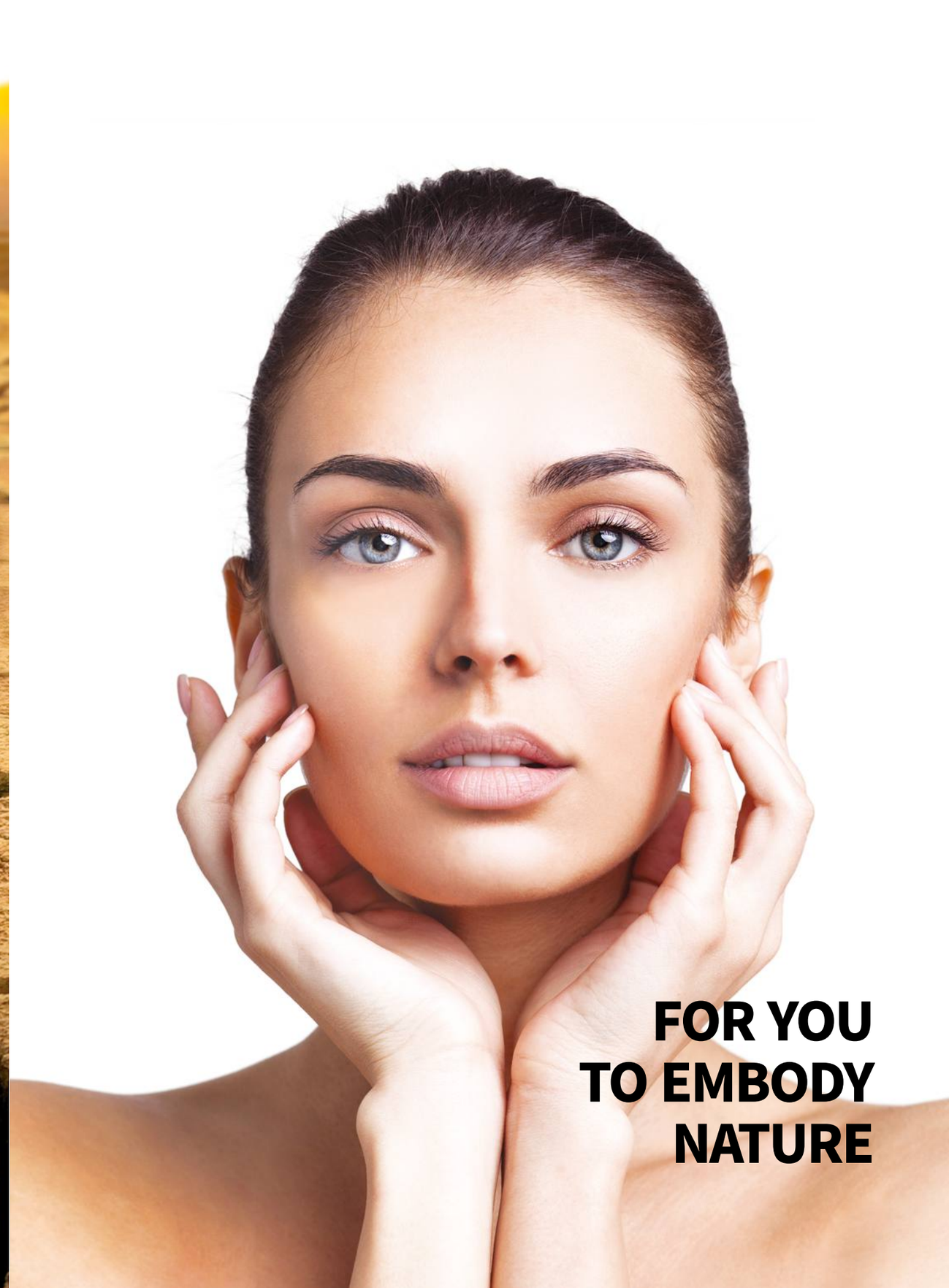
GreenDiol®

MADE IN NATURE,
NAMED FOR OUR BETTERMENT

GS Caltex


FOUND
IN NATURE


FOR YOU
TO EMBODY
NATURE

FOUND IN NATURE

A PLANT THAT SURVIVED DROUGHT

GS Caltex became interested in plants that grow in harsh environments and noticed its amazing drought resistance.

