Susterra® Propanediol
Heat Transfer Fluids

Performance is in our nature.

March 11, 2016
Who is DuPont Tate & Lyle?
DTL is a joint venture formed in 2004 between DuPont and Tate & Lyle to produce 1,3 propanediol (PDO) from corn starch, a sustainable & renewable resource.

DuPont is a world leader in science and innovation across a range of disciplines, including agriculture and industrial biotechnology, chemistry, biology, materials science and manufacturing. CY2015 revenues were $35 billion.

Tate and Lyle is a global provider of renewable ingredients, solutions and services to the food, beverage and industrial customers. Revenues were $4.3 billion for Fiscal Year ending March 31, 2015.
Process Technology
Renewably sourced feedstocks are harvested, fermented, and refined to manufacture Susterra® propanediol.

Harvest
Renewably sourced feedstocks are harvested, dried and then wet-milled to create a range of carbohydrate rich feedstocks such as glucose.

Fermentation
Glucose is converted into 1,3 propanediol using a patented microorganism under exact temperatures and conditions.

Refining
The 1,3 propanediol is refined to a final purity of 99.7% by deactivating and removing the microorganism, water, and other byproducts.
Production

Biotechnology enables our global headquarters and production in Loudon, Tennessee to produce a stable supply of renewably sourced 1,3 propanediol.

Awards
- 2003 EPA Presidential Green Chemistry Award
- 2007 ACS Heroes of Chemistry Award
- 2009 ACS-BIOT Industrial Biotechnology Award
- 2010 State of Tennessee Governor’s Award for Trade Excellence

Production
- Started November 2006
- Capacity expanded 35% in 2010
- Current Capacity = 140 million lb.
**Susterra® Propanediol Process Flow**

- **Fermentation**
  - Dextrose
  - Air
  - Water
  - Biocatalyst
  - Nutrients
  - CO₂-enriched air

- **Separations**
  - Water
  - Bioresiduals

- **Distillation**

- **Product Storage Tanks**

- **Recycle**
  - Trace Impurities
  - Not Meet Specification
  - Quality Checks:
    - PDO Purity (GC)
    - Color (Hazen)
    - Water (Karl Fischer)
    - Appearance (Visual)

- **World’s largest E. coli fermentation**

- **Re-use as fertilizer**

- **Meet Specification**
  - Susterra® 1,3-Propanediol

**Confidential**
Field Corn vs. Sweet Corn
Susterra® propanediol is derived from U.S. Field Corn

Yellow Dent or “Field Corn”:
90.6 MM planted acres
14.2 B bushels produced
Crop Value: $51.9 B

Sweet Corn:
0.555 MM planted acres
137 MM bushels produced
Crop Value: $1.02 B

Yellow Dent Facts:
• Grown on over 99% of U.S. corn field acres
• Produced for ethanol, livestock feed, cereals, and other manufactured goods
• Considered a grain
• Harvested when kernels are dry and mature

Sweet Corn Facts:
• Grown on less than 1% of U.S. corn field acres
• Consumed by humans
• Considered a vegetable
• Harvested when kernels are soft and immature

Source: Field corn statistics - U.S. Department of Agriculture, June 2015
Sweet corn statistics - U.S. Department of Agriculture, 2014
Field Corn

Susterra® propanediol utilizes the starch in the field corn while the other components are harvested for different applications including animal feed for livestock.

