

**zemea<sup>®</sup>**

**bio-based performance**

# Zemea® Propanediol

Performance in a wide range of Personal Care Applications



**zemea**  
bio-based performance

# Company Overview



# Who is DuPont Tate & Lyle?

DTL is a joint venture formed in 2004 between DuPont and Tate & Lyle to produce bio-based propanediol from fermentation of glucose.



DuPont is a global innovation leader with technology-based materials, ingredients and solutions that help transform industries and everyday life. 2018 revenues were \$22.6 billion.



Tate and Lyle is a global provider of renewable ingredients, solutions and services to the food, beverage and industrial customers. Revenues were \$3.8 billion for Fiscal Year ending March 31, 2018.



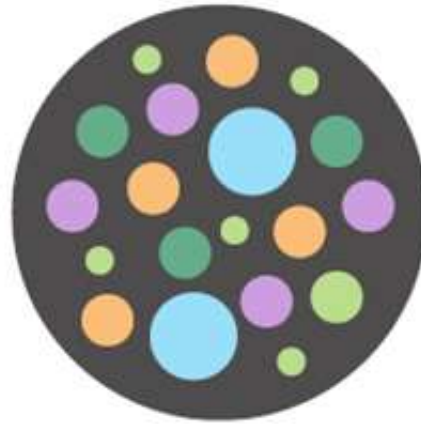
# Process Technology

Renewably sourced feedstocks are harvested, fermented, and refined to manufacture Zemea® 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 99.99% 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 100% sustainably and 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

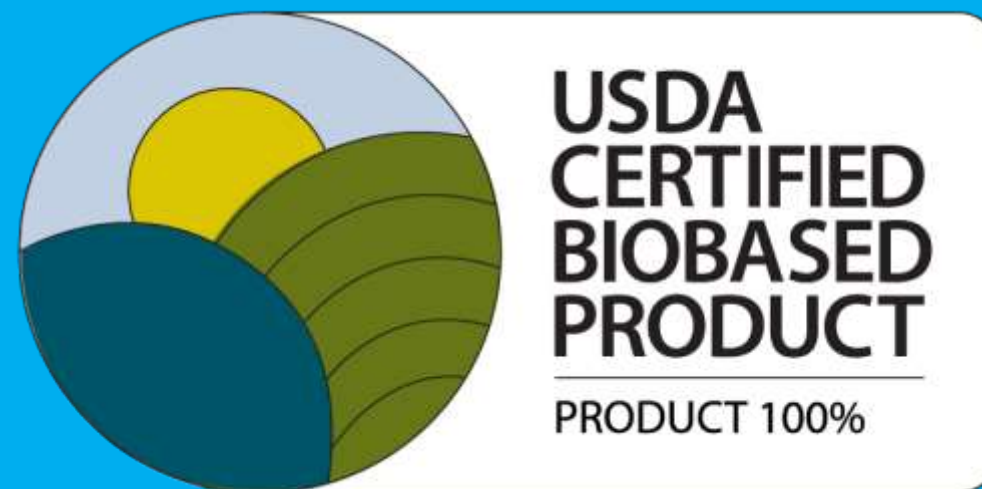
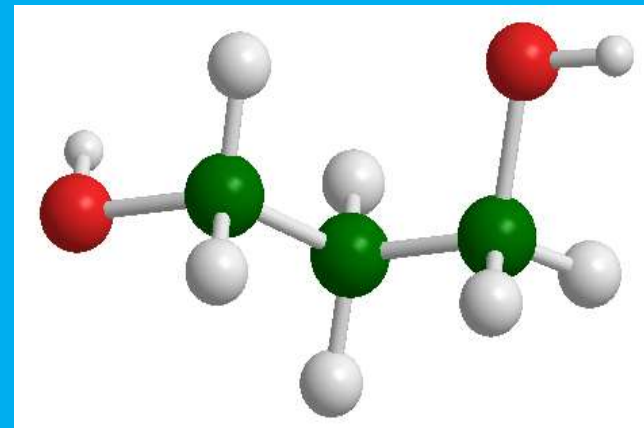
## Production

- Started November 2006: 45,000 tonnes
- Capacity expanded 35% in 2010
- Recently announced second expansion of 16,000 tonnes that came online mid-2019