SECRETS FOUND IN MICROORGANISMS OF NATURAL ORIGIN

Years of research discovered that the secret of drought resistance was in 2,3-Butanediol produced by natural microorganisms.

SUCCESSFUL COMMERCIALIZATION WITH ECO-FRIENDLY FERMENTATION METHOD

Produced by an eco-friendly fermentation method without chemical synthesis, GreenDiol® can be used in various fields from natural moisturizers to botanical extractants.

BORN OUT OF 100% NATURAL INGREDIENT

GreenDiol®, another name of the 100% natural substance 2,3-Butanediol found anywhere around us, is a novel product **GS** Caltex produces by an eco-friendly method that adheres to the principle of preserving the natural ecosystem.

FERMENTED AND NATURAL FOOD
wine, vinegar, kimchi, fermented sauce, honey, raspberry

ANIMAL
bee, fish, human body

PLANT AND SOIL

FOR YOU TO EMBODY NATURE

Dedicated to True Sustainability

BIO-BASED PRODUCTION

- GreenDiol® is produced by natural fermentation without chemical synthesis.
- **GS** Caltex is the only company that is mass-producing GreenDiol® with a 100% bio-based production process in the world.

THREE FREES

1

***GMO-FREE Biomass**

GreenDiol® uses Non-GMO biomass (cassava, sugar cane) as feedstock.

2

***LMO-FREE Microorganism**

GS Caltex is mass-producing GreenDiol® using Non-GMO microorganisms based on innovative bioengineering technology.

3

TOXIC CHEMICAL-FREE

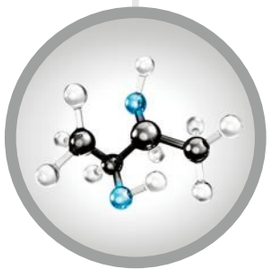
The production process only uses physical characteristics of the substance to separate and purify, without applying any harmful chemicals.

* GMO : Genetically Modified Organism
* LMO : Living Modified Organism

PRODUCTION PROCESS

Biomass

Fermentation



GreenDiol®

Safe from Toxicity and Irritation

- Various toxicity studies have shown that GreenDiol® contains no hazardous toxins and is therefore safe for the environment and the human body.
- Clinical patch studies on skin irritation have also shown that GreenDiol® does not cause skin irritation.

Types	Tests		Results
Toxicity and Irritation Evaluation	Phototoxicity		No toxicity
	Genetic toxicity	Bacterial Reverse Mutation Test	No toxicity
		In vitro Chromosomal Aberration Assay	No toxicity
	Eye Irritation/Corrosion (In vitro)		No irritation
	Skin Irritation/Corrosion (In vitro)		No irritation
	Skin Irritation (clinical test)		No irritation
	Skin Sensitization		No irritation

GreenDiol® PRODUCED THROUGH THE NON-TOXIC NATURAL PATHWAY

BIO PATHWAY

Sugar → Pyruvate → Acetolactate → Acetoin → 2,3-Butanediol → GreenDiol®

MICROORGANISM

Approved by ECOCERT RAW MATERIAL
COSMOS APPROVED

COSMOS Certification

GreenDiol® is COSMOS certified as an organic and natural cosmetic ingredient (non-GMO, non-LMO) that meets global standards.

EFFICACY

04 DISTINCTIVE FEATURES : SUSTAINABILITY | 05 DISTINCTIVE FEATURES : SAFETY | 06 DISTINCTIVE FEATURES : EFFICACY | 13 COMPOSITION, PACKAGING AND CERTIFICATES

Natural Humectant

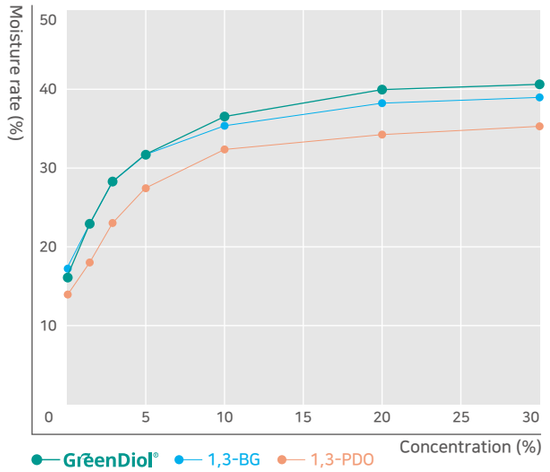
- GreenDiol® is a natural humectant that adds moisture to the skin.
- Clinical tests on 19 subjects showed that GreenDiol® has superior skin moisturizing effect compared to *1,3-BG and *1,3-PDO.

