



HME-DDS™: Eco-friendly nano platform for Health & Beauty market

Pharma first, Scalable to Beauty & Health-first



BeNatureBiolab Co., Ltd. | CEO Jong-Suep Baek

HME-DDS™

Hot Melt Extrusion - Drug Delivery System

- ✓ A Bio Company Based on Eco-Friendly HME-DDS™ Platform Technology
- ✓ Expanding From Natural Products to Biopharmaceuticals
- ✓ Innovation in the Pharmaceutical, Food, and Cosmetics Industries through Customized Solutions.



HME-DDS™ New
Technology
Certification (NET)
obtained (July 25)



17 patent registrations,
13 patent applications
(3 overseas)



100 SCI papers
published



ISO 14001, 9001,
22716 certifications
completed.

Growth History

2020
~
2021

- Company established
- Won DaesTar Platform Grand Championship

2022

- Moved plant to Chuncheon Gangwon Technopark
- Relocated HQ to KNU Bodeum Hall

2023

- Secured KRW 1.3B seed investment

2024

- Completed GMP facility and obtained HACCP
- Attracted investment from Douzone Bizon
- Selected as Chuncheon's first Deep Tech TIPS

2025

- Acquired NET (New Excellent Technology)
- Participated in CES and Bio USA
- Reached first-half BEP
- Received Gangwon Governor's Award for venture excellence
- Received the Excellence Award from CnA Intergreen
- Awarded the Minister of SMEs and Startups Award (Korea)
- Achieved ISO 14001, 9001, and 22716 Certification

Innovation bottleneck: expensive solvents, excessive additives... a cost structure that cannot be reduced

High-Cost reality

Expensive Solvents

Bulky Excipients

API

Sky-high Production Cost



Need for Innovation

Need for innovative technology

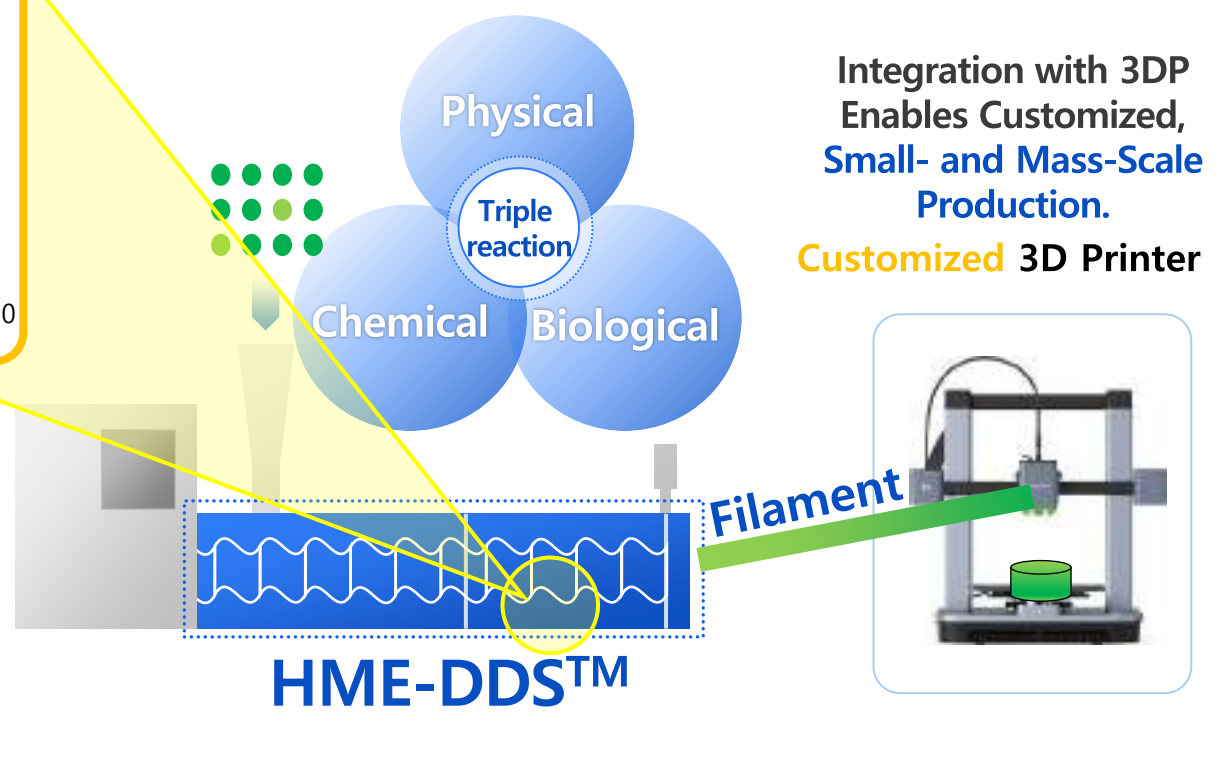
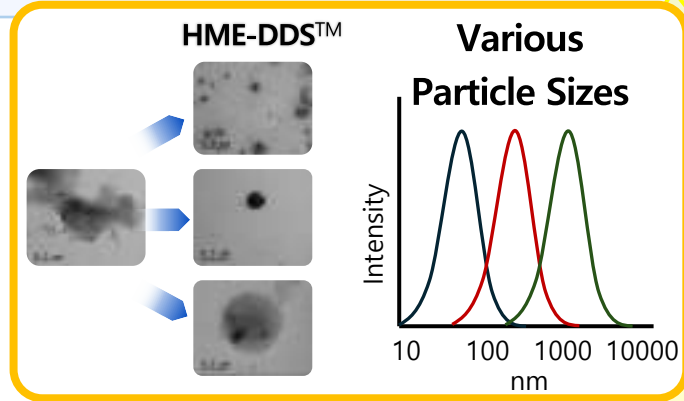
API