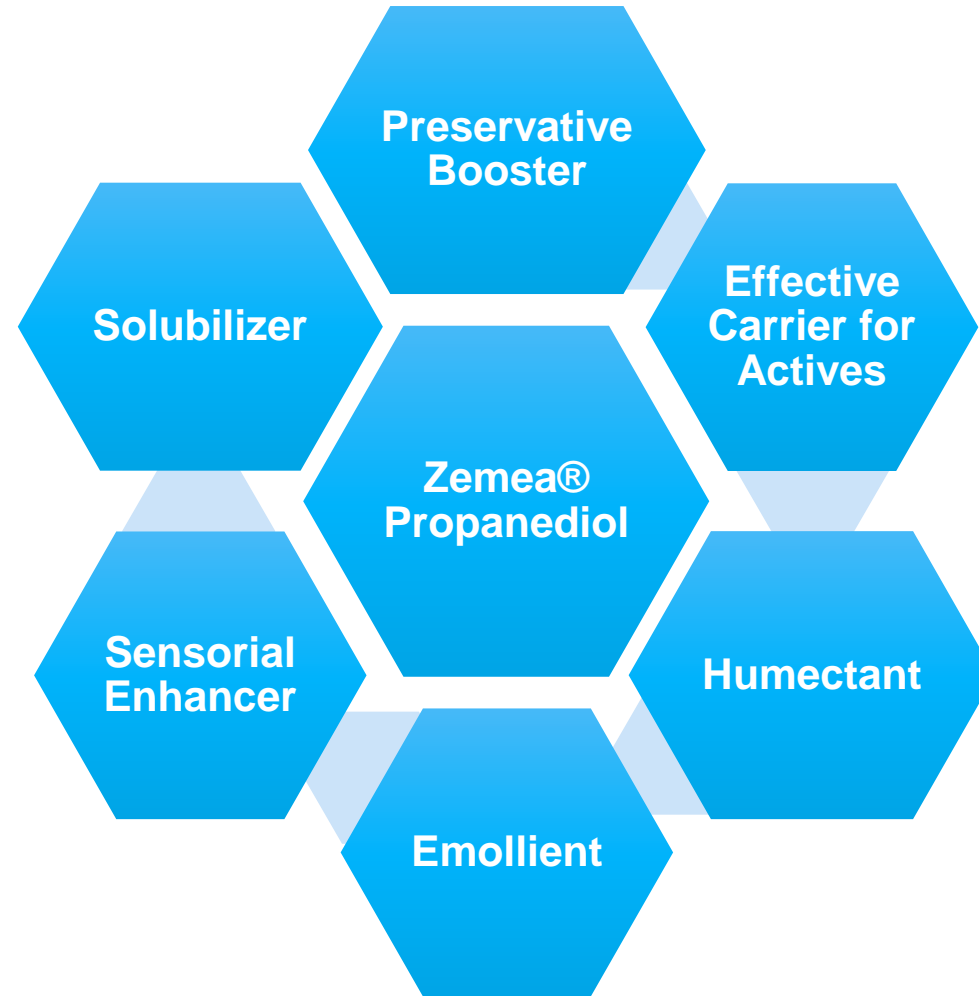
# Zemea® Propanediol

## What is Zemea®

- A pure, petroleum-free derived diol
- 100% sustainably and renewably sourced
- Used in a range of cosmetic and personal care applications
- **Approvals and Certifications:**
  - Natural Products Association (NPA)
  - USDA BioPreferred® Program – 100% Bio-based
  - Natural Health Products Ingredient – Health Canada
  - Natural Index is 1 and Natural Origin Index is 1 per ISO 16128
  - EPA's Design for the Environment (DfE)
  - FDA and FEMA GRAS
  - Halal
  - Kosher
  - USP-NF
- **Registrations:**
  - INCI Name: Propanediol
  - EINECS Number: 207-997-3
  - CAS Number: 504-63-2
  - REACH Registration Number: 01-2119489383-28-0000

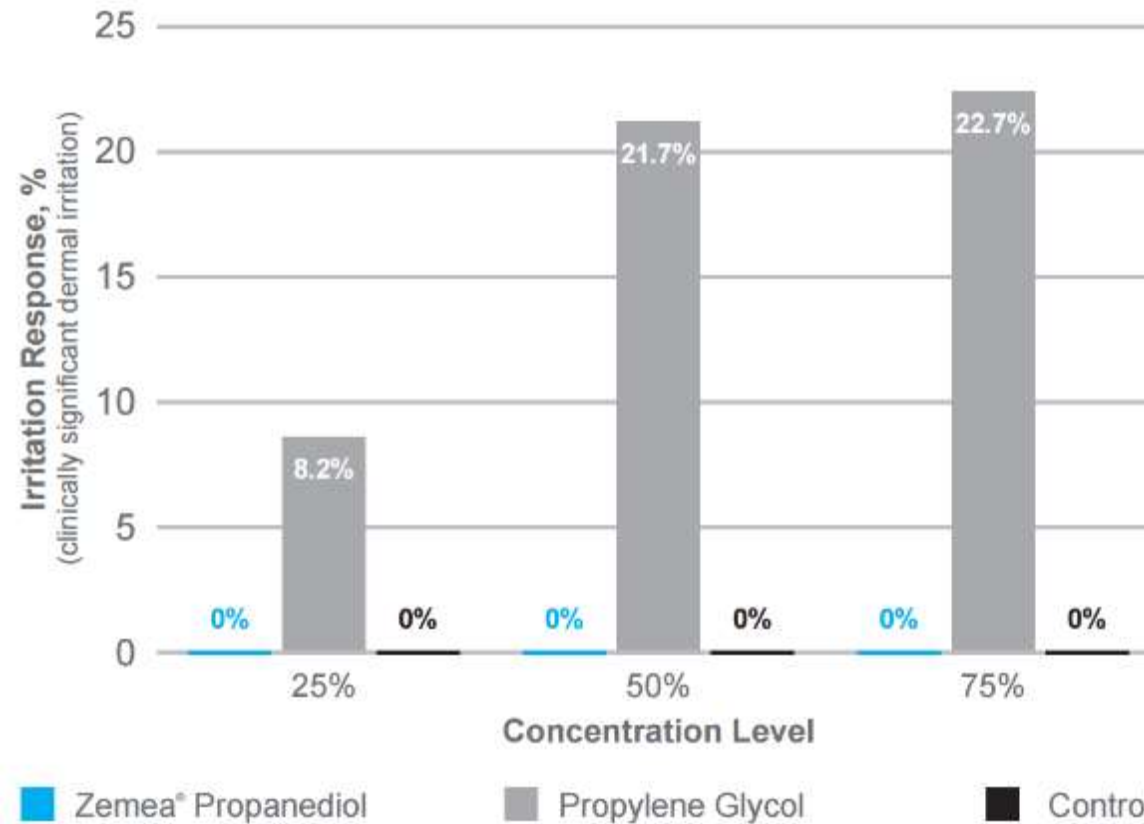


# Zemea® Propanediol - Multifunctional



# Human Skin Patch Test

Panel of 207 individuals were exposed to Zemea® propanediol, propylene glycol, or control at 7pH. At varying concentrations the irritation response was measured.

