Life Cycle Analysis Overview – Susterra® Propanediol

Introduction

DuPont Tate & Lyle Bio Products (DT&L) is a 50/50 joint venture between DuPont of Wilmington, Delaware and Tate & Lyle of Loudon that was formed to develop and commercialize 1,3 propanediol made from renewable resources. In November 2006, construction was completed on a world scale aerobic fermentation facility in Loudon, Tennessee. This facility utilizes a proprietary fermentation process to convert the glucose from corn starch into Susterra® 1,3 propanediol.

A cradle-to gate Life Cycle Analysis (LCA) based on ISO 14040 guidelines was completed on Susterra® propanediol. The following outline includes some frequently asked questions that provide some additional information on the production, processes, methodology, and results for the Susterra® propanediol.

Production

The manufacturing plant in Loudon, TN is located adjacent to Tate & Lyle's corn wet mill that supplies the glucose from corn starch to DT&L. The glucose from corn starch is introduced to the biocatalyst that converts the glucose to 1,3 propanediol through the fermentation process using a patented microorganism under exact temperatures and conditions. The 1,3 propanediol is refined to a final purity of 99.7% by deactivating and removing the microorganism, water and other byproducts.

Methodology - What methodology did DuPont use in the LCA for Susterra® propanediol?

General

In accordance to ISO 14040 all major raw materials, utilities and process outputs including emissions were considered as a part of the life cycle inventory from the growing of the corn through the production of the polymer. Wherever possible, site and region specific information was used in the study (e.g. use of region specific electricity grid, regional corn farming model).

Publically available database modules were applied to describe utility generation and raw materials.

The LCA represents a US based production scenario for Susterra® propanediol. The cradle-to-gate greenhouse gas emissions of the bio-based products include a credit for bio-based carbon sequestered in the product.

Functional Unit:

In this cradle-to-gate study, LCA results of the different benchmark materials are published on an equal mass functional unit basis. This is appropriate for the comparison of bio-derived PDO versus fossil derived PDO since the materials are chemically identical.

Processes including farming - What unit processes are modeled in the LCA?

Corn Farming:
Production of fertilizers and pesticides are included.

A US average corn grain farming model (2000-2003 timeframe) was developed based on an analysis of the environmental footprint of corn farming practices in different US counties (Hardin, IA; Fulton, IL; Tuscola, MI; Morrison, MN; Freeborn, MN; Macon, MO; Hamilton, NE; and Codington, SD) that are likely to supply corn to the Loudon, TN Susterra® propanediol plant. The corn farming model was built in cooperation with Michigan State University (MSU).

N_2O emissions from soil in the model have been determined by MSU simulating soil nitrogen dynamics according to the DAYCENT model (Del Grosso SJ, Mosier AR, Parton WJ, Ojima DS (2005); DAYCENT model analysis of past and contemporary soil N_2O and net greenhouse gas flux for major crops in the USA. Soil & Till Res 83, 9–24).

For the US average corn farming model applied in this study the N_2O emission factor is around 2.8% of the total nitrogen applied. Please note that this number is more conservative than the current IPCC convention (IPCC 1997 convention: Calculation of N_2O emission directly from crop production systems is based on an emission factor of 1.25 ± 1% of total nitrogen applied).

Electrical Grid:

The US average grid for corn farming was used.[1]

Corn Wet Mill:

The input data for the corn wet mill (CWM) model were provided by Tate & Lyle and are based on the feedstock production for the 100 million pounds per year facility at Loudon, TN in 2004.

Corn gluten feed and corn gluten meal are used as cattle feed and are considered valuable co-products. Hence, different allocation scenarios (no allocation, mass allocation, economic allocation and avoidance allocation) of the environmental burden at the CWM between the Susterra® propanediol feedstock glucose and the co-products have been performed to investigate the influence of by-product allocation at the CWM on the environmental burden associated with the Susterra® propanediol feedstock.

ISO 14040 standards recommend to apply an avoidance allocation scenario wherever the applications of the co-products are known. The DuPont LCA followed ISO recommendations and used the avoidance allocation. This is consistent with the way other bio-polymers have been reported in the literature.

Fermentation and Purification:

Fermentation and purification are modeled based on the design data for the Loudon, TN plant.

The production of the bacteria that produces the Susterra® propanediol is part of the fermentation process. This unit operation is included as part of the life cycle study.

Electrical Grid:

US SERC for Susterra® propanediol production (CWM, Fermentation and Purification)[2]

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[1] S. Kim, B.E. Dales, “Life Cycle Inventory Information of the United States Electricity System”, Int J LCA (2004), 1-17

Transportation - Was transportation included in the LCA data and how was this calculated?

Major transportation impacts (e.g. corn transport from the field to the fermentation plant, transport of Susterra® propanediol to the polymerization site) are included.

Sensitivity Analysis:

A sensitivity analysis investigating the impacts of different co-product allocation scenarios (no allocation, system expansion, mass allocation, economic allocation) at the corn wet mill was performed. ISO 14040 standards recommend to apply an avoidance allocation scenario wherever the applications of the co-products are known. Corn gluten meal and corn gluten feed are valuable co-products sold as cattle feed. Therefore, the system expansion case illustrates the most representative allocation case and is communicated on the DuPont webpage.

Results

The results of the DuPont LCA for Susterra® propanediol, petroleum-based propanediol, and propylene glycol were reviewed by Prof. Dr. Konrad Saur of Five Winds International.