Solvent/Excipients
ZERO

Low Cost
High Efficiency

03 Our Solution: HME-DDS™ (Hot Melt Extrusion-Drug Delivery System)

No Solvent - Eco-friendly Bio Platform

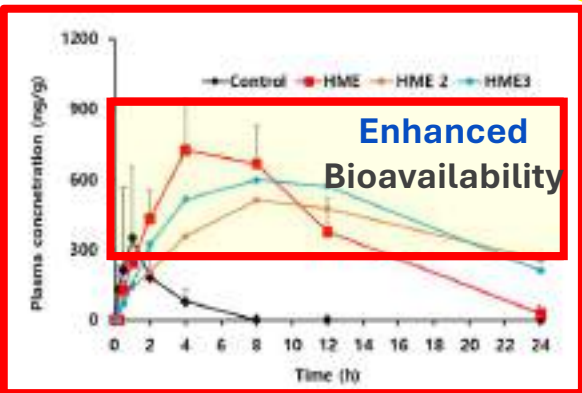


Integration with 3DP Enables Customized, Small- and Mass-Scale Production.
Customized 3D Printer

Can be manufactured in a variety of formulations



Applicable to various industries



Processable Materials

Natural, Synthetic & Macromolecules

Improved Bioavailability (Absorption Rate)

Up to 50x

Cost Savings

Up to 10X

Eco-Friendly Process

By-Product & Solvent Zero

Why BNBL HME?

– The Overwhelming Technological Gap Created by “Lattice Structure”

Beyond the limits of physical micronization: fundamentally blocking recrystallization through molecular-level control

(Detailed Effect): Rapid dissolution & enhanced permeability

Limitations of Conventional Technologies

Physical Grinding

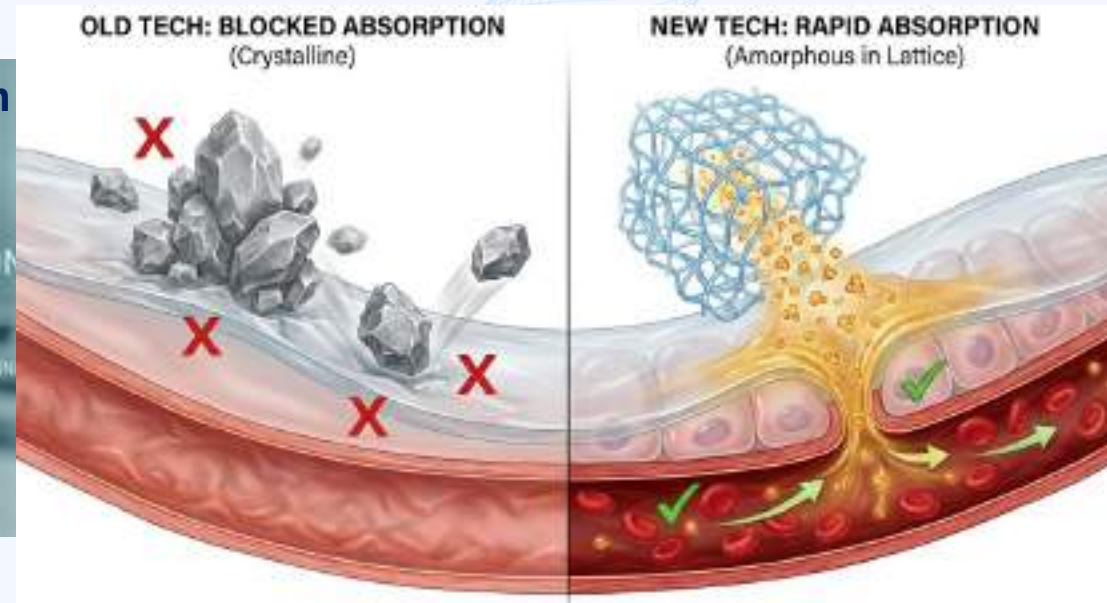
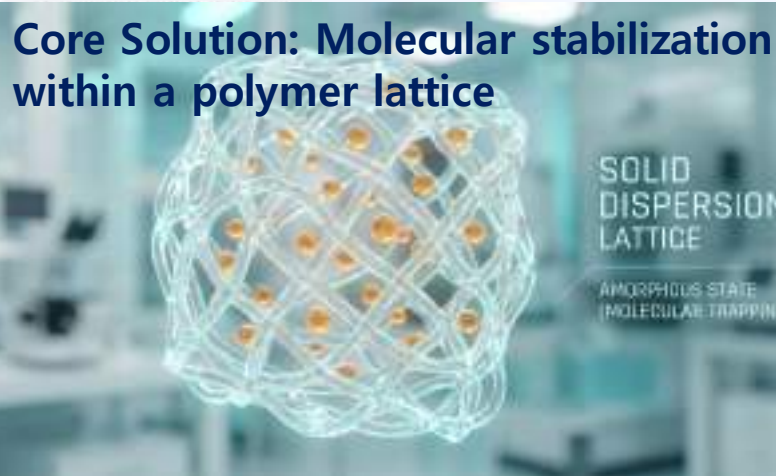
Recrystallization