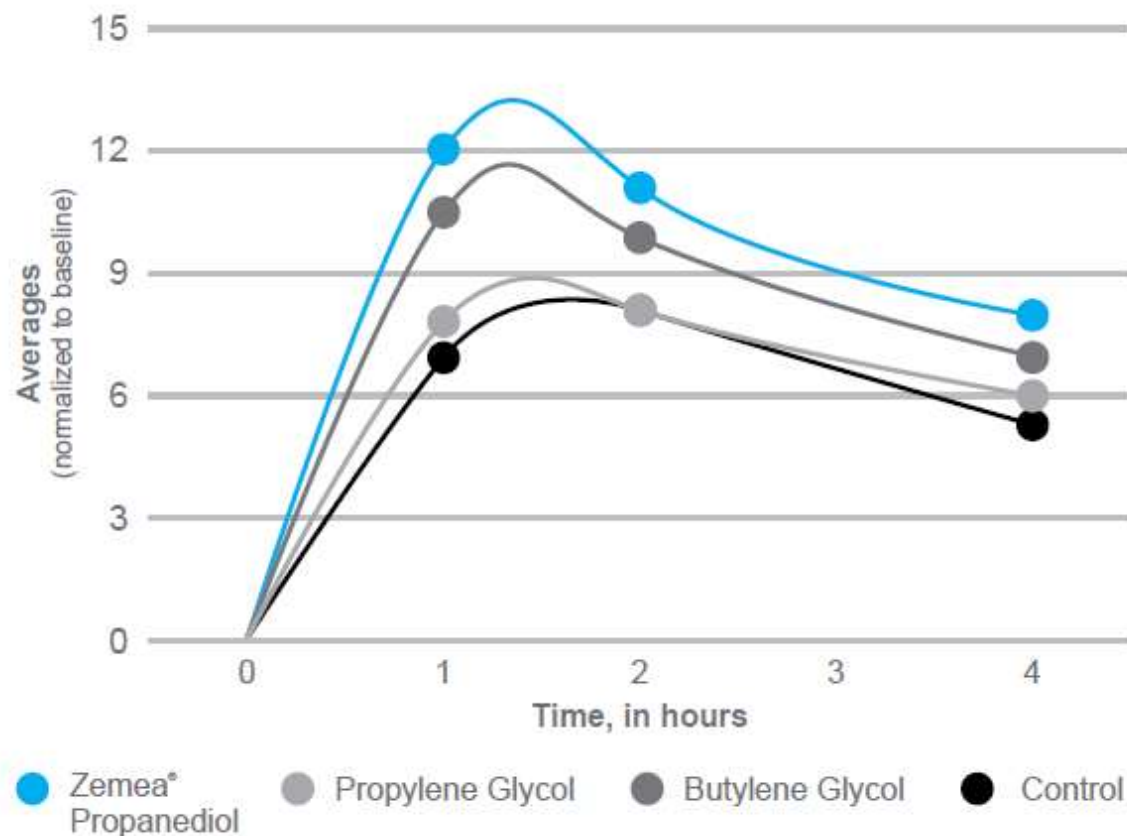


Zemea® propanediol produced no clinically significant dermal irritation following exposure of up to 75%. By contrast skin irritation was observed with propylene glycol at a concentration of 25%, with nearly one-quarter of the population indicating positive irritation at 75% concentration.

# Skin Moisturizing Performance

Measured the moisturizing performance of an o/w skin care emulsion with 5% varying humectant . A Corneometer® CM 825 (*Courage & Khazaka*) was used to measure skin moisturization.

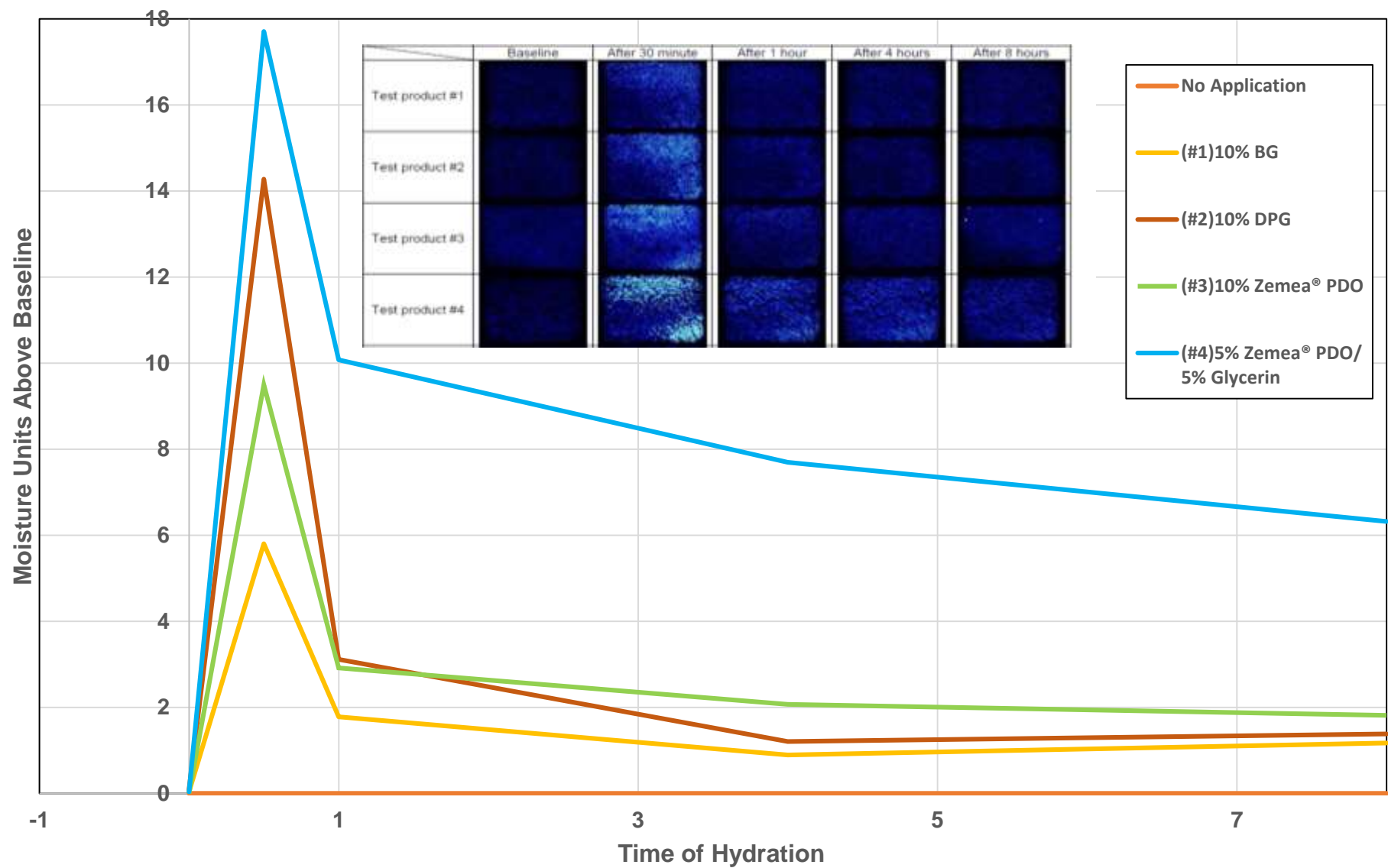
o/w Skin Care Emulsion with 5% Glycol	
INCI Name	wt. %
Deionized water	61.2
EDTA	0.1
Glycol	5.0
Carbomer (2%)	10.0
Mineral Oil	10.0
Hydrogenated Polydecene	5.0
Glyceryl Stearate & PEG-100 Stearate	2.5
Stearic Acid	2.5
Cetearyl Alcohol	0.5
Dimethicone	1.0
NaOH (20%)	1.2
Preservative	1.0



**Zemea® propanediol was more efficient than butylene glycol and propylene glycol in moisturizing the skin over the entire testing period..**

# Skin Moisturizing (Epsilon)

## Solutions in Water



# Boosting Preservative Efficacy

Minimum percentage of Zemea® propanediol needed to boost the preservative's efficacy at ½ their recommended use level