CLINICAL TEST

| METHOD | Skin moisture content is evaluated 3 hours after applying different concentrations of GreenDiol® to the skin.

| SUBJECT | 19 females

| RESULT | Subjects who have used GreenDiol® showed higher skin moisture content compared to those who have used 1,3-BG and 1,3-PDO.



Preservative Booster

- GreenDiol® has excellent antibacterial and antiseptic properties, so it can be effectively used to prevent oxidation and decay of various products including cosmetics.
- GreenDiol® is effective in enhancing antiseptic effects.

MIC (Minimum Inhibitory Concentration) **TEST**

* The MIC test is the most basic measure of the antimicrobial activity of substances. The sooner it reaches the MIC, which is the Minimum Inhibitory Concentration to suppress the reproduction of microorganisms, the higher the antimicrobial activity.

| METHOD | MIC test on bacteria and fungi

| RESULT | GreenDiol® showed reasonable preservation enhancement effects by inhibiting the growth of pathogens.

MIC TEST ON BACTERIA

Test Materials	15%	20%	25%
GreenDiol®	×	○	○
1,3-BG	×	×	○
1,3-PDO	×	×	○

MIC TEST ON FUNGI

Test Materials	15%	20%	25%
GreenDiol®	×	○	○
1,3-BG	×	×	○
1,3-PDO	×	×	○

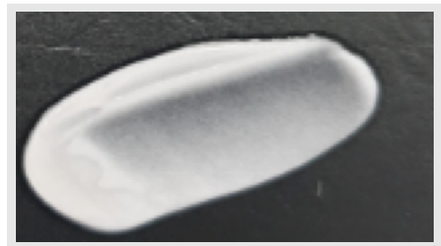
Novel Dispersant

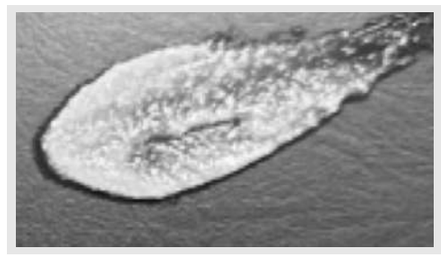
- GreenDiol® serves as a novel dispersant that helps active ingredients to stay dispersed and stabilized.
- A series of our tests showed that GreenDiol® was effective in dispersing vitamin C, allantoin and ceramide in various formulations.

① DISPERSION TEST ON VITAMIN C

| METHOD | Vitamin C was tested in a polyol-in-oil type formulation containing each of the four different polyols, given that P/O type formulation is commonly applied to resolve instability of pure vitamin C in water. Then sensory test was conducted on each formulation.

| RESULT | A P/O type formulation with GreenDiol® was found most effective in dispersing vitamin C pigments.


Texture of GreenDiol®-containing formulation


Texture of glycerin-containing formulation

SENSORY TEST ON P/O TYPE FORMULATION TEXTURE

Test Type	Test Materials
Feeling of homogeneity	GreenDiol® > 1,3-BG > 1,3-PDO > Glycerin

② DISPERSION TEST ON ALLANTOIN

| METHOD | 0.5g allantoin* was dispersed in an aqueous formulation containing each of the four different polyols, and to induce measurable precipitation, was stored at low temperature for 7 days. Then, the amount of allantoin precipitation from each formulation was weighed.
*Allantoin's solubility in water is 0.5g/100ml

| RESULT | A formulation with GreenDiol® was found with the least amount of precipitation.