1st Generation (Simple grinding)

2nd Generation (Solvent-based dissolution)

Core Solution: Molecular stabilization within a polymer lattice



Because the molecular structure is converted into an amorphous (non-crystalline) state with higher energy, it dissolves instantly and permeates cell membranes more easily.

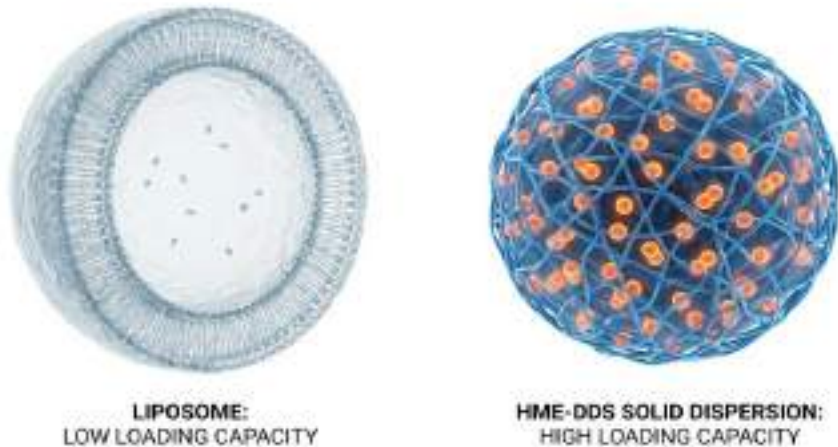
- Particle size reduction
- > Risk of recrystallization
- > Limited increase in absorption

05

Beyond Liposome: Next-Generation High-Efficiency, High-Loading Delivery System (HME-DDS)