		Challenge Organisms				
		gram-positive	gram-negative	gram-negative	yeast	mold
		<i>Staphylococcus aureus</i>	<i>Escherichia coli</i>	<i>Pseudomonas aeruginosa</i>	<i>Candida albicans</i>	<i>Aspergillus niger</i>
Preservatives	phenoxylethanol-based					
	Microcare PM3 (0.15%)	2%	2%	2%	4%	2% (1 log reduction)
	euxyl® PE 9010 (0.25%)	4%	4%	2%	6%	2% (1 log reduction)
	Neolone PE (0.3%)	2%	2%		6%	2% (1 log reduction)
	Jeecide CAP-4 Optiphen (0.25%)	2%	2%		6%	2% (1 log reduction)
	Lexgard® Natural (0.5%)					2% (1 log reduction)
natural	Dermosoft 688 ECO (0.1%)	Preservative levels provided sufficient reduction to <1.00 CFU/g without addition of Zemea® propanediol.			2%	2% (1 log reduction)
	Geogard® ULTRA (0.5%)				2%	2% (1 log reduction)
Organisms reduced to <1.00 CFU/g at Day 7						

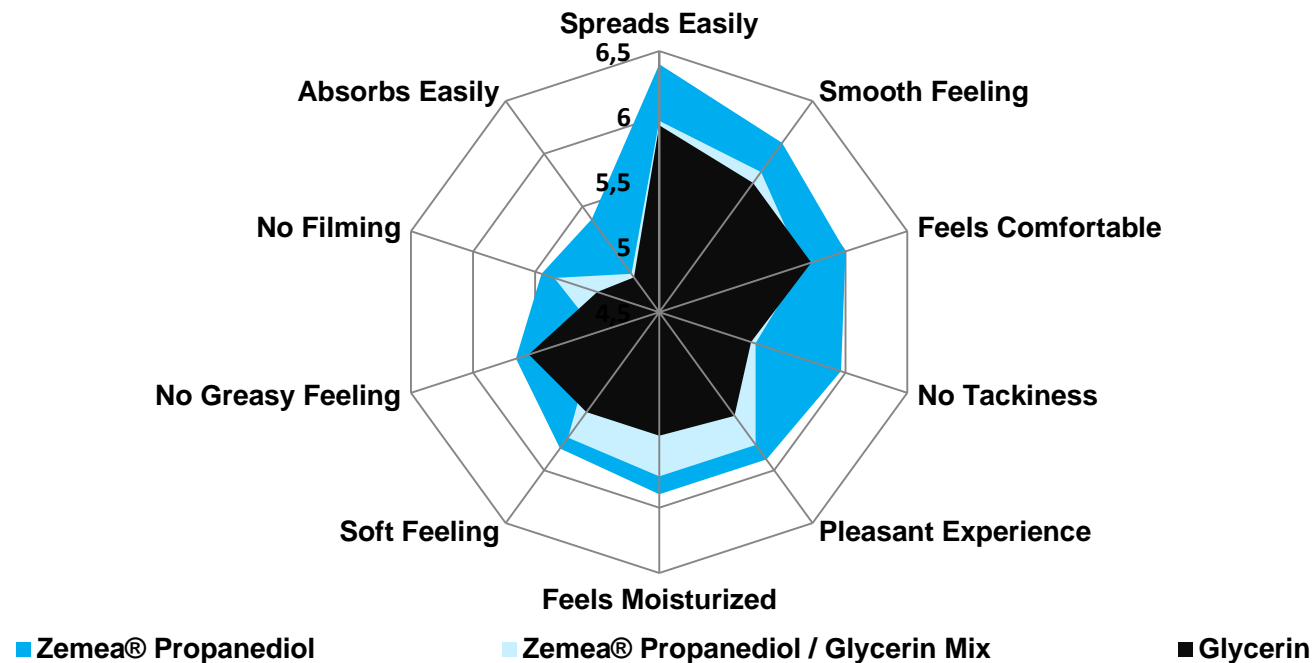
- Zemea® propanediol worked well with the phenoxyethanol-based preservatives and boosted the preservative efficacy for gram-positive, gram-negative, and yeast organisms.
- Zemea® propanediol consistently boosted the efficacy of each preservative tested with *Aspergillus niger*.
- Zemea® propanediol worked well with the natural based preservatives and boosted the preservative efficacy for yeast and molds.
- Zemea® propanediol may allow the use of less preservatives in formulations while providing additional performance benefits such as no skin irritation, increased humectancy and excellent aesthetics.
- Zemea® propanediol is not a preservative nor is it considered an active ingredient.

# Consumer Sensory Testing

Measured the sensory perceptions during a blind test of three randomized o/w skin care emulsion formulated with either:

- Zemea® propanediol (20 wt.%)
- Glycerin (20 wt.%)
- Zemea® propanediol / glycerin Mixture (10 wt.% each)

On days 1,2, and 3, each lotion was applied to the volar side of the forearms. On day 3, subjects reporting of the level of agreement on a scale of 1 to 7 with 10 different statements



The lotion containing Zemea® propanediol was rated higher on all attributes when compared to the locations containing glycerin or the Zemea® propanediol / glycerin mixture.

# Effective Carrier for Active Ingredients

Zemea® propanediol has a unique set of Hansen Solubility Parameters. Software modeling suggested that Zemea® can be an effective solvent for cosmetic actives and functional materials.

Cosmetic Active/Ingredient	Function	Objective	Result with Zemea® Propanediol
Ferulic acid	Renew and rejuvenate skin texture	Find primary solvent to maximize solubility.	High solubility, but not in water.
Allantoin	Soothe, stimulate, and moisturize skin	Find primary solvent to maximize solubility	Higher solubility than in water.
Ascorbic acid	Antioxidant	Find secondary solvent to extend delivery time.	Reasonably soluble. Extends delivery time as water evaporates.
Glycolic acid	Exfoliation, anti-aging	Find secondary solvent to extend delivery time.	Highly soluble. Extends delivery time as water evaporates.
Salicylic acid	Treat blemishes and prevent clogged pores	Optimize natural formulation of 1% salicylic acid and a fixed 25% oil phase with 2% cetearyl alcohol and 1% caprylyl glycol, using only Zemea® propanediol and isostearyl alcohol.	Reasonably soluble. The natural formulation can be optimized for maximum delivery using an 11.8% Zemea® propanediol and 9.2% isostearyl alcohol combination.
Hexylresorcinol	Lighten and stimulate skin, antioxidant	Optimize skin lighten formulation with 1% hexylresorcinol in aqueous phase of emulsion.	Reasonably soluble. Optimization for maximized solubility and delivery using 17% Zemea® propanediol in a 75% aqueous phase emulsion.