WEIGHT MEASUREMENT OF ALLANTOIN PRECIPITATION IN EACH FORMULATION

Test Materials	Duration	GreenDiol®	1,3-BG	1,3-PDO	Glycerin
The amount of precipitated allantoin (%)	After 1 day	0	26	10	0
	After 7 days	29	48	39	28

EFFICACY

04 DISTINCTIVE FEATURES : SUSTAINABILITY | 05 DISTINCTIVE FEATURES : SAFETY | 06 DISTINCTIVE FEATURES : EFFICACY | 13 COMPOSITION, PACKAGING AND CERTIFICATES

③ DISPERSION TEST ON CERAMIDE

| METHOD | Ceramide was kept directly in each polyol and observed for 4 weeks.

| RESULT | GreenDiol® worked well in dispersing ceramide without re-agglomeration throughout 4 weeks.

※ Also, when kept at 45℃, GreenDiol® was able to solubilize ceramide completely, while 1,3-PDO was not.

Anti-inflammatory Agent

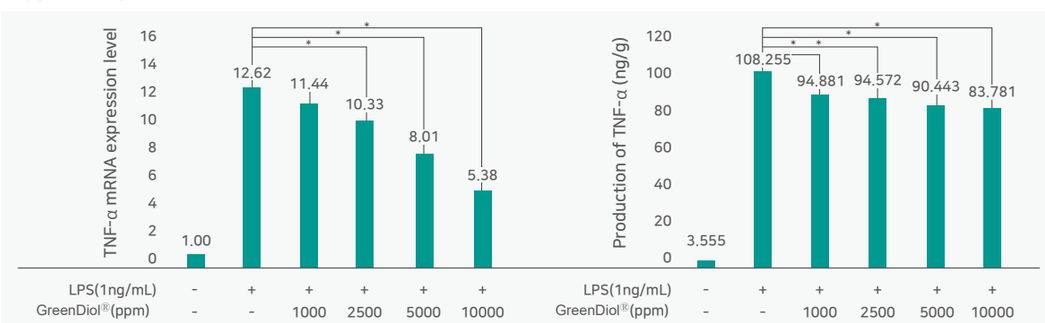
· GreenDiol® can potentially act as an anti-inflammatory agent to the similar extent as a pharmaceutical drug.

MEASUREMENT OF PRO-INFLAMMATORY CYTOKINES

| METHOD | In-vitro anti-inflammatory test (RAW 264.7 cells) was performed by various concentrations of GreenDiol® and 1ng/mL of LPS* for 24 hours, and the levels of TNF-α and IL-6** induced from LPS were measured.

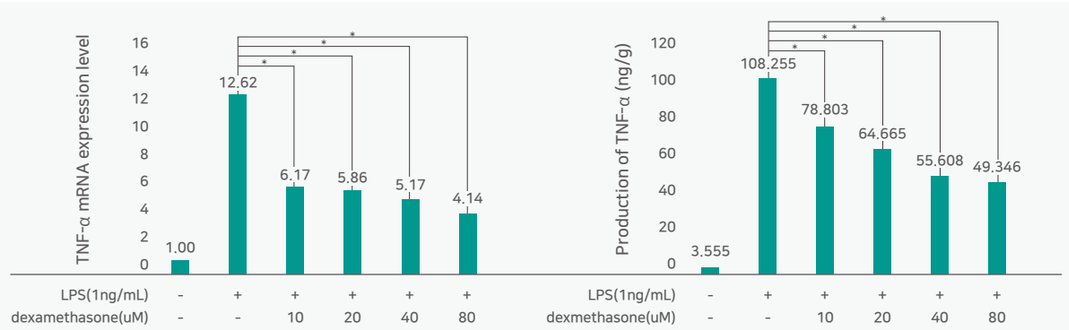
| RESULT | GreenDiol® inhibits LPS-induced cytokine production such as TNF-α and IL-6 in a dose-dependent manner.

Suppressed production of TNF-α and TNF-α gene expression by GreenDiol® in RAW 264.7 cells