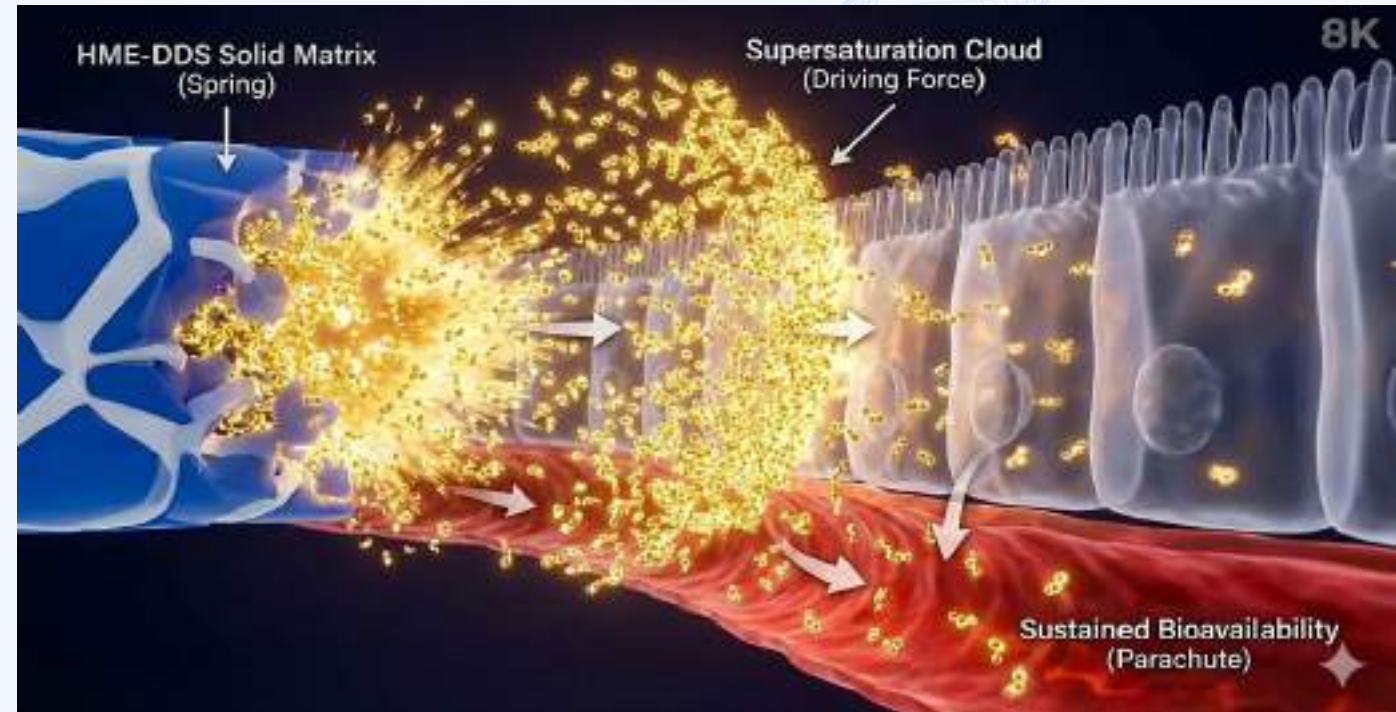
Overcoming the limitations of conventional nanoparticles (low loading, instability) and maximizing bioavailability through the principle of supersaturation

Structure: Overwhelming Loading Efficiency



- **Conventional (Liposome):** A “nitrogen snack”-like structure where ~90% consists of the carrier (lipid shell)
→ Low active ingredient content (5–10%) and **high production cost**
- **BNBL(HME-DDS): High-density compressed matrix** containing up to 50% active ingredient
→ Up to **50-fold increase** in drug delivery per unit volume

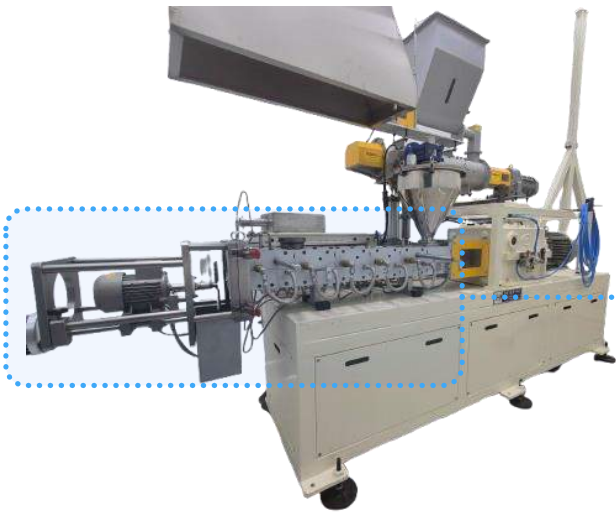
Absorption Mechanism: Spring & Parachute Effect



- **Spring:** Upon administration, rapid and explosive supersaturation occurs, generating a strong driving force for absorption
- **Parachute:** The polymer matrix inhibits recrystallization, maintaining the supersaturated state for an extended period and maximizing systemic absorption (AUC)

The only team to have perfected precision-controlled HME-DDS™ technology.

HME-DDS™



Know-how 01

Module optimization



- **Dozens of types** of screw elements and die holders
- **Customizable process design** for each formulation and physical property
- Module design optimized for **customer conditions** possible

Know-how 02

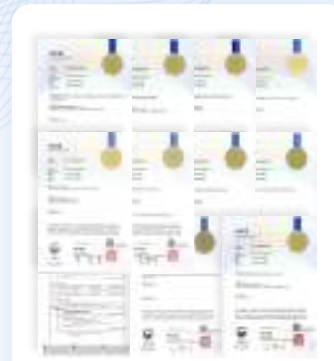
Triple Reaction



- Precise combination of **temperature, pressure and shear force** in the process
- **Chemical, physical, and biological** reaction induction
- **Nano-scale particle size** control