Yellow Dent Corn Components:
- 62% Starch
- 19.2% Protein & Fiber
- 15% Moisture
- 3.8% Corn Oil

One bushel of wet-milled field corn

Produces

- 1.5 pounds of crude corn oil
  Used in consumer & industrial products
- 13.5 pounds of gluten feed
  Used in animal feed
- 2.6 pounds of gluten meal
  Used in animal feed
- 31.5 pounds of starch
  Used as the feedstock for Susterra® propanediol

Source: Tate & Lyle; National Corn Growers Association
Susterra® Propanediol
From the Field to Market Applications

DuPont Pioneer hybrids → DuPont enzymes → DuPont microorganism → Fiber

Corn → Glucose → Bio-PDO™

DuPont™ Sorona®

Zemea®
- Cosmetics and Personal Care
- Food and Flavors
- Laundry and Cleaning
- Pharmaceuticals

Susterra®
- Heat Transfer Fluids
- Polyurethanes
- Unsaturated Polyester Resins
- Paints, Coatings, and Inks
- Deicing Fluids

Applications:
- Carpet
- Apparel
- Auto
- Personal Care
- Industrial

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Susterra® Propanediol

What is it?

• A pure, petroleum-free derived glycol
• 100% sustainably and renewably sourced
• Used in a range of applications

How is it made?

• Made by a fermentation process derived from glucose
• Made in the USA
• USDA 100% Certified Bio-Based Product
• GRAS, Halal, Kosher
• Ingredient for use in Heat Transfer Fluids with Incidental Food Contact (HTX-1)
Susterra® Propanediol
Performance advantages in heat transfer fluids

• Less thermal degradation compared to EG and PG
• Higher boiling point vs EG and PG based fluids
Objective: Evaluate the performance of glycol heat transfer fluid systems simulating a stagnant high thermal event for a semi-closed loop heat transfer system.

Reflex time: 16 hours  
Reflex temperature: 192 ± 10 °C  
Inhibitor package: 2.2% Penray 2792  
Dilution: 50% deionized water  
Glycols: Susterra® propanediol, propylyene glycol, and ethylene glycol

Glycol cracking occurs as heat transfer fluid sees temperature fluctuations, producing corrosive organic compounds and darkened fluid.

Visual appearance of fluids after reflux:

- Propylene Glycol
- 1,3 Propanediol
- Ethylene Glycol
Susterra® Propanediol
Glycol comparison – high temperature reflux

Objective: Evaluate the performance of glycol heat transfer fluid systems comparing glycolate formation in inhibited glycols after reaching its boiling point.

The Susterra® propanediol based fluid produced fewer Glycolates, a thermal decomposition product of glycol, than the inhibited PG and EG fluids.
Objective: Evaluate the performance of glycol heat transfer fluid systems comparing nitrite depletion of inhibited glycols after reaching its boiling point.

The Susterra® propanediol based fluid retained more nitrites than the inhibited PG and EG fluids. Conversion of nitrite (NO$_2$), found in the inhibitor package, to nitrate (NO$_3$) indicates that significant higher level of oxidation products are present in the EG and PG fluids after boiling.
Life Cycle Analysis (LCA)

LCA is the only standardized method to evaluate the environmental footprint of a whole supply chain. Energy consumption and Green House Gas (CO₂) emissions are key factors in determining environmental footprint.

Biodegradation of product results in no net CO₂ increase
Life Cycle Analysis
Susterra® propanediol

From “cradle to gate” (extraction and production prior to delivery to the consumer), Susterra® propanediol produces 56% less greenhouse gas emissions and consumes 42% less nonrenewable energy than petroleum-based 1,3-propanediol. Compared with propylene glycol, Susterra® propanediol produces 42% less greenhouse gas emissions and uses 38% less nonrenewable energy from cradle to gate.

**GHG Emissions (kg CO₂ equiv / kg)**
- Susterra® Propanediol: 2.18
- Propanediol (PO route): 5.0
- Propylene Glycol: 3.75

**Non-Renewable Energy Use (MJ/kg)**
- Susterra® Propanediol: 63.9
- Propanediol (PO route): 111.0
- Propylene Glycol: 103.6

**Greenhouse Gas Emissions**
- 56% less than Propanediol
- 42% less than Propylene Glycol

**Non-Renewable Energy Use**
- 42% less than Propanediol
- 38% less than Propylene Glycol
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