European BioPlastic Perspective

Bio Based Chemical Symposium
Edmonton, February 17, 2010

Martien van den Oever, et al.

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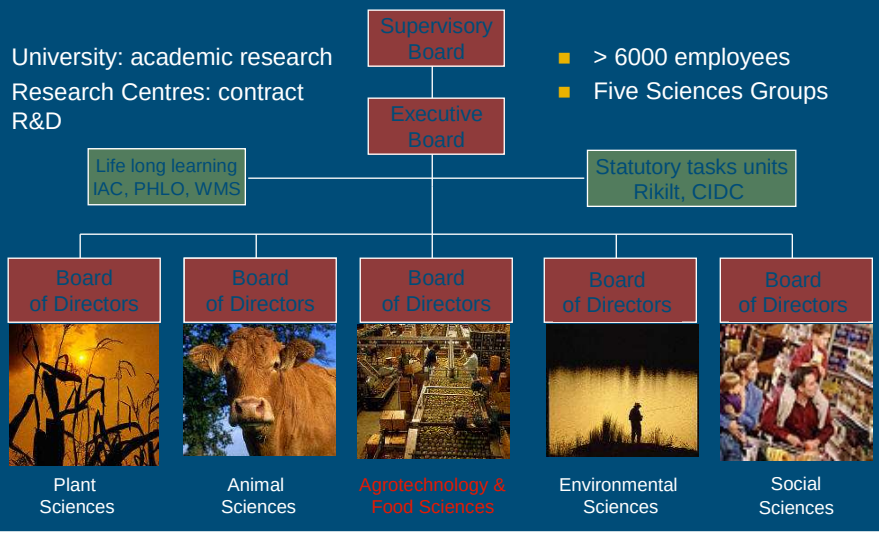
Wageningen University & Research Centre

- University: academic research
- Research Centres: contract R&D



- > 6000 employees
- Five Sciences Groups

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Wageningen UR - Food and Biobased Research

- AFSG: ~ 1000 employees
  - University: ~ 700
  - Research Centre: ~ 300
- FBR: two business units
  - Fresh, Food & Chains
  - Biobased Products
- BU Biobased Products
  - Biomass conversion technologies
  - Renewable chemicals and materials development

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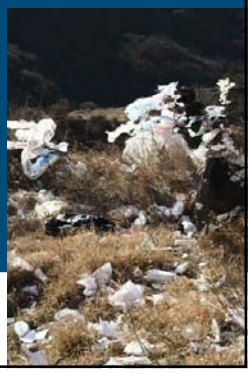
Definition of BioPlastic

- BioPlastic is a collective term
- Referring to Source of material
  - Building blocks are mainly of Bio Based origin
  - Not necessarily Biodegradable
- Referring to Functionality: BioDegradable
  - building blocks may be derived from fossil oil



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Biodegradable vs. Biobased materials

Raw materials	Finished product: Non-biodegradable	Finished product: Biodegradable
Non Renewable	Traditional PE, PP PET	Ecoflex (BASF) Bionolle (Showa Denko)
(partly) Renewable	Rilsan (Arkema) Sorona (Dupont) Bio – LDPE (Braskem)	PLA (Natureworks) Starch based (BIOP) PHB (Biomer)

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Biodegradable plastics

- Biodegradation: degradation catalyzed by biological activity leading to mineralization and/or biomass
- Biodegradability: degree to which biodegradation leads to mineralization and/or biomass
- Mineralization: the conversion of (organic) constituents in naturally occurring gasses, water and inorganic constituents

- Standardisation and certification is very important!
- Demands for biodegradable products are described in EN13432

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Biobased plastics

- Renewable or biobased polymers are polymers from which the raw materials originate directly or indirectly from nature
- Classification of biobased polymers:
  - (Modified) natural polymers
  - Directly from micro-organisms or gene-modified crops
  - From biobased feed stock (eg via fermentation)
- Biobased plastics ≠ biodegradable plastics