GreenDiol®-treated group's mRNA expression level of TNF-α

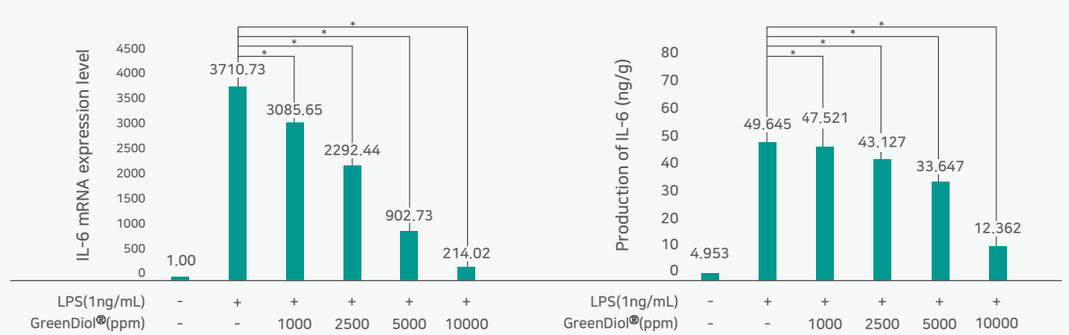
GreenDiol®-treated group's production of TNF-α
*Probability p (Mann-Whitney U test with Bonferroni correction)



Dexamethasone***-treated group's mRNA expression level of TNF-α

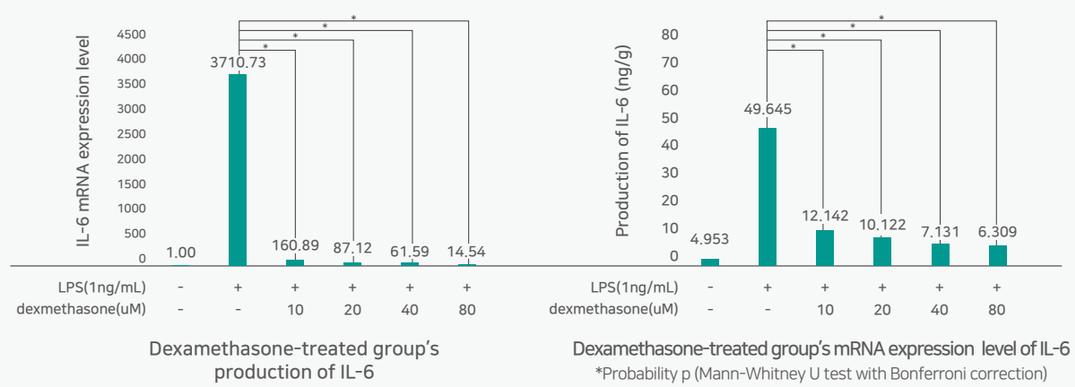
Dexamethasone-treated group's production of TNF-α
*Probability p (Mann-Whitney U test with Bonferroni correction)

Suppressed production of IL-6 and IL-6 gene expression by GreenDiol® in RAW 264.7 cells



GreenDiol®-treated group's mRNA expression level of IL-6

GreenDiol®-treated group's production of IL-6
*Probability p (Mann-Whitney U test with Bonferroni correction)



Dexamethasone-treated group's production of IL-6

Dexamethasone-treated group's mRNA expression level of IL-6
*Probability p (Mann-Whitney U test with Bonferroni correction)

* LPS (Lipopolysaccharide), found in Gram-negative bacteria, induces toxic activity.

** TNF(Tumor necrosis factor)-α and IL(Interleukin)-6 measured in our tests are pro-inflammatory cytokines.

*** Dexamethasone is a pharmaceutical drug commonly used for inflammation control.

EFFICACY

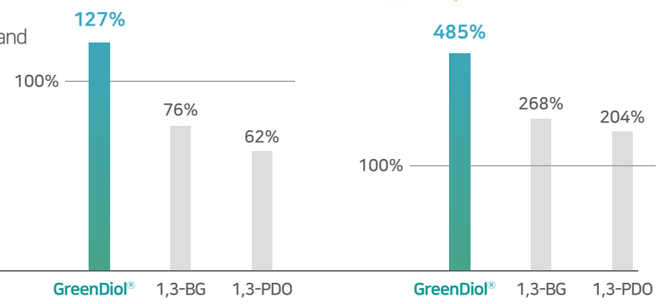
Select Extractant

- GreenDiol® which has not undergone any and all chemical synthesis is, by definition, the product that can extract active ingredients from natural substances in the shape of true nature.
- GreenDiol® has exhibited a superb performance as a botanical extractant compared to other polyols.

