

Growing and Strengthening the Biobased Chemicals Industry

USDA BioPreferred™ Forum

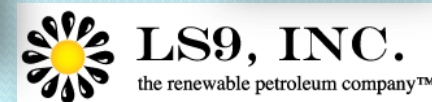
April 1, 2010





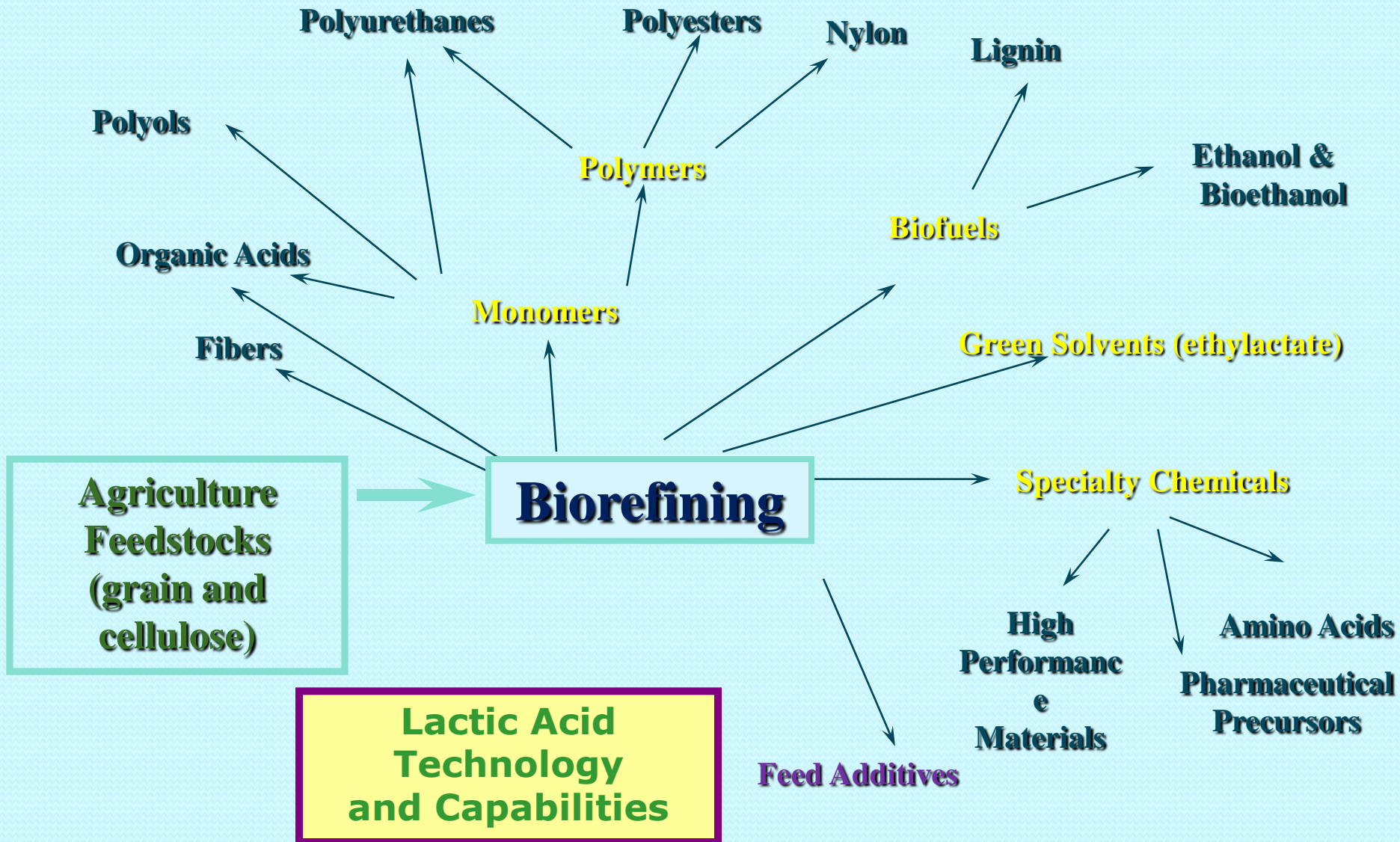
Rina Singh, PhD
Director Policy
Industrial and Environmental Section

Some Industrial and Environmental Section Members

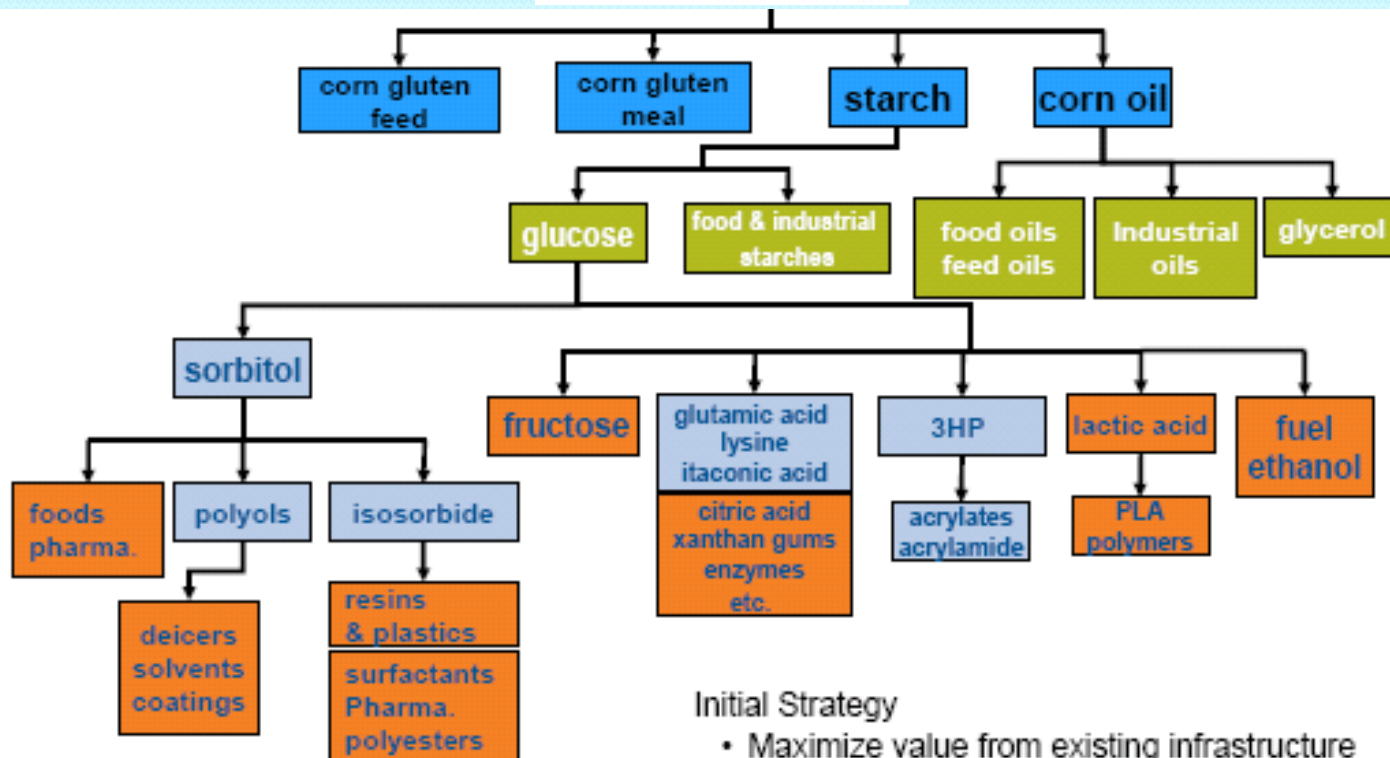


Biorefining

It's Not Just About Ethanol!