# USDA Bio Preferred Product Portfolio



# High performing, natural personal care products portfolio

## Goals

1. Develop a portfolio of high performance CPC formulations: 15 innovative, consumer-ready formulations.
  - **Skin Treatment:** Face cream, Face lotion, Face serum, Eye gel, Hand cream, Body lotion.
  - **Sun & Color:** Daily facial moisturizer SPF 15, Face sunscreen SPF 30, Beach sunscreen SPF 30, Liquid Foundation.
  - **Cleaning & Conditioning:** Shampoo, Conditioner, Facial cleanser, Body wash, Hand wash
2. Obtain USDA BioPreferred® product certification for each formulation as a new way to quantify the definition of “natural” ingredients. The quantitative ASTM test method is performed by a certified ASTM laboratory to determine bio-based content.

## Collaborators & Contributors

- DuPont Tate & Lyle Bio Products: Humectant/preservative booster, Osmolyte, Protectant.



- Corbion: Emulsifiers, Surfactants, Acids/salts/actives.



- INOLEX: Emollients Preservatives, Film formers



- ACT Solutions Corp.: CPC Consultant & formulator.



# USDA BioPreferred Program

❖ Established in the 2002 Farm Bill.

## ➤ Purpose:

- Economic development, create new jobs, and provide new markets for farm commodities.
- Primary agricultural and food policy legislation of the federal government.
- Directed the U.S Department of Agriculture (USDA) to develop a certification and labeling program for bio-based products.
- Requires that U.S. Federal government agencies and contractors give preference to bio-based products in categories designated by the USDA.
- Revised every few years.

## ➤ USDA BioPreferred program “bio-based” definition (ASTM D6866):

- Substance containing organic carbon of renewable origin from agriculture, plant, animal, fungi, microorganism, marine, or forestry material living in a natural environment in equilibrium with the atmosphere
- ASTM D6866 provides an absolute measurement of a product’s bio-based carbon content using radiocarbon analysis.

# Current formulation list and example formulation

Skin Treatment Products		
Category	Formulation	% Bio content
Face Cream	Nourishing Night Cream	100
Face serum/lotion	Sincere Serum	100
Eye gel	Olive Eye Gel	97
Hand Cream	Hand Healer	98
Body Lotion	Moisturising Spray Lotion	100

Sun and Color		
Category	Formulation (SPF & Critical wavelength)	% Bio content
Daily Facial Sunscreen SPF15	Daily Dose Sunscreen, SPF 30 (375 nm)	100
Facial Sunscreen SPF30	Sun Sport, SPF 25 (370 nm)	100
Beach Sunscreen SPF30	Radiant Beach Sunscreen, SPF 30 (380 nm)	100
	Baby Sun Bum, SPF 157 (378 nm)	100
Liquid Foundation	Lightweight Tint Moisturizer	100

Cleansing and Conditioning		
Category	Formulation	% Bio content
Shampoo	Signature Shampoo	87
Conditioner	Creamy Conditioner	100
Facial Cleanser	Perfectly Peach Cleansing Wash	87
	Cucumber Cleanser (cleansing lotion, make-up remover)	100
	Mycellular Water (water, make-up remover)	100
Body Wash	Perfectly Peach Cleansing Wash	87
Hand Wash	Perfectly Peach Cleansing Wash	87



## Olive Eye Gel

Rejuvenating Eye Gel / ACTS20914

**Description:** This Rejuvenating Eye Contour Gel packs moisturization, gentle pH correction, and invigoration for tired eyes. This eye gel will help reduce redness and puffiness while providing intense hydration.

**Ingredients:** Water, Propanediol, Hydroxypropyl Starch Phosphate, Caprylhydroxamic Acid, Glyceryl Caprylate, Glycerin, Polysorbate 80, Lactic Acid, Potassium Lactate, Fragrance, Olea Europaea (Olive) Leaf Extract

Phase A				
Water	-	-	-	Solvent
Phase B				
Propanediol	Zemea*	DuPont Tate & Lyle	15.0%	Humectant
Caprylhydroxamic Acid (and) Glyceryl Caprylate (and) Glycerin	Spectrast™ G2	Inolex	1.0%	Preservative
Polysorbate 80	Tween 80	Croda	1.0%	Surfactant
Water (and) Lactic Acid (and) Potassium Lactate	PURAC® BF P41	Corbion	0.5%	Active
Olea Europaea (Olive) Leaf Extract (and) Glycerin (and) Water	PhytoTrace™ Olive	Inolex	0.2%	Active
Hydroxypropyl Starch Phosphate	TEXTURLUX™ Feel	*Tate & Lyle	6.50%	Polymer
Fragrance	Orchidia Eye Cream Fragrance	Orchidia	0.45%	Fragrance

### Procedure

1. Premix B until uniform
2. Add B to A with slow stirring until uniform and clear

### Formula:

ACTS 20914 provided by:  
ACT Solutions Corp.,  
Newark, Delaware, USA

**For additional information or samples:**  
**DuPont Tate & Lyle Bio Products**  
**Customer Service**

198 Blair Bend Drive, Loudon, TN 37774  
Tel: +1-866-404-7933 • www.duponttateandlyle.com



Copyright © 2019 DuPont Tate & Lyle Bio Products Company, LLC. Zemea® is a registered trademark of DuPont Tate & Lyle Bio Products Company, LLC, for its brand of bio-based propanediol. All rights reserved.  
This technical product information is presented in good faith and is believed to be accurate and reliable as of the date of publication. DuPont Tate & Lyle Bio Products makes no guarantee or warranty of any kind, expressed or implied, regarding the product or information contained herein. Purchaser assumes all risk and liability in acting on the information provided herein. It is the sole responsibility of the Purchaser to determine whether Zemea® propanediol is appropriate and suitable for the Purchaser's specific use and, as required, to obtain approval by appropriate regulatory authorities for such use. Statements concerning the use of Zemea® propanediol are not to be construed as recommendations, suggestions, or inducements to use it in the infringement of any patent or in violation of any applicable laws or regulations. DuPont Tate & Lyle Bio Products disclaims any liability for infringement of any patent by reason of customer's use of any products or information contained herein in combination with other materials or in any process. (4/2019)

### Formulation Sheet



In collaboration with:

**Adaptive**  
ACT Solutions Corp.  
179 W. Chestnut Hill Rd., Suite 7  
Newark, DE 19713  
Tel: 1-302-525-8110  
www.ACTSolutionsCorp.com  
info@actsolutionscorp.com

**Corbion**  
Corbion  
8250 Flint Street  
Lenexa, KS 66214  
To request Corbion samples:  
Lisa Swain  
Lisa.Swain@corbion.com

**INOLEX**  
Inolex Inc.  
2101 S. Swanson Street  
Philadelphia, PA 19148  
To request Inolex samples:  
https://inolex.com/po/Home/Sample-Request