GREEN TEA EXTRACTION TEST

| EXTRACTANT | Powdered green tea from Jeju Island
| METHOD | Immersion Extraction

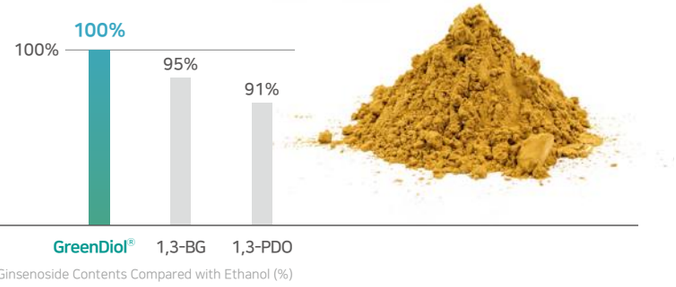
Active Ingredient 1 – **Catechin**
Active Ingredient 2 – **Amino acid**



RED GINSENG EXTRACTION TEST

| EXTRACTANT | Powdered Red Ginseng
| METHOD | Immersion Extraction

Active Ingredient 1 – **Ginsenoside**



THREE DISTINCTIVE FEATURES OF GREENDIOL®
03

Low Friction Coefficient

- Friction test showed that GreenDiol® induced the lowest coefficient of friction compared to other polyols.
- The result implies that GreenDiol® has the potential to contribute to improved sensual feelings of cosmetics products.

| METHOD | Each polyol was spread on synthetic leather by 5mm/min, and friction rate was measured at a speed of 1mm/min with KES-SE friction tester.

| RESULT | GreenDiol® had the lowest coefficient of friction.

MEASUREMENT OF FRICTION COEFFICIENT BY INDEPENDENT POLYOL

Test Material	MIU*	MMD**
GreenDiol®	0.334	0.0103
1,3-BG	0.561	0.0137
1,3-PDO	0.497	0.0126

*MIU : mean coefficient of friction, **MMD : mean deviation of MIU

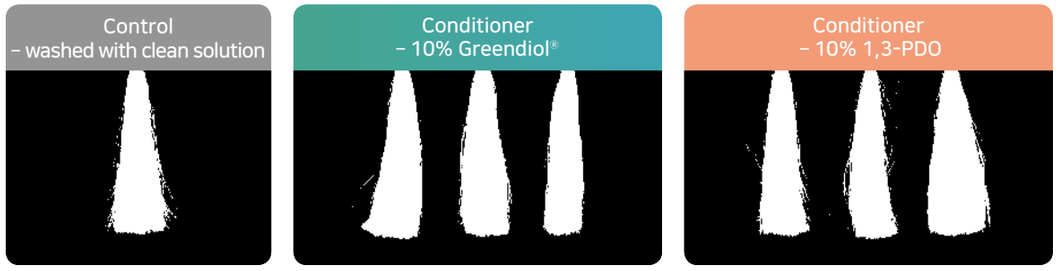
Compatibility with Haircare Products

- Analysis specifically with haircare products showed that GreenDiol® helps with frizz control and hair alignment better than a commonly used 1,3-PDO.

RUMBA ANALYSIS

| METHOD | After 1g of clean solution was applied to each 4g strand of hair and washed off for two repeated times, 0.4g of each of the conditioner types was applied and massaged, and the strand was analyzed at Rumba.

| RESULT | The conditioner with 10% of GreenDiol® was shown most effective at frizz control and hair alignment.



Additional Benefits on Skin

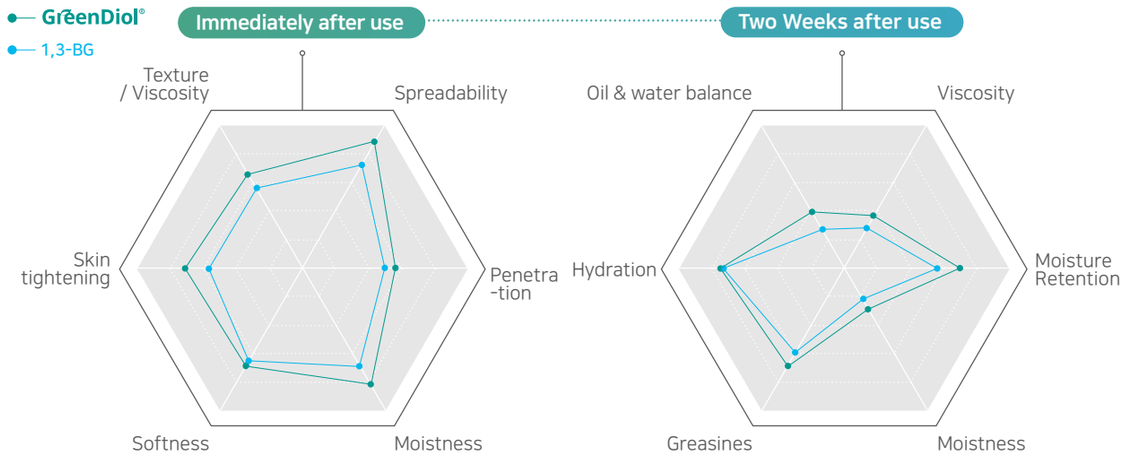
· Tests with essence cream containing GreenDiol® has shown that GreenDiol® is effective for skin health.