Example of a Bio-refinery: Wet Mill



Examples of Biochemicals & Biopolymers

- Butanol
- Isobutanol
- Ethanol
- Acrylic Acid
- Propylene Glycol
- 1,3-Propanediol
- Glycolic Acid
- Acetic Acid
- Caprolactam
- Hydroxy Alkanoates
- Adipic Acid
- Isosorbide
- Acrylamide
- Fumaric Acid
- Isosorbide
- Succinic Acid
- 1,4-Butanediol
- Methyl Ethyl Ketone
- Isoprene
- Ethyl Acetate
- Algae Based Chemicals
- Itaconic Acid
- SAP
- Acetone
- PLA
- PHA
- PVC
- PET
- UPR

Bio-Derived Plastics - First Wave

Recent Advances In Renewable Chemicals
DuPont, NatureWorks, Dow

	DuPont Bio-PDO (Serona®)	NatureWorks™ PLA	Dow/Crystalev JV
Plant Scale	45 kTA	140 kTA	350 kTA
Fermented Product	1,3-Propanediol	Lactic Acid	Ethanol
Key Processes	Fermentation, Condensation Polymerization	Fermentation, Oligomerization, Ring-Closing, & Ring-Opening Polymerization	Fermentation, Dehydration, Polymerization
Initial Product	PDO/TPA Copolymer	Polylactic acid	Ethylene, Polyethylene, Copolymers
Flexibility	Moderate	Low	High

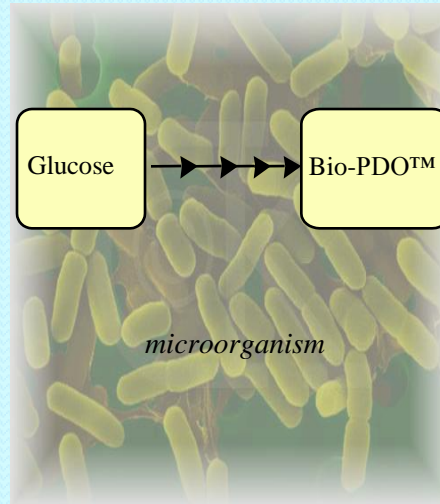
Availability of New Renewable Raw Materials

Example: Conversion of glucose to 1,3-propanediol (PDO)

TATE & LYLE
CONSISTENTLY FIRST IN RENEWABLE INGREDIENTS

DU PONT
The miracles of science™

DuPont Tate & Lyle
Susterra™
renewably sourced™ propanediol

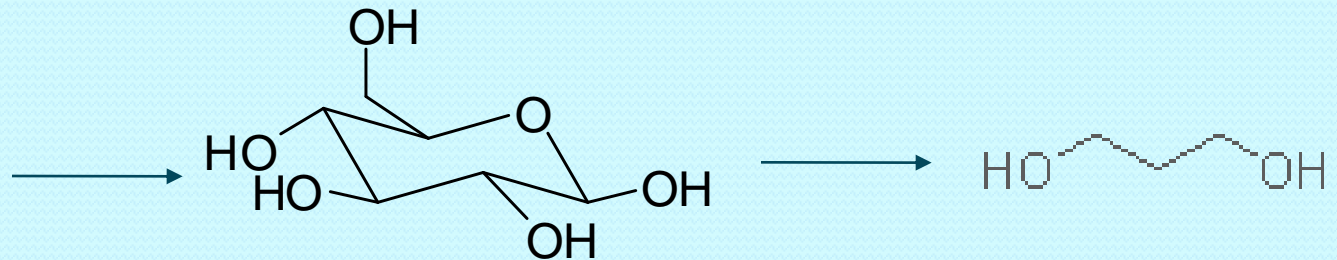


Ferment glucose to PDO
using patented microorganism

Refine to 99.7% purity



Corn



Glucose

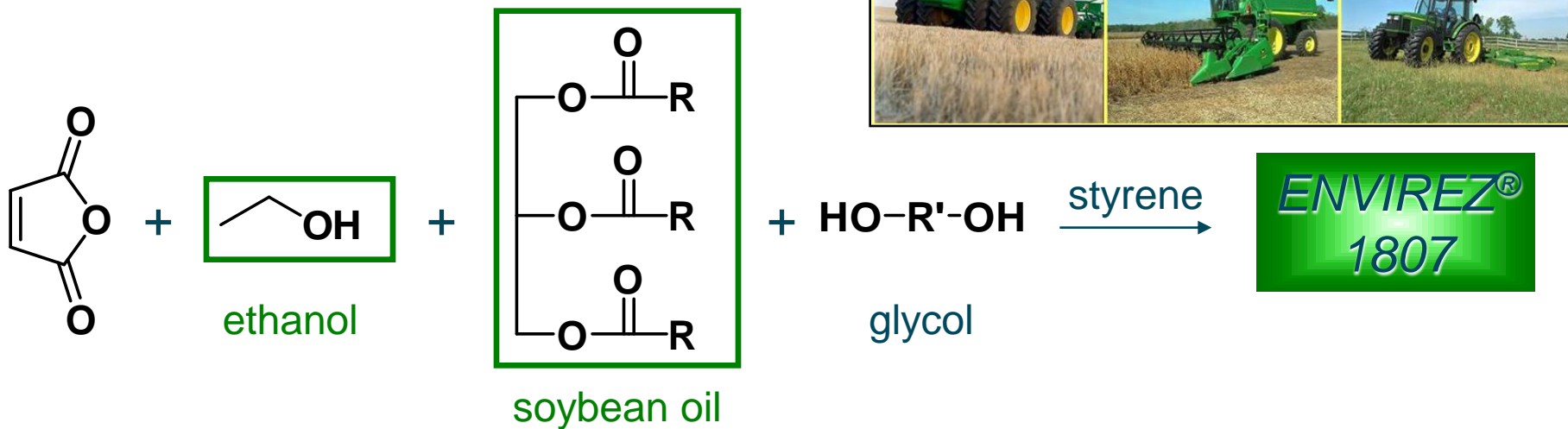
1,3 Propanediol

Courtesy of DuPont Tate & Lyle BioProducts LLC

¹Susterra is a trademark of DuPont Tate & Lyle BioProducts LLC

ENVIREZ[®] Resin Platform

- Ashland developed the first commercially available bio-based product in 2003
 - ENVIREZ 1807 Resin was first used in SMC applications.
 - This was originally developed by Ashland at the request of the United Soybean Board and John Deere