\*Tate & Lyle  
2200 E. Eldorado Street  
Decatur, IL 62521  
Jeremy Zimmerman 217-358-2676  
Jeremy.Zimmerman@tateandlyle.com



**Zemea® Propanediol in Broad  
Spectrum, Water Resistant SPF 25+  
Daily Facial Moisturizer**



# Zemea® Propanediol is an Effective Solvent

- Ensulizole and sulisobenzene are utilized globally, but concerns exist around their effectiveness as they return to their crystalline state as they fall out of solution

Active	Type	Performance	Other
Ensulizole	Organic, water-soluble UVB filter	Crystalline solid and loses effectiveness if too much solvent is lost	Mode of action is absorption
Sulisobenzene (Benzophenone-4)	Organic, water-soluble UVB and UVA (UVA-II) filter	Crystalline solid and loses effectiveness if too much solvent is lost	Needs combination of UVA absorber to attain broad spectrum protection

- Multiple studies simulating an aqueous phase were completed:
  1. An aqueous phase of 4% ensulizole and Zemea® propanediol at 10% showed that solubility can be maintained when 75% of the water in the aqueous phase has evaporated
  2. An aqueous phase of 10% sulisobenzene and 10% Zemea® propanediol showed that solubility can be maintained when 75% of the water in the aqueous phase has evaporated

**Zemea® propanediol is an essential ingredient for keeping ensulizole and sulisobenzene in solution resulting in greater efficacy for both.**

# Broad Spectrum, Water Resistant, SPF 25+ Daily Facial Moisturizer

Phase	Ingredient	INCI Name	Supplier	Function	Wt.%
A	Water	Water	-	-	52.40%
	Spectrastat™	Caprylhydroxamic Acid (and) Caprylyl Glycol (and) Glycerin	Inolex	Preservative	0.80%
	AquaSul	Sulisobenzone (Benzophenone-4)	SandreamImpact	Active	2.00%
B	Zemea® Propanediol	Propanediol	DuPont Tate & Lyle	Humectant	10.00%
	Parsol HS	Ensulizole	DSM	Active	3.00%
C	Tris Amino Ultra PC	Tromethamine	Angus	Neutralizer	2.20%
D	Solaveil™ XT-40	Titanium Dioxide (and) Aqua (and) Polyglyceryl-2 Caprate (and) Sucrose Stearate (and) Simmondsia Chinensis (Jojoba) Seed Oil (and) Stearic Acid (and) Alumina (and) Glyceryl Caprylate (and) Squalane	Croda	Active	3.00%
E	KerrSoft AVG	Acetylated Hydrogenated Vegetable Glyceride	Kerry	Emollient	15.00%
	KerrEmul PGPR	Polyglyceryl-3 Polyricinoleate	Kerry	Emulsifier	2.50%
	Solaveil™ AT-300	Caprylic/Capric Triglyceride (and) Titanium Dioxide (and) Polyhydroxystearic Acid (and) Stearic Acid (and) Alumina	Croda	Active	3.00%
	Xperse® 201	Zinc Oxide, Caprylic/capric triglyceride, Polyhydroxystearic acid, Triethoxycaprylsilane	Umicore	Active	3.00%
	CosmoSurf® CE-100	Octododecyl Citrate Crosspolymer	SurfaTech	Emollient	3.00%
	CAB-O-SIL® TS-610	Silica Dimethyl Silylate	Cabot	Thickener	0.10%
Total					100.00%

Procedure:

- 1) Premix Phase A, add Phase B to Phase A
- 2) Add Phase C until (AB) is clear
- 3) Add Phase D to (ABC) while mixing with propeller stirring
- 4) Premix Phase E
- 5) Add (ABCD) to Phase E very slowly while mixing with propeller stirring
- 6) Add Phase F while mixing with propeller stirring

# Zemea® SPF 25+ daily facial moisturizer

Conclusions	Confirmed
Zemea® is a high performing solvent keeping ensulizole and sulisobenzene in solution through evaporation boosting their efficacy	✓
Achieving combination of high SPF and critical wavelength is rare.	✓
Achieved an SPF 3x the level of sunscreen active is not common when using lesser-efficient sunscreens	✓
Combining organic and inorganic actives and placing both actives in the aqueous and oil phase maximize sun protection	✓
Zemea® improves aesthetics of formulation, specifically daily facial moisturizer (non-irritating, increased moisturization, excellent sensory characteristics)	✓

# Zemea® Propanediol in Mouthwash



# Formulating Alcohol-Free Mouthwashes

**“Negative media headlines around the alleged dangers of using alcohol-based mouthwash excessively (link to oral cancers), have contributed to declining consumer engagement with mouthwash.”**

**\*Mintel Oral Hygiene Insights – February 2018**

Alcohol provides benefits such as dissolving flavors and antiseptic agents in water, providing preservative properties, and freshening sensation in the mouth

Without alcohol, a greater burden is placed on the surfactant solubilizer (Polysorbate 80) to achieve clarity of flavors, actives and antiseptic agents

When nonionic surfactants are used at higher concentrations, they exhibit an unpleasant taste and localized gelling when added to water

# Alcohol-free Antiseptic Mouthwash

Phase	Ingredient	INCI Name	Suppliers	Function	Wt.%
A	Deionized Water	Aqua (Water)	-	Solvent	47.24%
	Zemea® Propanediol	Propanediol	DuPont Tate & Lyle Bio Products	Humectant	50.00%
	Tween® 80	Polysorbate 80	Croda	Solubilizer	1.50%
	Menthol	Menthol	Kerry	Flavor	0.042%
B	Peppermint Oil	Mentha Piperita Oil	FlavorChem	Flavor	0.50%
	Methyl Salicylate	Methyl Salicylate	Kerry	Antiseptic	0.060%
	Thymol	Thymol	Kerry	Antiseptic	0.064%
	Eucalyptol	Eucalyptol	Kerry	Antiseptic	0.092%
	Splenda®	Sucralose	Tate and Lyle	Flavor	0.50%
Total					100.00%

**Eliminates  
solubilizer gelling**

**Reduces  
surfactant load**

**Improves taste**

**Enables  
formulation clarity**

**Alcohol-free  
formulation  
possible**

# Great Tasting Alcohol-Free Mouthwash

Phase	Ingredient	INCI Name	Suppliers	Function	Wt.%
A	Deionized Water	Aqua (Water)	-	-	76.25%
	Zemea® Propanediol	Propanediol	DuPont Tate & Lyle Bio Products	Humectant	20.00%
B	Tween® 80	Polysorbate 80	Croda	Solubilizer	2.00%
	Menthol	Menthol	Kerry	Flavor	0.25%
	Peppermint Oil	Mentha Piperita Oil	Kerry	Flavor	0.50%
	Splenda®	Sucralose	Tate and Lyle	Flavor	1.00%
	Total				100.00%

