td>Biopolymer (year 10)</td>
<td>3.086</td>
</tr>
<tr>
<td>Biopolymer (year 3)</td>
<td>1.654</td>
</tr>
<tr>
<td>Biopolymer (year 1)</td>
<td>(1.764)</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>(2.041)</td>
</tr>
<tr>
<td>Polystyrene (general purpose)</td>
<td>(3.017)</td>
</tr>
<tr>
<td>PET Aus</td>
<td>(4.567)</td>
</tr>
<tr>
<td>Nylon 6.6</td>
<td>(7.877)</td>
</tr>
<tr>
<td>Cellulose</td>
<td>(14.363)</td>
</tr>
</tbody>
</table>

Source: Cargill Dow LLC; PHB Industrial Analyses
Historical Prices

Prices Sugar, Corn and Oil

Base = 100

- Light Crude Oil - Continuous Contract
- Corn - Continuous Contract
- World Sugar (CSCE) - Continuous Contract
Energy Balance

Fossil-fuel energy used to make the fuel (input) compared with the energy in the fuel (output).

Corn Ethanol

Input (fossil – fuel)

Output

1.3

Sugar Cane Ethanol

Input (fossil – fuel)

Output

8.0
The Consequence Therefore Is:

- Polymer Production from Renewable Resources
- Minimization of Energy Input from Fossil Resources

Production via „WHITE BIOTECHNOLOGY“
The PHB production consumes only 10% of the energy no renewable used in the PP production process. The renewable energy sources used in PHB production process include the sugar cane, the sugar, the solvent and all the utilities.

During the whole process (Life cycle – Production, use, discharge) the PHB uses almost only renewable energy sources.
Scale 20 m³ Production Reactor
Sugar Cane Field
Sugar Cane Crop
Sugar Cane Crop
Sugar Cane Reception
Sugar
Ethanol
Cogeneration – Renewable Energy
Highlights

- A fully biodegradable biopolymer has been produced from fully renewable materials and source of energy, in an industrial pilot-plant in Serrana / Brazil

- A set of patents have been filed / published to protect the intellectual capital developed regarding PHB manufacturing and commercialization and also compounds and blends

- PHB has been successfully tested in blends and compounds to replace traditional plastics, specially PP, PS and PU

- PHB has been processed in traditional plastics manufacturing equipment to successfully produce parts and pieces to the market – extrusion, thermo forming, injection, coating paper
Such tests identified the technical characteristics of the base polymer that can be improved through polymer blends and alloys with PHB.

- Processing Technology – viscosity, crystallization and reactive extrusion
- Mechanical Properties – tensile strength and impact resistance
- Thermal Properties – heat deflection, melting point, glass transition and decomposition
- Biodegradability – velocity and rate
- Cost
Biocycle® Process Technology
As result of investments and technology studies – PHBISA has managed to manufacture pre-commercial scale – a list of products based on PHB

<table>
<thead>
<tr>
<th>Traditional Polymer Replaced</th>
<th>Process</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene</td>
<td>Extrusion, Thermoforming, Injection</td>
<td>Recipients for nursering crops, Automotive parts, Parts to crop monitored growth, Toys, Packaging parts – caps</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>Thermoforming</td>
<td>Trays for plants, Disposable cutlery</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>Injection, Extrusion</td>
<td>Elastomers and foams, – Isolation (construction), – Shoes, – Automotive parts</td>
</tr>
<tr>
<td>ABS</td>
<td>Extrusion, Thermoforming</td>
<td>Banking cards</td>
</tr>
</tbody>
</table>

Such products have been obtained through joint efforts with potential clients – Automotive manufacturers, pulp and paper producers, etc...
Polymers, fillers and natural fibers blends with PHB were tested

- Copolyesters
- Poly(caprolactone)
- Poly(lactic acid)
- Wood Powder
- Starch
- Sugar Cane Fiber
- Sisal Fiber
- Others
Cosmetic Packaging
Packaging Caps
Poliuretanos
Fibras
Espuma
Chapas para Termoformagem
Cartões

CARTÕES DERIVADOS DA CANA-DE-ÁÇUCAR / CARDS MADE FROM SUGAR CANE

Características:
- Recurso renovável e não renovável.
- Reciclável e uso de recursos fósseis.
- Biodegradável.
- Química:
- Cartão plástico produzido com PHB.

Principais aplicações:
- Cartões comerciais;
- Cartões presentes;
- Cartões pré-pagos.

Características:
- Resíduos de material de origem renovável.
- Reciclável, uso de recursos fósseis.
- Biodegradável.
- Composto à base de PHB.
- Plástico produzido com PHB.

Main Applications:
- Commercial cards;
- Gift cards;
- Prepaid cards.

Cartões derivados da Cana-de-áçúcar
Coating Paper
APlicações Automotivas
APLICAÇÕES AUTOMOTIVAS
APLICAÇÕES AUTOMOTIVAS
APlicações automotivas
Braçadeiras para Crescimento Monitorado
Tubetes para Reflorestamento
Seedling Recipient – Eucalyptus

35 days – Nursery fase
Seedling Recipient – Eucalyptus

90 days
Seedling Recipient – Eucalyptus

120 days
Amostras de Produtos
Amostras de Produtos
Certification

- The BIOCYCLE has been certified by Din Certco and AIB-Vinçotte as a biodegradable and compostable material
NOTIFICATION OF REGISTRATION

The company

PHB Industrial S/A
Fazenda Da Pedra, S/N
14150-000 SERRANA – SP
BRAZIL

hereby receives the confirmation that the product's
Compostable material
of the type
BIOCYCLE 1009
conforms to
DIN EN 13432:2000-12
Certification scheme products made of compostable materials

Registration No.: 7W0079

This Notification of Registration is valid in connection with above stated Registration No.
for an unlimited period and becomes ineffective only upon termination.

See annex for further information.

DIN CERTCO Gesellschaft für Konformitätsbewertung mbH
Albertstraße 59, 12105 Berlin

2007.07.30

S. Schatz
Acting Head of Certification Body

For the product(s) described hereafter:
Product group: Biodegradable
Product family: Basic material
Make: Bicycle
Type(s): Bicycle 5000
Particulars: Granulation of powder for film with a minimum thickness of 542 μm
grade: W02

Conformity examination applied for by:
P.H.B. Industrial S/A
Fazenda Da Pedra, S/N – PO BOX 02
14150-000 Serrana – São Paulo
BRAZIL

Criteria for certification:
- All test Program with reference 01.01.1.01.001
- Requirements for packaging accepted through a joint cooperation – Test scheme and evaluation criteria for the Sertifikat Verpackungsgüte

Validity of the certificate:

Conclusions of the examination:
The products comply with the above mentioned certification criteria, as confirmed by the test report of AIB no O 09/99 001 (07/3200)

Applicable certification system:
Type examination followed by supervision through verification tests on samples from the distributor's stock.
The conformity of the product is guaranteed by the procedure for awarding and use of the "OK Compost" conformity mark. This only applies to specimen bearing the "OK Compost" mark.

This certificate is issued in English.

Dorge Van Gestel
Contract Manager

Philippe De Vos
President of the Committee

Brussels, 15 February 2007,
Thank you!

Sylvio Ortega Filho

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