- Ashland continues to invest in the research and development of green resins
 - Commercial products are now available for SMC/BMC, pultrusion, casting, infusion, and general laminating

Solid Surface Counters USDA BioPreferred Listing

- Using ENVIREZ SS 70419 Resin
- Application listed on USDA BioPreferred procurement database
 - “Vendura solid surface material manufactured with bio-resin supplied by **Ashland Inc.**”



Sinks and Surfaces



- ENVIREZ SS 71301 Resin
- Won the 2009 ACMA Green Aces award

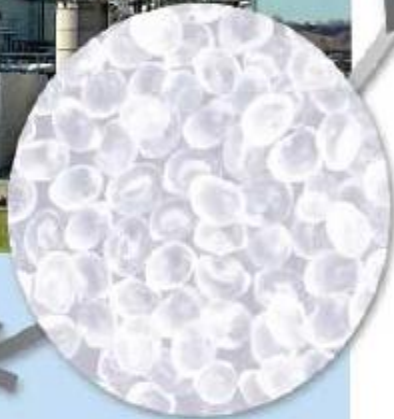


- Using ENVIREZ L86300 Series Resin
- Public announcement of full production – January 2010

Boat Hulls & Decks



Polylactic Acid (PLA)



- World's leading biopolymer player
- Proprietary PLA biopolymer marketed under the Ingeo trademark
- Competitive on a cost and performance basis with traditional plastics
- Superior environmental characteristics
- Significant manufacturing know how and an extensive IP position
- Established global market channels
- Over 20 applications in more than 70,000 store shelves globally
- Over 100 million pounds in annual sales volume
- Customers include Wal-Mart, Frito-Lay, and Coca-Cola