**Eliminates  
solubilizer gelling**

**Reduces  
surfactant load**

**Improves taste**

**Enables  
formulation clarity**

**Alcohol-free  
formulation  
possible**

# Zemea® Propanediol in Toothpaste



# Formulating SLS-Free Toothpaste

**“Concerns and studies linking increased frequency of aphthous ulcers and limiting bioavailability of fluoride to SLS use in toothpaste has formulators looking for alternative formulation techniques”**

**\*ACT Solutions Corp.**

**\*Massachusetts Dental Society**

- Sodium Lauryl Sulfate (SLS) is the industry standard as a good-tasting, foaming agent in toothpaste
- Alternative foaming surfactants offer while available fall short on aesthetics due to poor taste and foaming characteristics
- Gums like Cellulose and Xanthan, commonly used in toothpaste formulations, exhibit gelling when directly added to water

# Great Tasting SLS-Free Gel Toothpaste

Phase	Ingredient	INCI Name	Suppliers	Function	Wt.%
A	CMC Cekol® 2000	Cellulose Gum	CP Kelco	Thickener	1.00%
	Zemea® Propanediol	Propanediol	DuPont Tate & Lyle Bio Products	Solvent	4.00%
	Splenda®	Sucralose	Sweet Solutions	Sweetener	0.20%
	Peppermint Oil	Mentha Piperita Oil	Kerry	Flavor	0.75%
	Water	-	-	-	22.75%
B	Zemea® Propanediol	Propanediol	DuPont Tate & Lyle Bio Products	Humectant	25.00%
	Sorbogem™	Sorbitol	Ingredion	Sweetener	20.30%
C	Zeodent® 116	Zeodent 116	Huber	Thickening Silica	23.00%
	Zeodent® 165	Zeodent 165	Huber	Thickening Silica	2.50%
D	Lathanol® LAL	Sodium Lauryl Sulfoacetate	Stepan	Foaming Agent	0.50%
Total					100.00%