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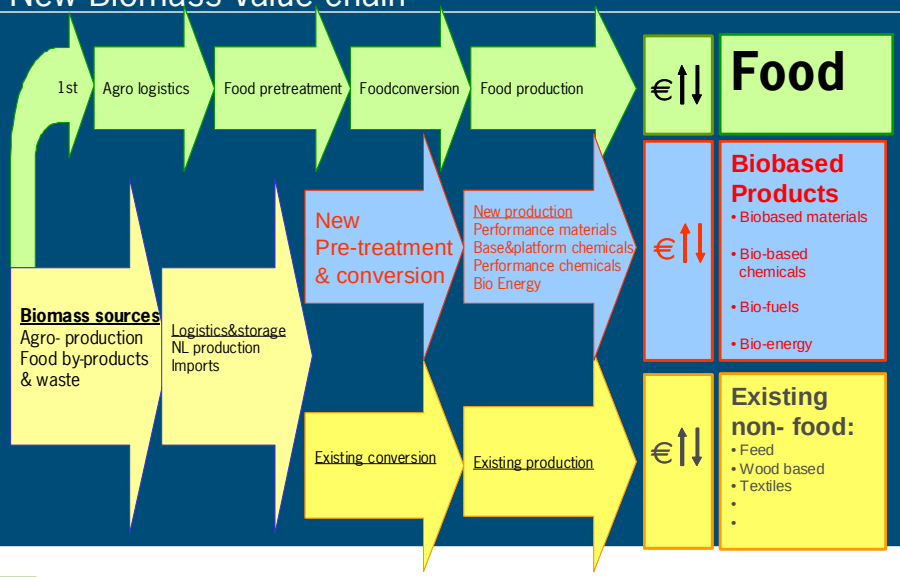
New Biomass value chain



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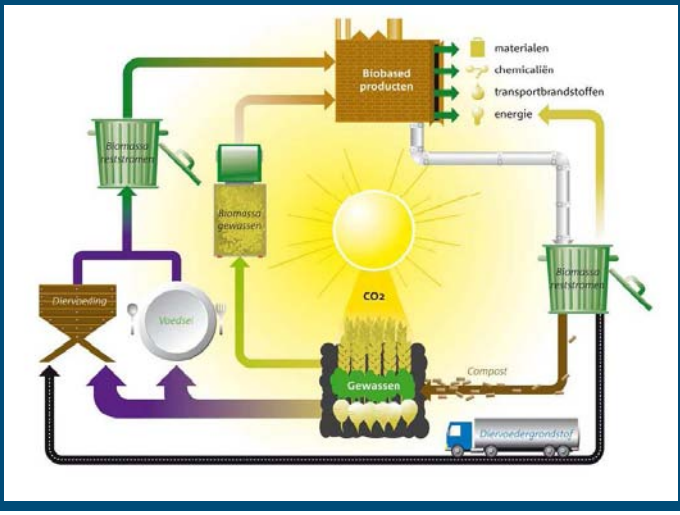
Competing Food, Fuel (energy), Future (environment)

Dutch Government vision Biobased Economy



Biorefinery

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Efficient use of Biomass

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Polymers with biobased content

Plastics

- Starch
- PLA
- Cellulose esters
- PHA
- Other polyesters
- Polyamide

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Trends in product development

First generation film — xth generation film

- Research topics
  - Specialty products: (hot fill materials/microwavable materials
  - Coextruded/laminated/blended structures (e.g. barrier bottles, films, sheets)
  - Foamed structures (3-D products)
  - Reduction of the price of the material
- Try to maximize the added value of biodegradable materials by using a series of positive properties

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Starch based bioplastics

Advantages:

- Good mechanical properties (properties vary from LDPE-like till polystyrene-like)
- Materials have excellent gas barrier properties (comparable with PET, nylon)
- Anti - static
- Foaming possible without extra foaming agents
- Speed of degradation can be adjusted by changing the composition
- (partly) renewable

Disadvantages

- Materials behave humidity dependent
- Films are not completely transparent

Price: 2-5 €/kg

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Starch Processing aspects

- Can be processed as delivered, do not dry this material, in many cases water is an essential part of the composition
- Can be used for:
  - Film blowing (mono- or multilayer)
  - Injection moulding
  - Sheet extrusion (and thermoforming)
  - Foam extrusion
- Processing temperatures: 120 to 180 °C

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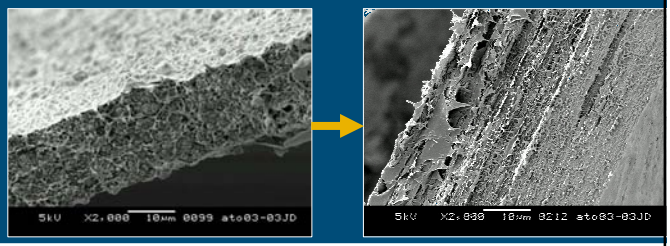
Starch Developments

- Compatibilization of blends
- Reduce costs: Increase starch content
- New sources for starch: in paper industry
- Improve properties: co-continuous structure
  - Impact strength
  - Barrier properties
  - Transparency



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PLA

Advantages:

- Good mechanical properties (mechanical properties are comparable with PET)
- Transparent
- Good UV resistance (better than PET)
- Rather cheap in comparison with other biodegradable material (1.8 – 2 €/kg)
- Renewable

Disadvantages

- The material doesn't degrade at temperatures below 45 ℃
- The material is sensitive for water during processing