PLA Product Applications

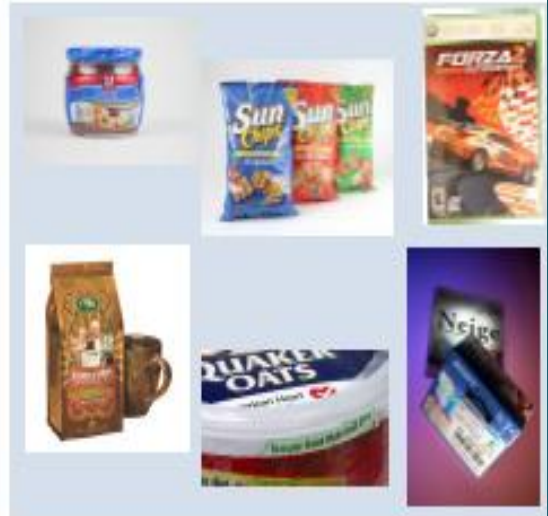
Fresh food packaging



Food serviceware



Films/cards



Beverages



Nonwovens/fibers

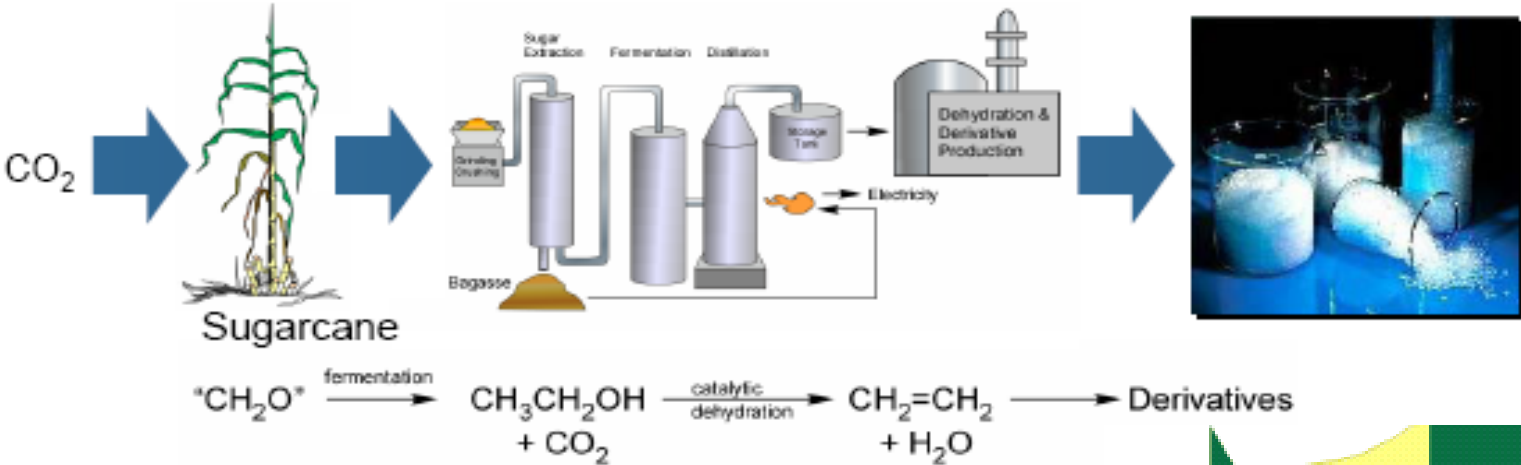


Durables

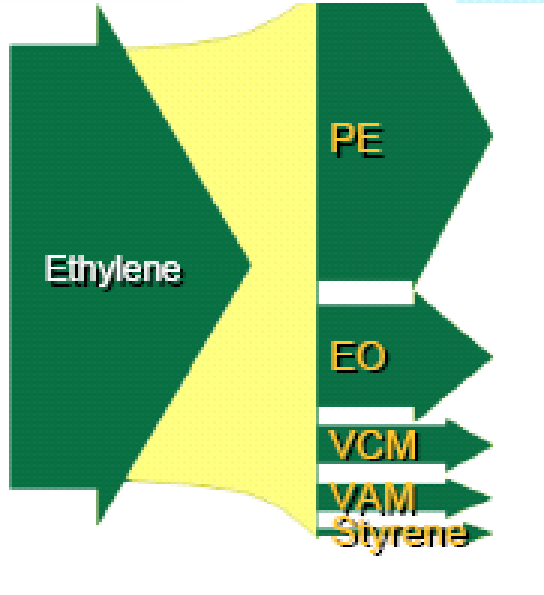


Dow Crystalev JV

Polyethylene from Cane - Brazil

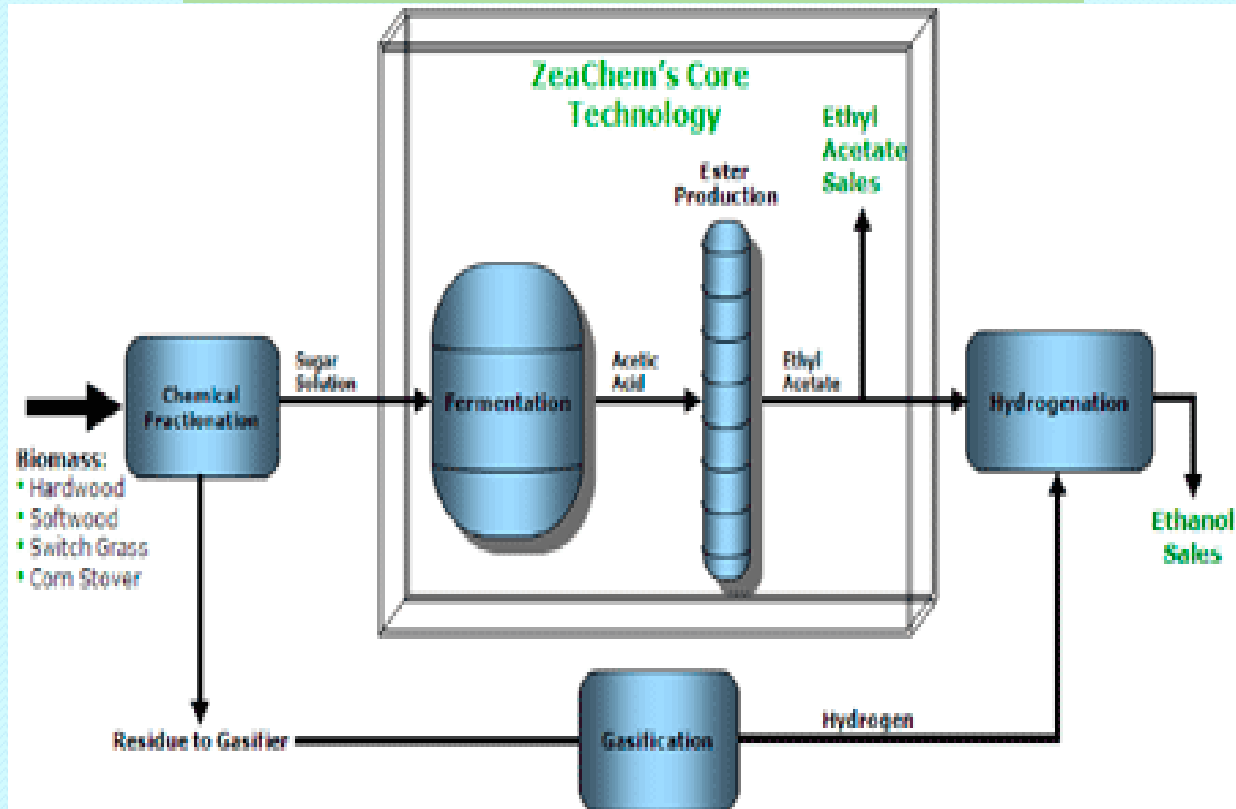


- 350 kT of LLDPE (700 MM lbs)
- 120,000 hectares of cane
- Recyclable plastic (CO₂ fixation)
- Cheaper than many fossil sources
- Lower capital footprint
- Walled off from oil volatility



Hybrid-biotech and thermochemical

Products - ethyl acetate and ethanol



The sugar stream (both xylose [C₅] and glucose [C₆]) is sent to fermentation where an acetogenic process is utilized to ferment the sugars to acetic acid without CO₂ as a by-product. In comparison, traditional yeast fermentation creates one molecule of CO₂ for every molecule of ethanol. Thus the carbon efficiency of the ZeaChem fermentation process is nearly 100% vs. 67% for yeast



Solvay Renewable PVC Production



From sugar and salt to make plastic

Solvay Indupa's Brazilian new plant (start in 2010)



60 Kton/ year of Bio-Ethylene and 125 Kton/year of Renewable PVC



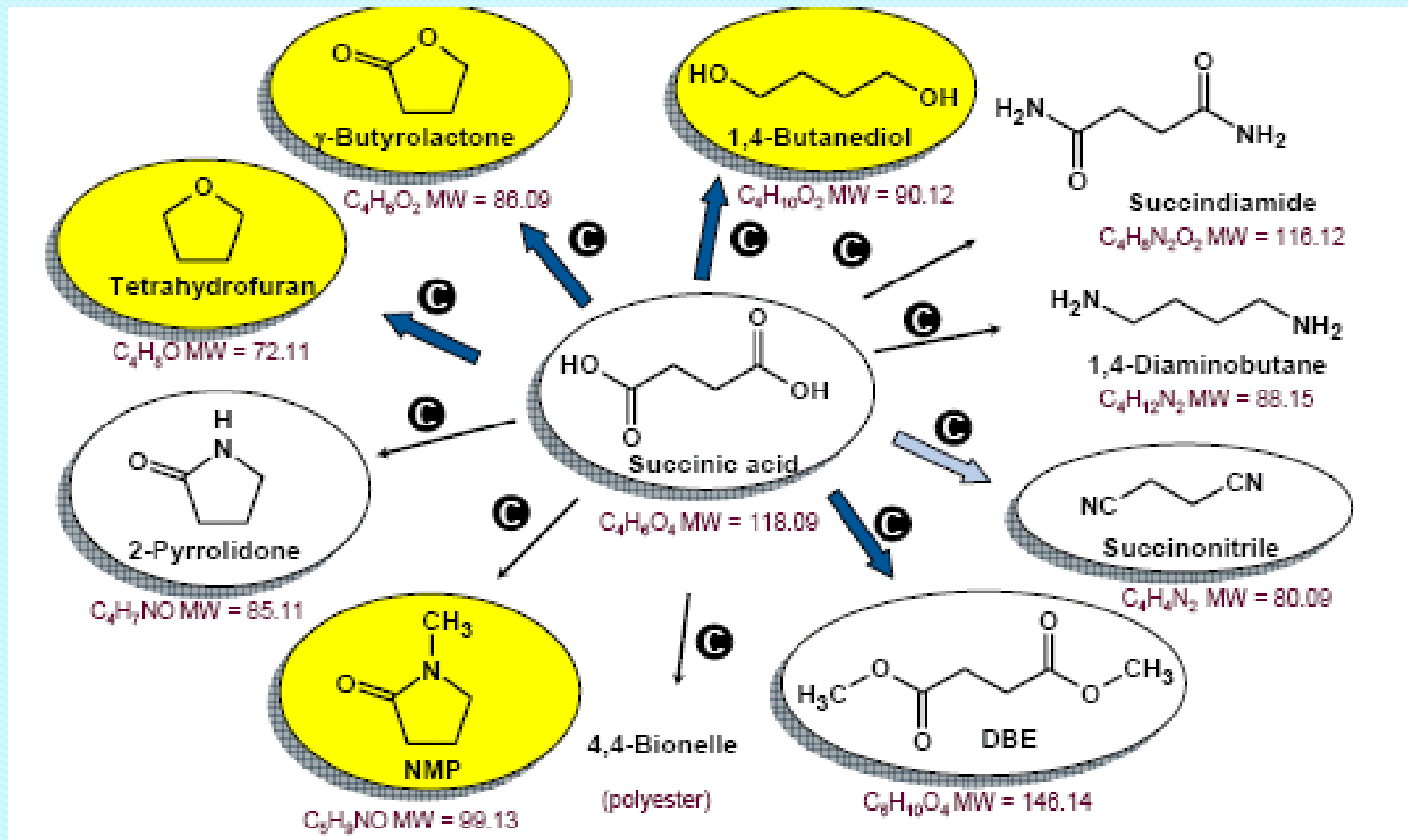
Reduction of 300 Kton/ year of CO₂ emissions