USER EXPERIENCE TEST

GreenDiol® has light texture, high penetration, as well as long moisture retention time.

| METHOD | After applying essence products containing GreenDiol® for one group and 1,3-BG for the other repeatedly for 2 weeks, the test subjects were surveyed on the satisfaction level for each item related to the user experience.

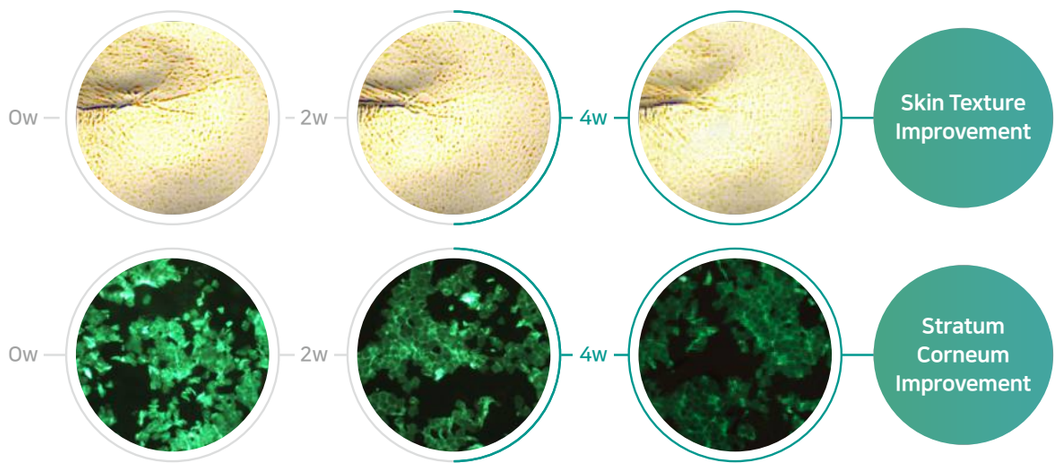
| SUBJECT | 50 test subjects for each product



SKIN EFFICACY TEST

| METHOD | After using essence cream containing 10% GreenDiol® for 4 weeks, the test subjects were observed on their skin texture(wrinkle) enhancement.

| SUBJECT | 23 subjects



COMPOSITION, PACKAGING AND CERTIFICATES

Composition

Property	Units	Limits	
2,3-Butanediol	wt %	90.0	92.0
Water	wt %	8.0	10.0

Packaging

Industrial Standard Pack	Plastic packaging of 20kg and 200kg
Samples	100g, 250g, 500g, 1kg, 2kg

Certificates

- COSMOS ('19)
- EU-REACH ('19)
- Vegan ('19)
- USDA BioPreferred® Program – 100% Bio-based ('18)
- New Excellence Technology by Korea Ministry of Trade, Industry and Energy ('18)
- New Excellent Product by Korea Ministry of Trade, Industry and Energy ('19)
- EWG Green Grade 1

Product Summary

· INCI Name: 2,3-Butanediol
· IECIC name: 2,3-Butanediol
· EC Number: 823-920-1, 208-173-6
· CAS Number: 5341-95-7, 513-85-9
· Functions
  · Humectant
  · Emollient
  · Hand-feel modifier
  · Preservative booster
  · Botanical extraction and dilution
  · Carrier for active cosmetic ingredient

CONTACT INFORMATION

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