Establishment of a

Proprietary and Unrivaled HME-DDS™ Platform

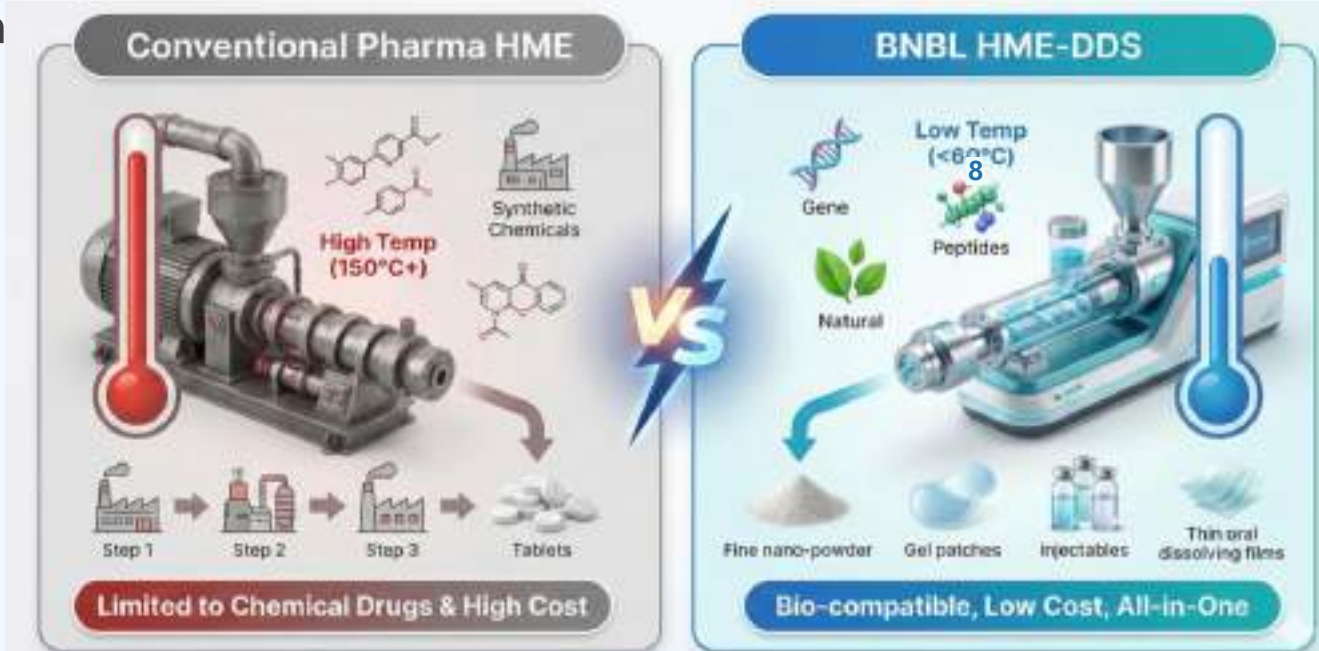


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Beyond Global Standard: A “Low-Temperature · Low-Pressure Hybrid” Technology Surpassing the Limits of Conventional