Second Wave Bioproducts Beyond Ethanol And Biodiesel

*Bio Conversion– Second Wave
Bioprocesses vs. Chemical Processes*

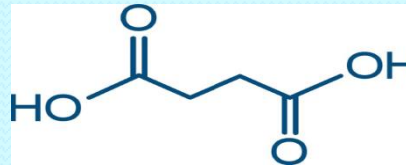
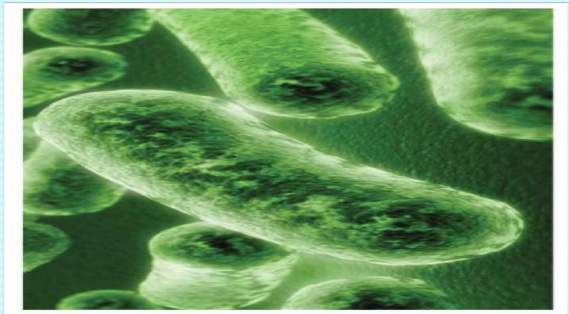


Succinic Acid Platform



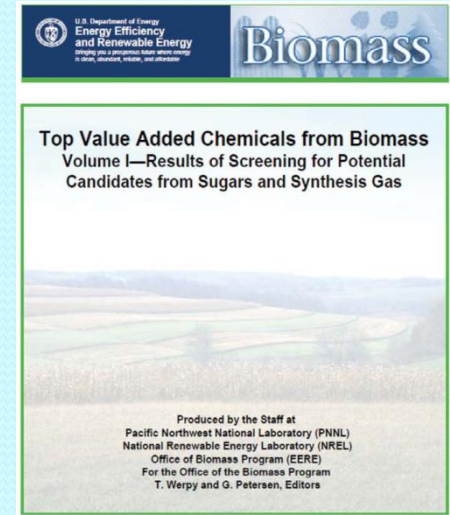
Production of Succinic Acid

Uses metabolic engineering and metabolic evolution to construct organisms that make high value, high purity, renewable chemicals such as succinic acid from sugar



Robust and Scalable Process for Succinic Acid

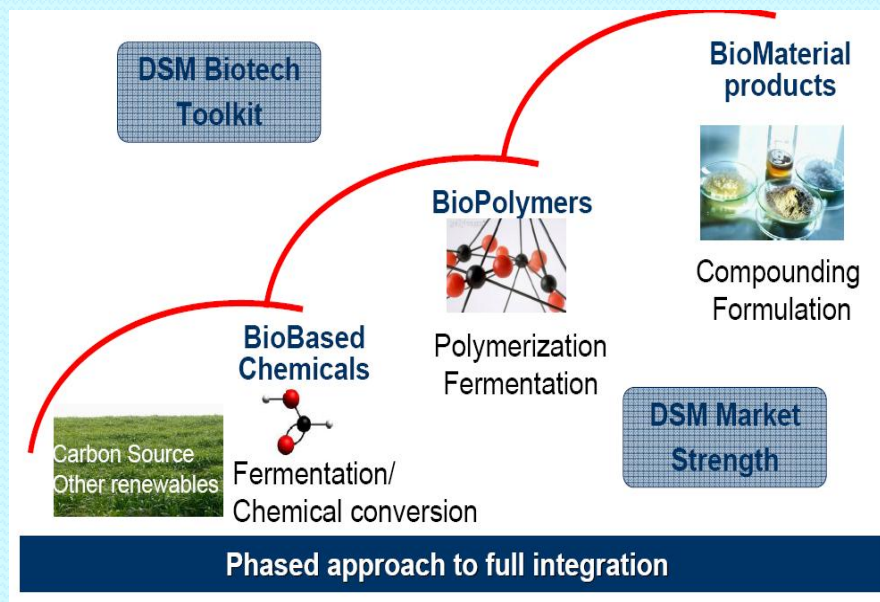
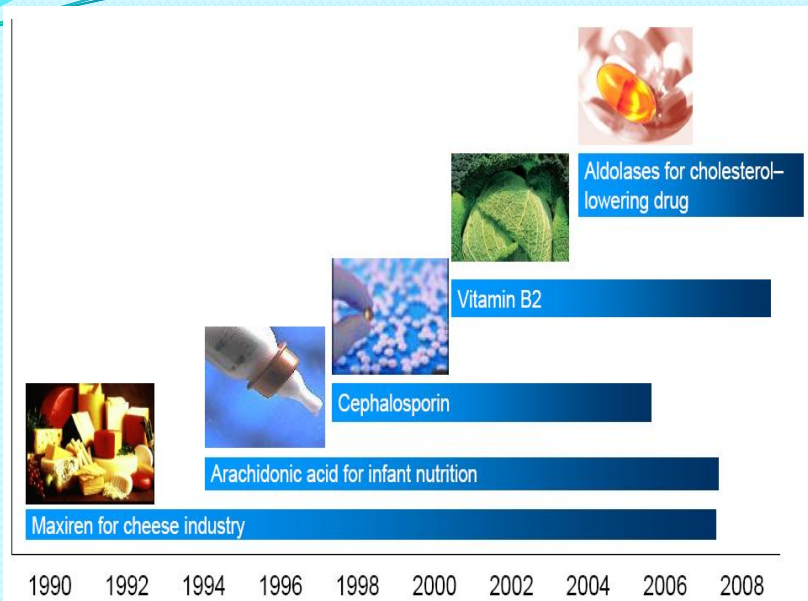
- **Faster:** reduce capital investment
- **Cheaper:** nutrients, energy, process chemicals
- **Cleaner:** fermentation and downstream separation/purification are integrated