**Solvent for  
sorbitol and  
sweeteners**

**Carrier for gums**

**Improves taste**

**Gels with clarity  
and rheology**

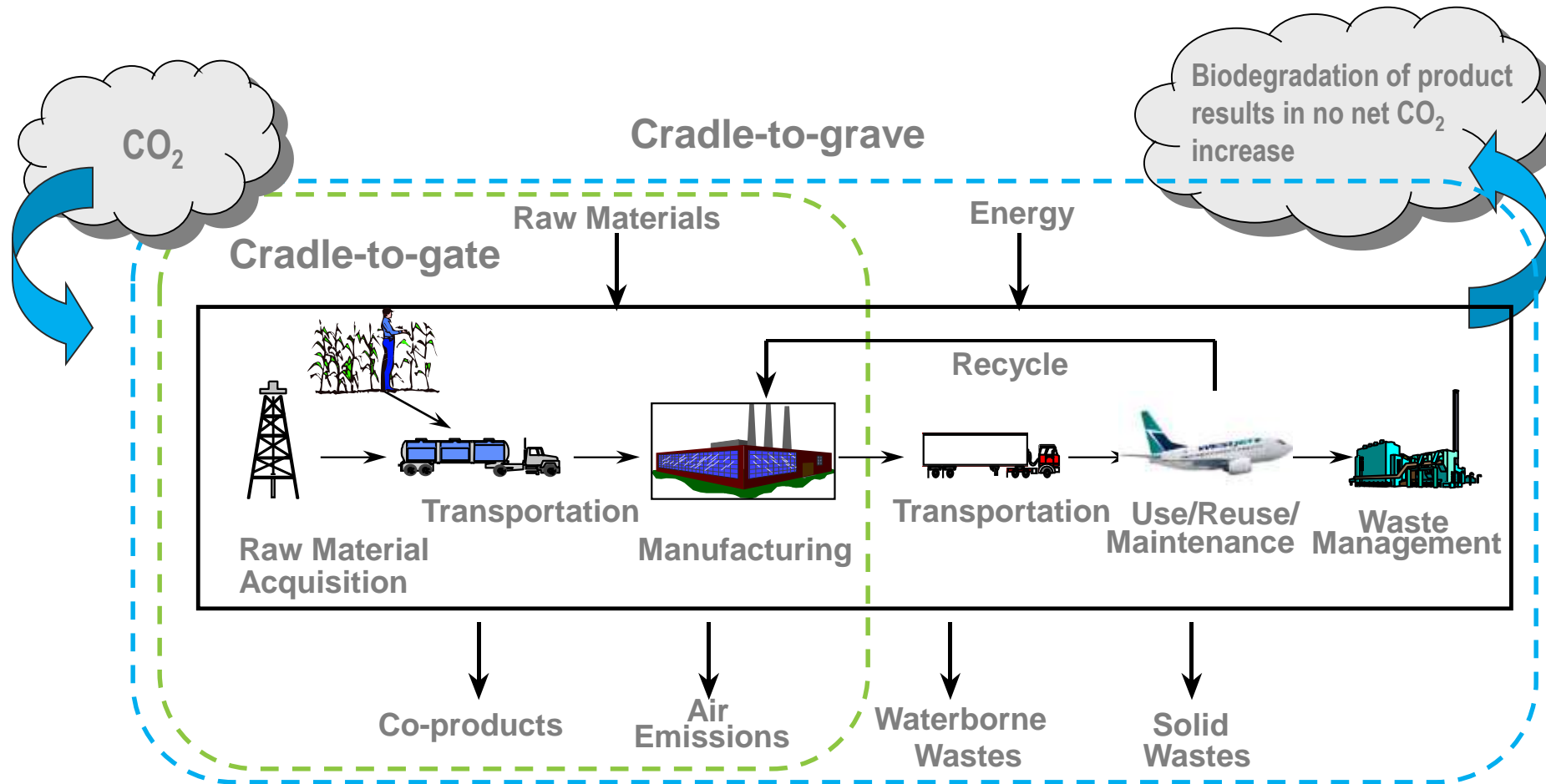
**SLS-free  
formulation  
possible**

# Life Cycle Analysis



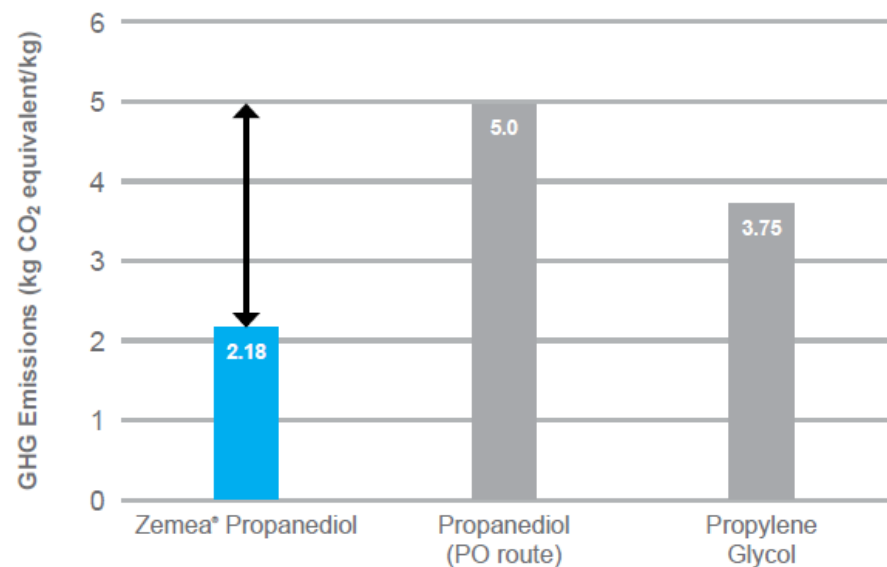
# Life Cycle Analysis Approach

LCA is the only standardized method to evaluate the environmental footprint of a whole supply chain. Energy consumption and Green House Gas (CO<sub>2</sub>) emissions are key factors in determining environmental footprint.

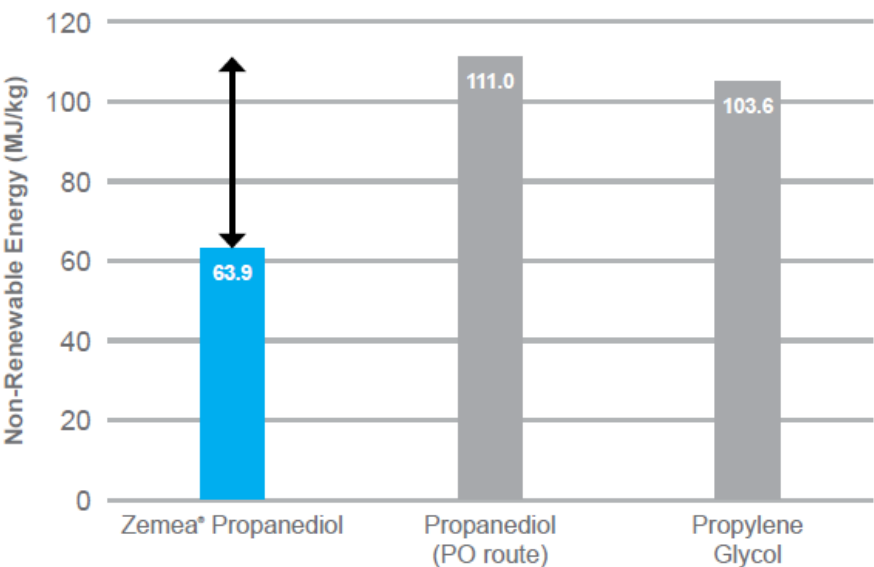


# Zemea® Propanediol Life Cycle Analysis

From “cradle-to-gate,” Zemea® propanediol produces 56% less greenhouse gas emissions and consumes 42% less nonrenewable energy than petroleum-based 1,3-propanediol. Compared with PG, Zemea® propanediol produces 42% less greenhouse gas emissions and uses 38% less nonrenewable energy from cradle-to-gate.

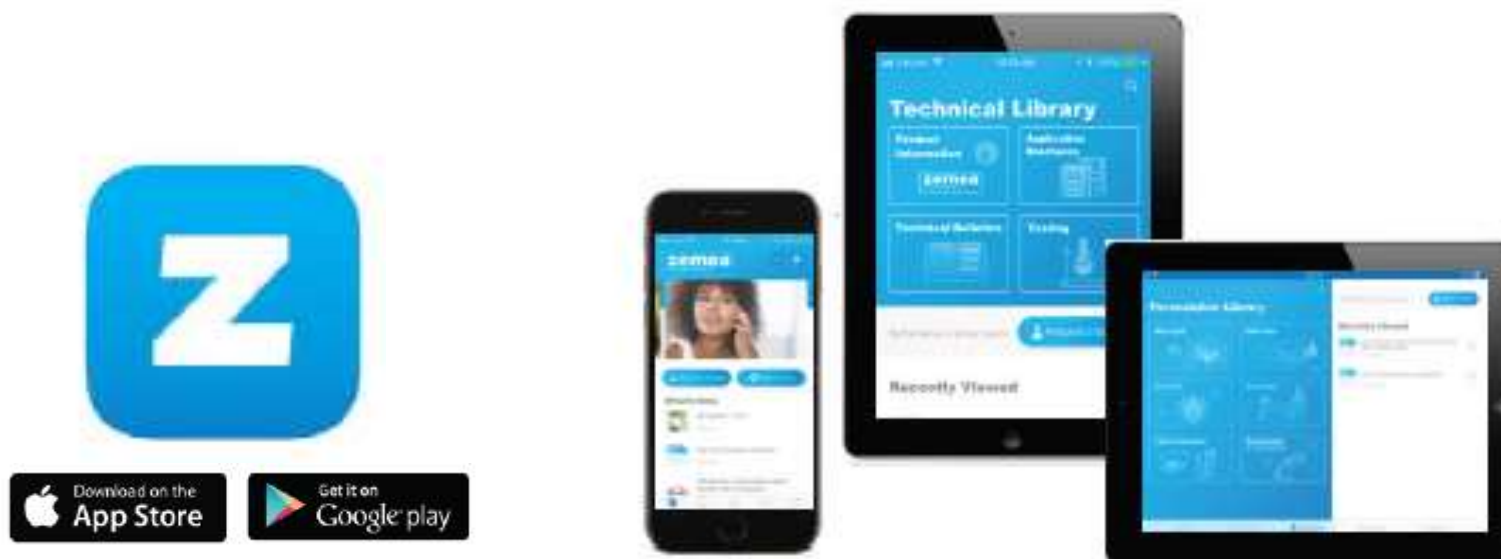


Greenhouse Gas Emissions  
56% less than Propanediol  
42% less than Propylene Glycol



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

# Smart Phone Application for Zemea® Propanediol





**Heather Malino**

Marketing Manager - Global

DuPont Tate & Lyle Bio Products Company, LLC.

200 Powder Mill Road

Wilmington, DE 19803

+1 (302) 695 7861 - Office

+1 (302) 650 9557 - Mobile

Heather.L.Malino@dupont.com

www.duponttateandlyle.com