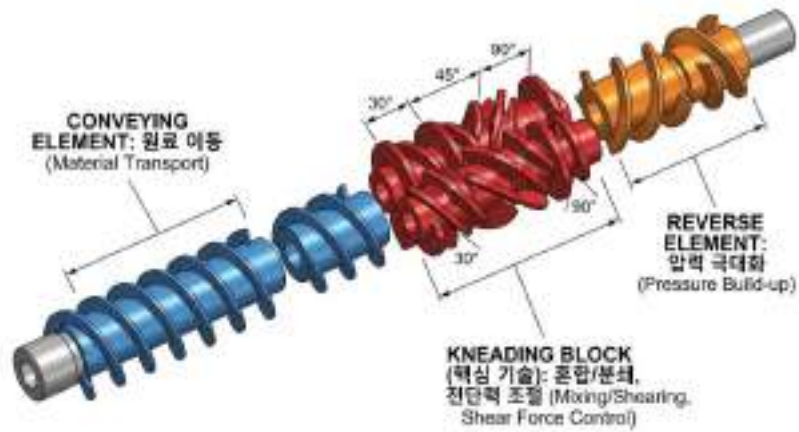


Category	Conventional Global Pharma HME	BNBL HME-DDS (Advanced Hybrid)	Advantage
Key Processing Conditions	High temperature ($\geq 150^{\circ}\text{C}$), high pressure (risk of thermal degradation)	Low temperature ($-20\sim 80^{\circ}\text{C}$), low pressure (minimized active ingredient degradation)	Applicable to bio- and natural materials
Matrix Materials	Primarily synthetic polymers (e.g., PVP, HPMC; high-cost excipients)	Lipids and natural polymers (bio-friendly, low-cost materials)	Cost reduction and enhanced safety
Excipient Ratio	High (typically $\geq 70\%$) to ensure processability	Less than 30% (minimized), enabling high active loading	Smaller dosage form and improved patient compliance
Applicable Substance	Low-molecular-weight chemical drugs (limited to heat-stable materials)	Polymers, peptides, natural products (including heat-sensitive bio-materials)	Strong pipeline expandability
Process Flow	Multi-step process (extrusion → cooling → milling → tableting)	One-step continuous process (raw material input → finished product/formulation)	~50% reduction in processing time and cost
Final Dosage Forms	Oral solid dosage forms (primarily tablets and capsules)	Versatile formulation platforms (nano-powder, ODF, exosomes, injectables, etc.)	Flexible response to market demand
Key Players	AbbVie, Capsugel (Lonza), Thermo Fisher	BeNatureBioLab (BNBL)	Proprietary patented technology

08 HME-DDS™ Differentiation: The Only Team That Has Mastered Precision-Controlled HME-DDS™ Technology

“You can purchase the hardware, but you cannot replicate the optimal recipe (configuration).”

Screw Configuration Diagram



Conveying Element:

Moves raw materials forward (basic transport function)

★Core Technology- Mixing/Dispersing Section (Kneading Block):

By adjusting angle (30°, 45°, 90°) and thickness, shear force and residence time are precisely controlled to disrupt crystalline structures

Reverse Element: Restricts flow to increase pressure and induce polymer entrapment

The Butterfly Effect of Small Differences (Small Difference, Big Change)

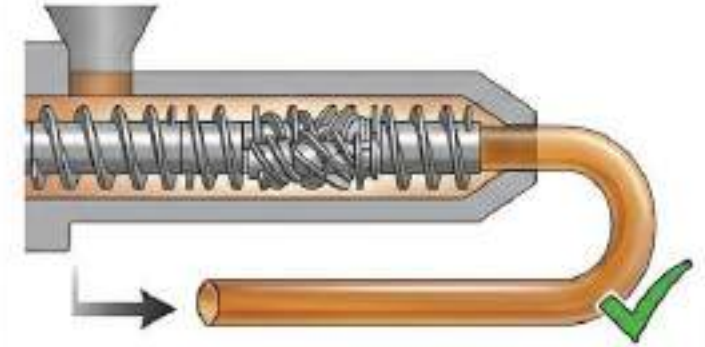
A single difference in element arrangement determines product quality

Case A (General Configuration): Failure in screw optimization



Excessive heat generation leading to active ingredient degradation (dark discoloration)

Case B (BNBL Optimized): Precision arrangement of kneading blocks



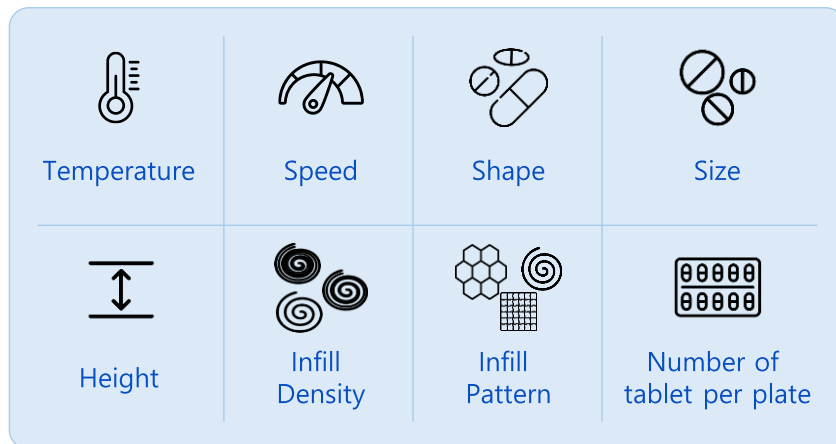
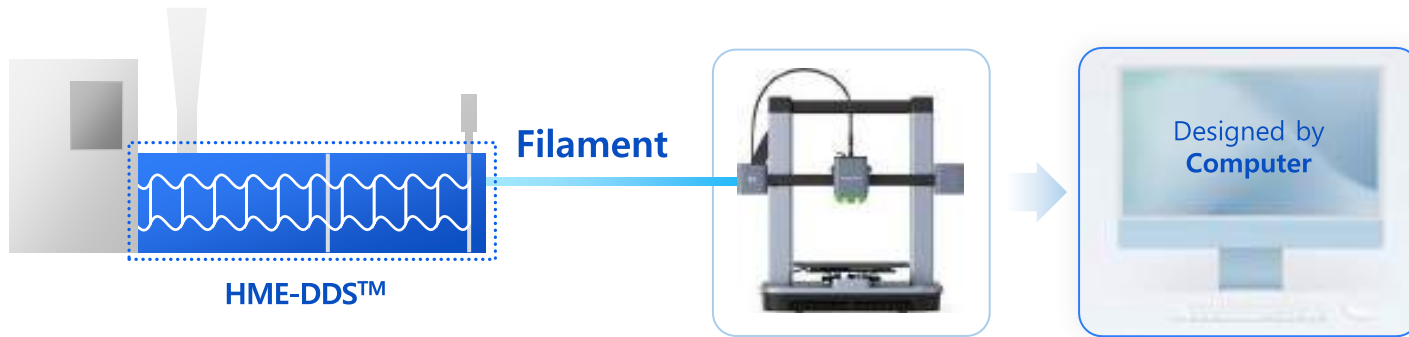
100% preservation of active ingredients + successful complete amorphization