*“Top Value Added
Chemicals from Biomass”
- U.S. DOE*

***“We are competitive
at today’s oil prices
and down to less
than \$45/barrel
equivalent!”***

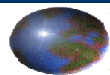
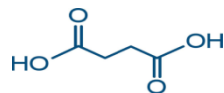
DSM Track Record in White Biotechnology



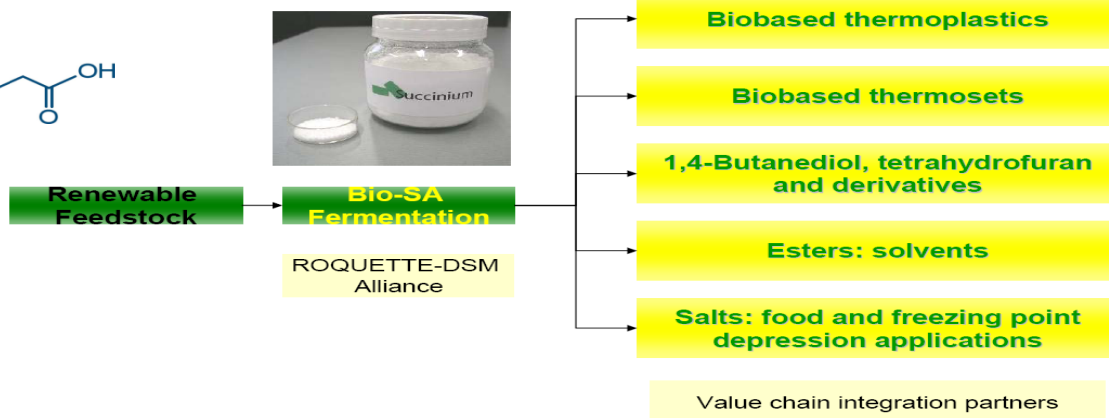
Roquette the partner in bio-succinic acid

Producing succinic acid via biological routes has several advantages:

1. Lower environmental impact
 1. No use of fossil fuels (crude oil)
 2. Bio-renewable feedstocks
 3. Absorbs instead of emits CO₂
 4. Cost proposition allows for high volume green chemicals and materials
2. New biobased & biodegradable applications feasible
 1. Production of 'green' plastics like PBS (for a.o. agricultural films)
 2. Biobased fibers for clothing
 3. Bio-based resins (e.g. polymer of bio-succinic acid and isosorbide [biobased product made by Roquette])



Market approach via partnerships

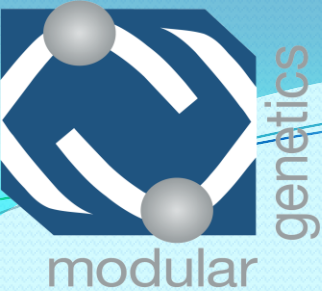


Third Wave - Plant Expression

Synthetic Biology & Systems Biology

*Contributions to Biofuels, Renewable Chemicals,
Specialty Chemicals, Bioproducts*





Surfactants Platform Using Synthetic Biology

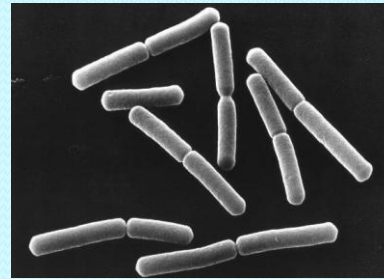
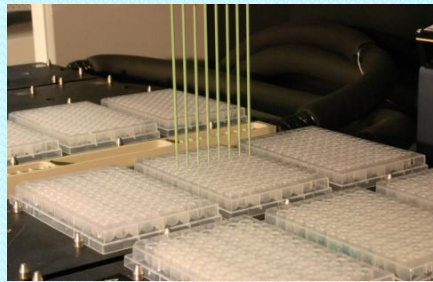
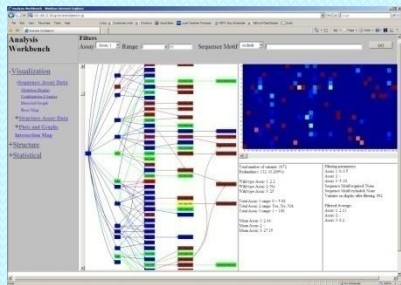
Software

Robotics

Biology

Manufacturing

Chemicals



Specialty Chemicals Surfactants

Foaming agents

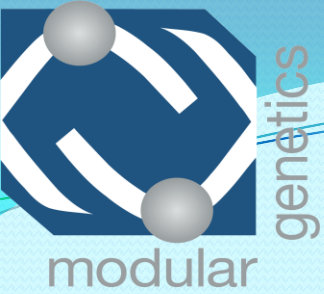
Emulsifiers

Dispersants

- \$24 billion market

- Annual global production 13 million metric tonnes





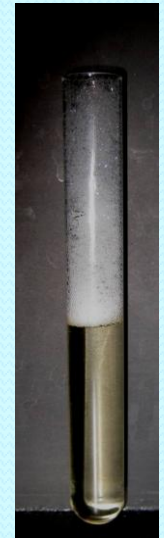
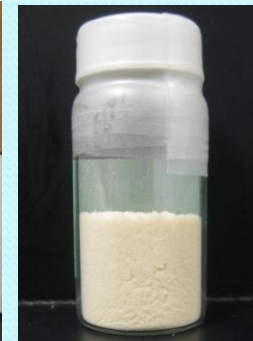
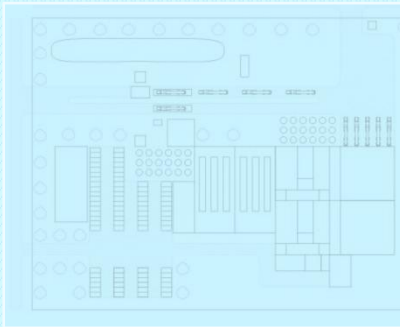
Surfactant Manufacturing Today

- 32 billion kg CO₂ annually
- Equal to burning 3.6 billion gallons of gasoline annually



- Palm and coconut plantation expansion threatens rainforest

Surfactant Manufacturing Tomorrow



Terpenes Provide Processing Advantages

- Historically, terpenes have been too expensive to produce through traditional manufacturing processes
 - ✓ Chemical synthesis
 - ✓ Extraction
- Allylix proprietary metabolic engineering fermentation platform offer significant advantages:
 - ✓ Step change in the cost of production
 - ✓ Sustainable
 - ✓ Stable supply
- Allylix technology opens the use of terpenes broadly across all market

Value In Multiple Industries



Industry

Example products

Flavor & Fragrances

Menthol
Nootkatone

Insect Repellents
& Crop Protection

Geraniol
Citranella



Natural
Sweeteners

Steviaside
Rebaudioside



Biofuels

Terpene
hydrocarbons



Pharmaceuticals

Taxol



GENENCOR[®]