The results of the LCA for Susterra® propanediol are included in Appendix A, B and C.

[2] S. Kim, B.E. Dales, "Life Cycle Inventory Information of the United States Electricity System", Int J LCA (2004), 1-17

Appendix A: Susterra® Propanediol Life Cycle Data

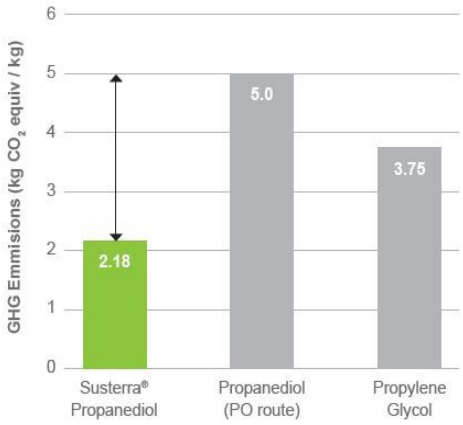
Susterra® Propanediol

Background Information	Our Product	Conventional Product	Substitute Product
Product Name	Susterra® Propanediol	Petroleum-Based PDO	Propylene Glycol
Chemical Name	1,3 propanediol	1,3 propanediol	1,2 propanediol
Major Uses	functional fluids, polymer intermediates	polymer intermediates	personal care, functional fluids, coatings
DuPont Manufacturing Location	DuPont Tate & Lyle Bio Products, LLC Loudon, TN USA	n/a	n/a
Cradle-To-Gate Manufacturing Parameters			
Greenhouse Gas Emissions kg CO2 equivalent s/kg	2.18 [1,2]	Propylene route: 5.00 [1]	3.75 [3]
Non Renewable Energy Consumption MJ/kg	63.9 [1,4]	Propylene route: 111.0 [1,4]	103.6 [3,4]
Product Properties			
Renewable content % by weight	100%	0%	0%
Bio-based Carbon Content % by weight [5]	100%	0%	0%
Biodegradability [6]	Yes	Yes	Yes
Composability [7]	n/a	n/a	n/a

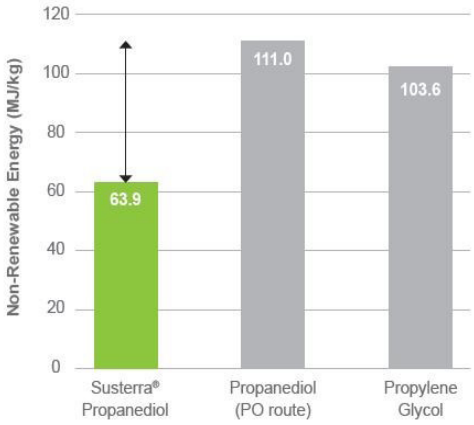
References

1. Peer-reviewed LCA of Bio-PDO / Sorona production (Peer reviewer:Prof. Konrad Saur, Five Winds International)
2. Includes bio-based carbon stored in product
3. H. Althaus, SimPro-Software Manual (2004); Life Cycle Inventories of Chemicals: “Propylene Glycol, liquid, at plant”
4. Based on higher heating values (HHV)
5. ASTM Standard D 6852: Standard Guide for Determination of Bio-based Content, Resources Consumption, and Environmental Profile of Materials and Products
6. ASTM Standard E1720 Standard Test Method for Determining Ready, Ultimate, Biodegradability of Organic Chemicals in a Sealed Vessel CO2 Production Test
7. ASTM Standard D6400 Standard Specification for Compostable Plastics

Appendix B: Susterra® Propanediol Life Cycle Chart

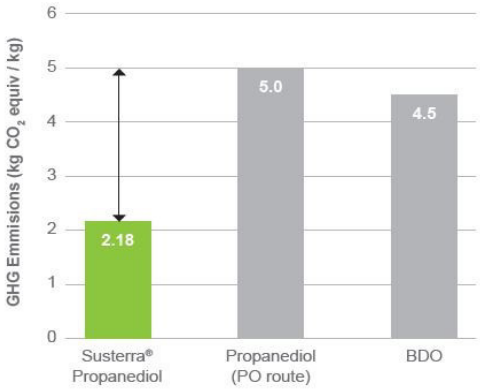


Greenhouse Gas Emissions
56% less than Propanediol
42% less than Propylene Glycol

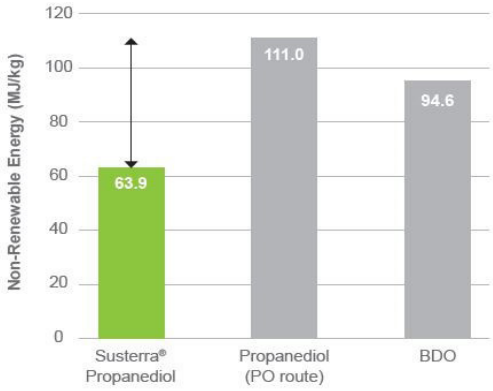


Non-Renewable Energy Use
42% less than Propanediol
38% less than Propylene Glycol

Appendix C: Susterra® Propanediol Life Cycle Chart



Greenhouse Gas Emissions
56% less than Propanediol
52% less than BDO



Non-Renewable Energy Use
42% less than Propanediol
32% less than BDO

For additional information or samples:

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