It is not about simply rotating the screws; the core challenge lies in identifying the one correct configuration among thousands of possibilities, tailored to the material's properties.

Based on Material-Specific Characteristics, BNBL Possesses a “Golden Configuration” Database

HME-DDS™-Based 3D Printing: A Next-Generation Personalized Drug and Nutrition Delivery Platform

HME - DDS™ + 3D Printer



Simulation I

10 tablet
20~35% porosity
300mg

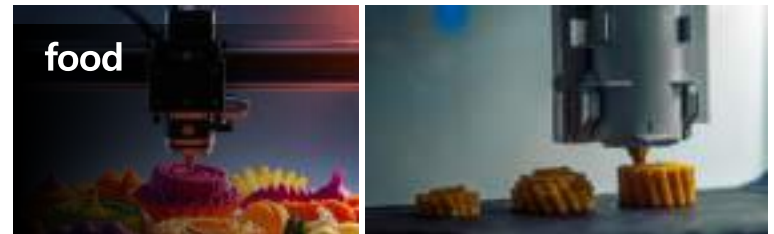
Simulation II

50 tablet
5~15% porosity
550mg

Printing



HME - DDS - 3DP conjugation



10 Customized product differentiation

HME-DDS™ offers customized release profiles for multiple drugs, allowing for precise tailoring to minimize side effects and maximize efficacy.

Customized formulation company A

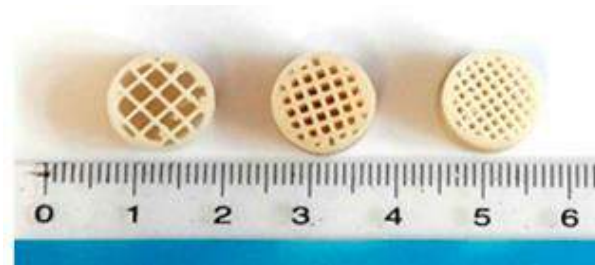


- Multi-layer structure design possible
- Consists of layers each containing specific functional ingredients

however,

- Low release control
- Actual delivery efficiency in the body is low

HME-DDS-3DP™ Differentiation

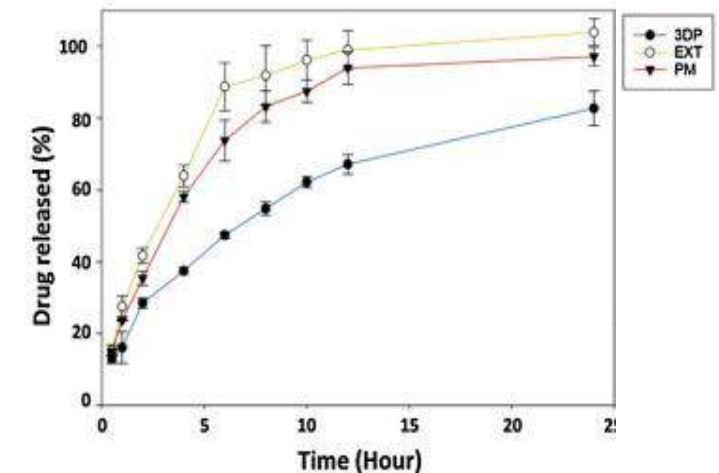


Based on HME-DDS™, improved bioavailability and stability

Through 3DP

- Precise release control
- Minimize dosage and frequency of administration
- **Securing global competitiveness** based on FDA recommended continuous process