A Danisco Division

a history of breakthrough innovation

Biochemicals Commercialized from Genencor

- Lysine
 - Threonine
 - Tryptophan
 - Indigo
 - Biotin
 - Ascorbic Acid
- **PDO polymer DuPont Tate & Lyle**
 - Sorona[™] carpets, cosmetics, etc.
 - 40% less energy, GHG reduced 20%
 - **Biosioprene[™]: strategic biobased alternative**
 - Major potential to reduce tire & rubber industry dependence on oil, natural rubber
 - Broad applications in rubber, adhesives, fuel
 - LCAs to ensure process will be sustainable



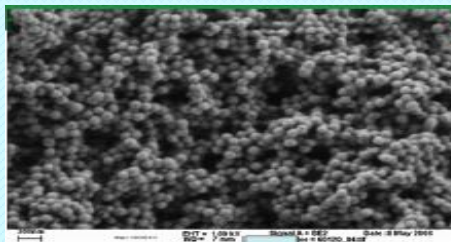
Concept Biosioprene[™] Tire
for the UN Climate Summit, Dec 2009,
CPH



Biobased Polymers Derived from Itaconic Acid



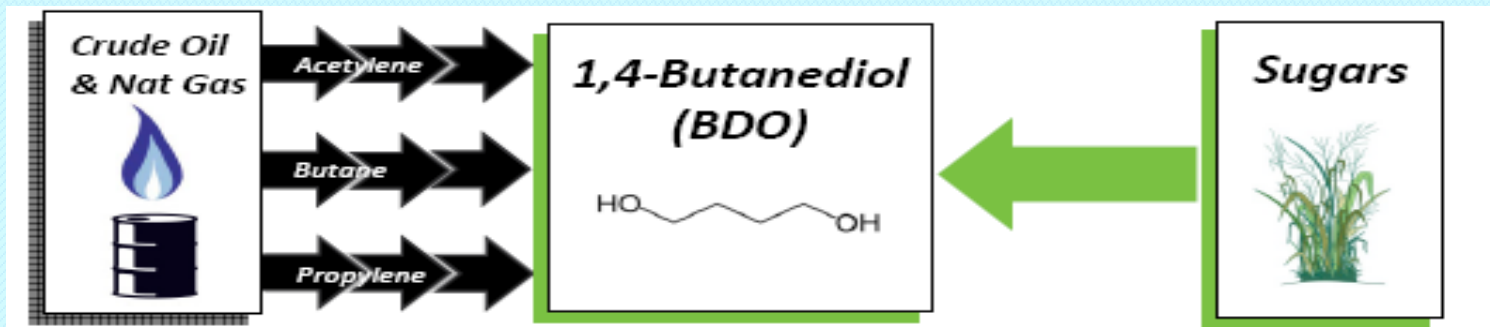
Applications for Polyitaconic Acid



pH, Biocides
 Viscosity modifiers
 Fillers, dispersion stabilizers
 Coalescing aids
 Pigments



1,4-Butanediol Platform Sustainable Process



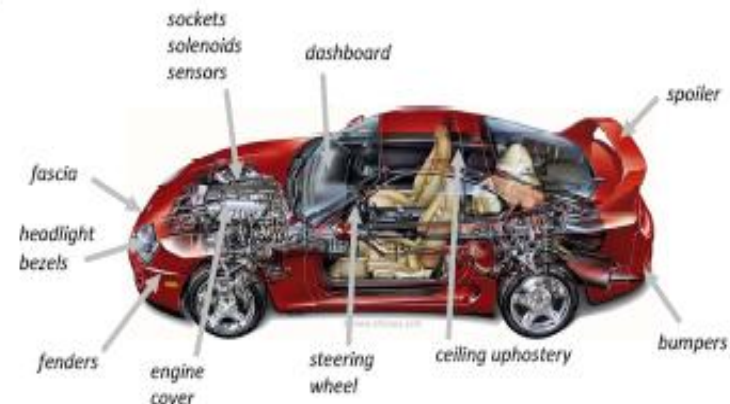
Genomatica's Process Overview

- Direct conversion to BDO
- 100% renewable BDO
- Cost-advantaged (even at \$50/bl oil)
- Over 50% lower fossil energy
- Reduced CO₂ and GHG emissions

BDO Today

- 2.5B lbs/yr. (\$3B market)
- Key chemical intermediate
- Range of applications:
 - Polyesters (PBT)
 - Polyurethanes (TPU)
 - Co-polyester ethers
 - Co-polymers (spandex)

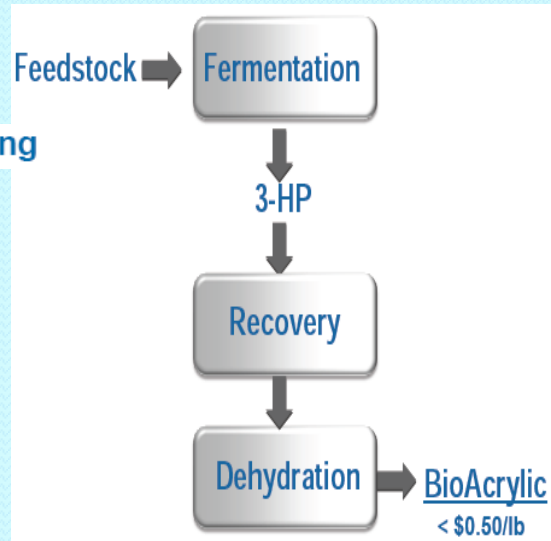
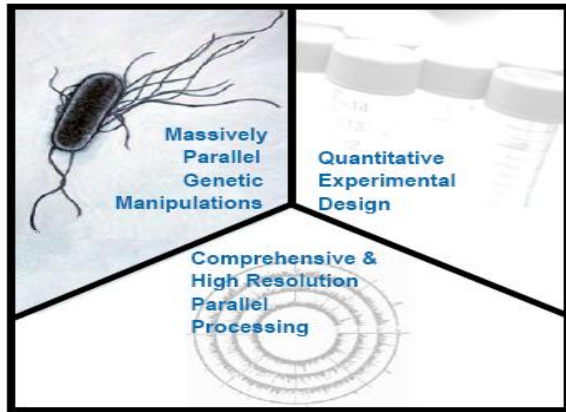
Current BDO Applications