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PLA Processing aspects

- For good product properties the material has to be dried
- Can be used for:
  - Film extrusion (and thermoforming)
  - Blow moulding
  - Injection moulding
  - Fibre extrusion
- Processing temperatures: 170 to 240 ℃

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PLA Developments

- Plasticizers
  - Modification of properties and processing
- Chain extenders
  - Increase melt viscosity, expand processing possibilities
  - Recycling of PLA
- Nucleating agents
  - Crystallization rate, enhance high temperature properties

Hot coffee in PLA cup for cold drinks

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PLA Developments

- Impact modification
  - Injection moulding
  - Toughness of films
- Natural fibre - PLA composites
  - Mechanical performance
  - Degradability
- Copolymerization
  - Modification of properties

Formulation & processing conditions

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Chain extenders: processing of PLA

Without rheology modifier

With rheology modifier

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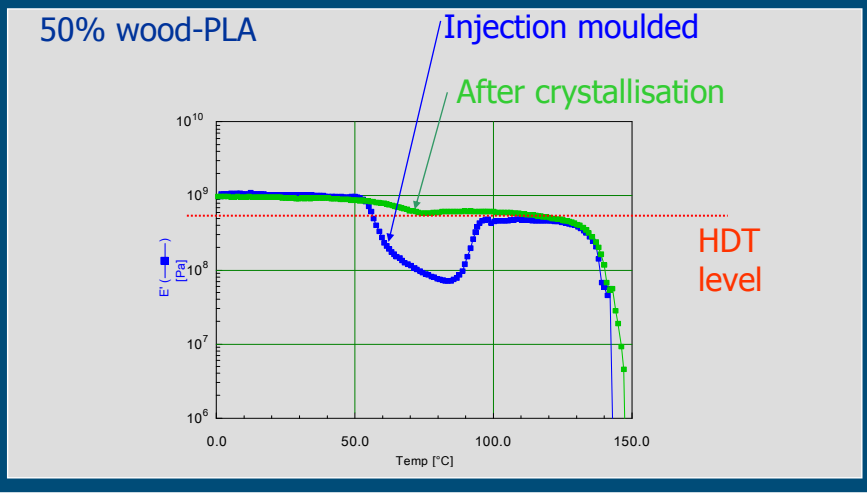
PLA composite materials



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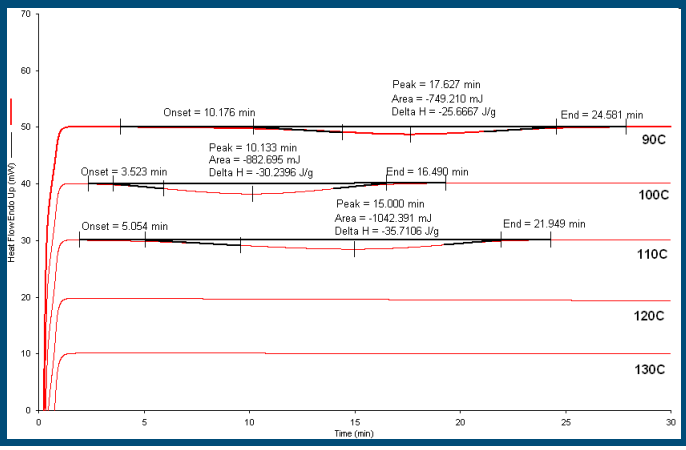
Nucleating agents; DSC measurements

- PLA 4032D



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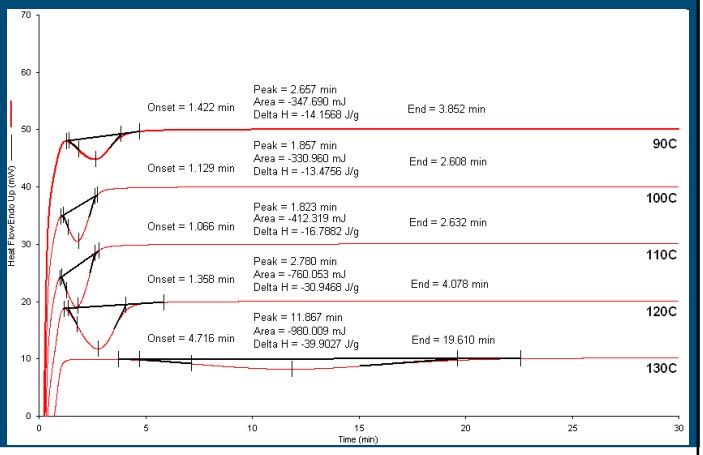
Nucleating agents; DSC measurements