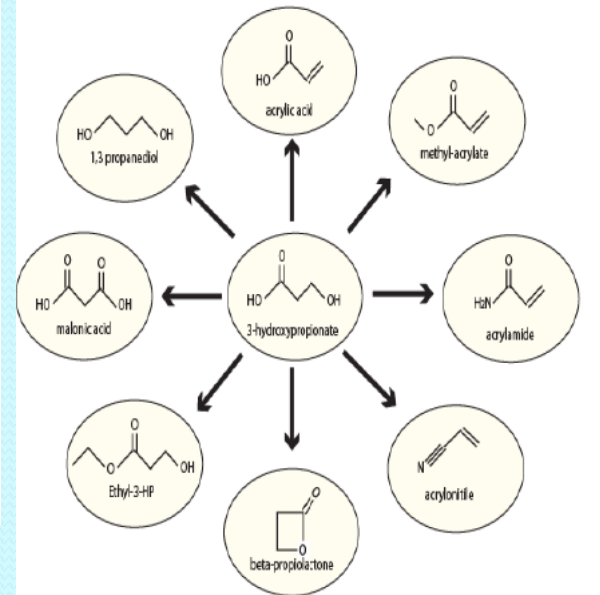
EDGE - BioAcrylic Acid

EDGE Technology Platform

Efficiency Directed Genome Engineering



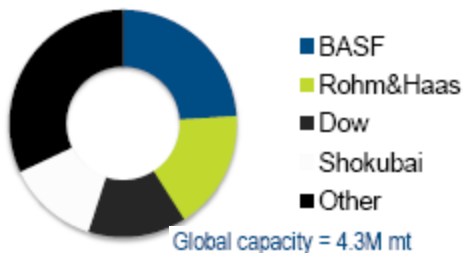
Platform 3-HydroxyPropionate (3-HP)



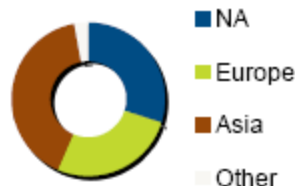
Acrylic Acid Market Opportunity

\$10 B market
4% growth
Produced by 2-step catalytic oxidation of propylene

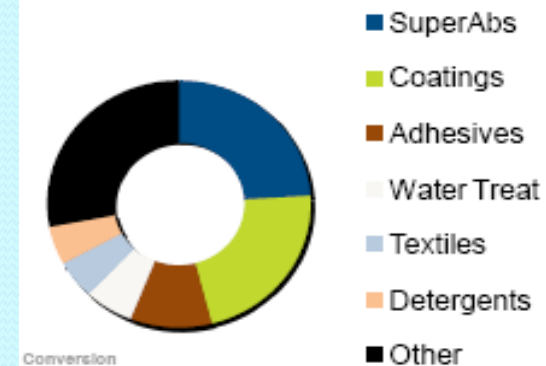
Producer Capacity Share



Regional Capacity Share

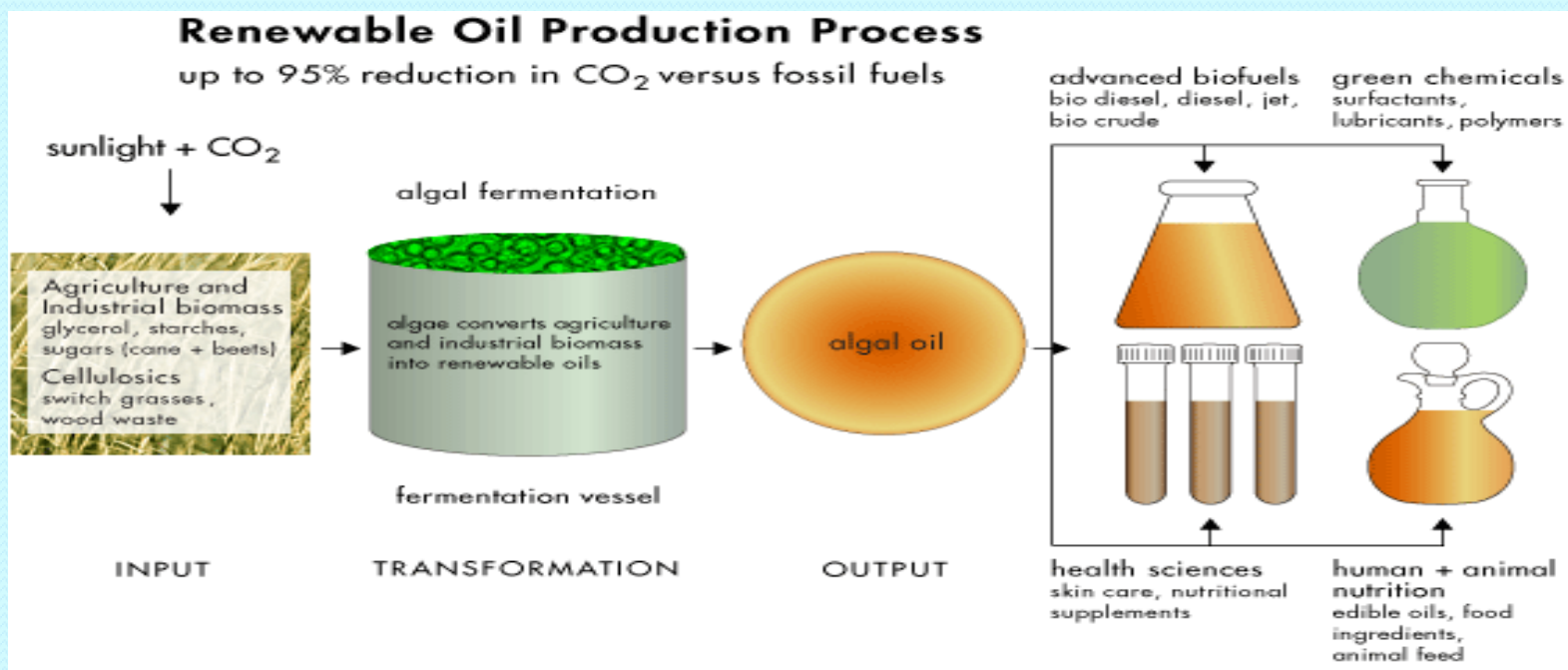


End-Use Demand Share



Microalgae Converts Biomass to Bio-based Chemicals

- Indirect photosynthesis bio-production
- Process uses microalgae to convert biomass directly into bio-based chemicals and biofuels
- A process performed in standard commercial fermentation facilities cleanly, quickly, and at low cost and large scale
- Manufactured thousands of gallons of oil and hundreds of tons of bio-chemicals for replacing fossil petroleum and plant oils in a diverse range of products from oleochemicals to cosmetics and food



Summary

- BIO was first organization to endorse Farm Bill's energy title 2001 and 2002
 - Supported the expanded Bio-Preferred Bill 2008
 - ✓ Proposed voluntary labeling program offers potential to expand biobased markets, "USDA Certified Biobased Product," label
- Role of the entire value chain from feedstocks to intermediates (biomonomers and biopolymers) to final products needs to be recognized to achieve maximum potential
- BIO strongly supports the inclusion of biobased intermediates as eligible to receive the label under current rulemaking

World Congress on Industrial Biotechnology

- World largest conference on industrial biotech
- June 27-30, 2010
- Washington, D.C. –Gaylord Resort and Convention Center
- Over 200 speakers
- First year for investor sessions for CEO presentations
- 1,300 attendees----www.BIO.org/worldcongress