- PLA 4032 + Nucleating agent



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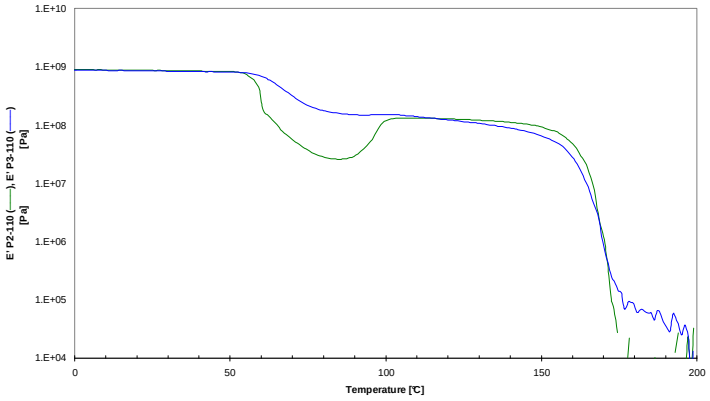
Nucleating agents: DMTA



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PLA Application: Thermoformed products

- High HDT
  - PLA type
  - Nucleation
  - Processing

Desch Plantpak

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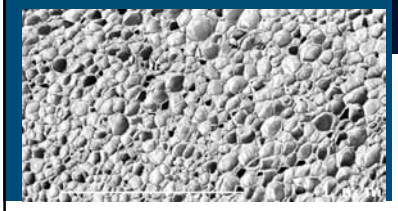
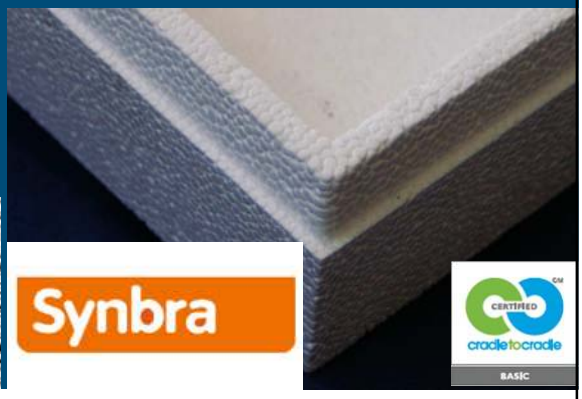
PLA Application: 3D-foamed structures

- Expandable bead technique
  - Good cell structure
  - Density <30 g/l





Synbra

cradle to cradle CERTIFIED BASIC

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PLA Application: PLA composite materials

- Large injection moulded panels
  - Excellent strength
  - Good impact
  - Good processing

GreenGran
Serving the bio-based economy

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Cellulose acetate

Advantages:

- Good mechanical properties (rather stiff material comparable with PS)
- Material can be capable to withstand boiling water
- Glossy transparent appearance (in most cases)
- Renewable

Disadvantages

- Plasticizer needed
- Price: 3-7 €/kg

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Cellulose Processing aspects

- Can be processed as delivered, better is drying of the material
- Can be used for:
  - Injection moulding
  - Sheet extrusion (and thermoforming)
  - Fibre extrusion
- Processing temperatures: 190 to 240 ℃
- Thermal degradation during processing possible

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PHA

Advantages:

- Mechanical properties can be varied from elastomeric to PP
- Rather hydrofobic (low water vapour permeability)
- Rather high HDT-temperature (> 100 ℃)
- Renewable

Disadvantage

- Low melt strength
- Price: > 4 €/kg

Processing

- Suitable for:
  - Injection moulding
  - Sheet extrusion (and thermo forming)
  - Film blowing, Film casting

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Furan resin based wood modification

Impregnation
Curing & Drying

LOW VALUE WOOD
- Easily biodegradable
- Mostly soft (European Species)
- Moisture sensitive
- Inconsistent quality

NATURAL RESINS
processed from plant waste
- Sugar canes
- Corn cobs
- Wood

HIGH QUALITY WOOD
1. Increased lifetime
2. Increased mechanical properties
3. Consistent quality & supply
4. Environmentally friendly

Resins from Biomass

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Furan resin is also used in (metal) casting industry, and as a binder for substrate mats in horticulture

Towards biodegradable products

Biodegradable product

=

1. Biopolymer +
2. Additives +
3. Processing +
4. Assemblage (glue tape) +
5. Marketing (inks, labels)

Integral approach is important!

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Examples of (existing) agricultural applications

Concluding remarks

- Consumer trends ask for new packaging/material concepts, Natural polymers can add to a solution
- Biopolymers are increasingly available from various suppliers
- Properties of polymers can be modified, opening new processing routes and applications
  - Effect depending on polymer grade and processing conditions
  - Properties include: biodegradability/compostability, mechanical, thermal and barrier properties, clarity
- Product development requires integrated approach:
  - polymer + additive + processing + assemblage (glues) + marketing (inks)

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Thank you for your attention

With contributions from:
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