Precision release control design



Time-specific release rate and volume precisely adjusted

Infographic Illustration of 'Food Tech Evolution' Driven by HME-DDS



HME-DDS™ Platform Differentiators

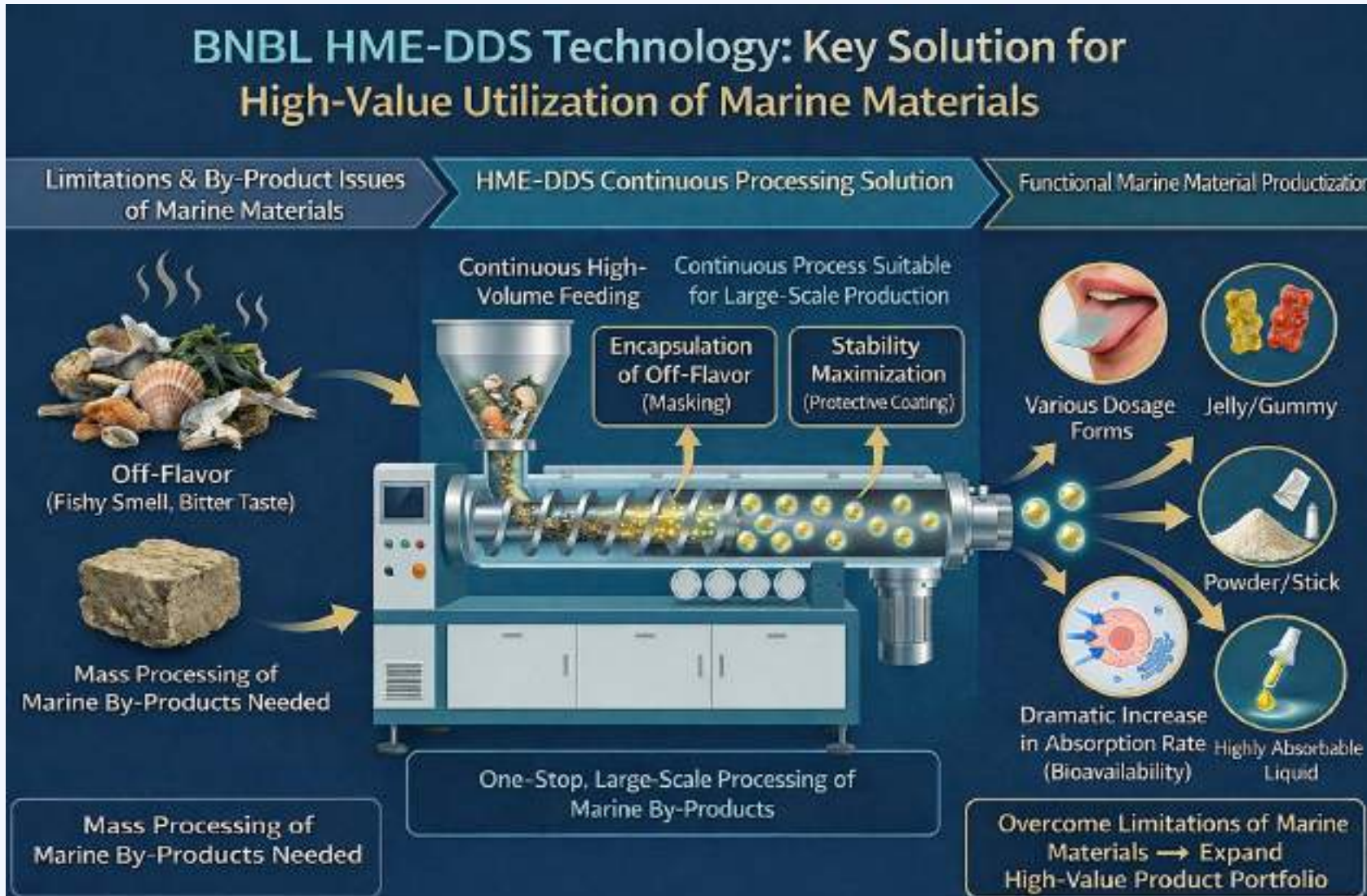
Up to 10x improvement

Solvent-free, eco-friendly process

Maintaining functionality and ensuring light and heat stability

Customized combinations by disease and age.

Various formulations available, including film, stick, and chewable



BNBL HME-DDS: Ongoing Marine Material Projects & Partnerships

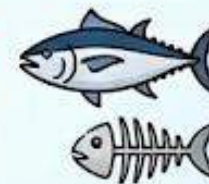
DAESANG (Microalgae)



→ Odor/Taste Masking

→ One-Step Drying & Formulation

DONGWON F&B (Tuna By-products)



→ Functional Ingredients

Omega-3,
High-Absorption Calcium,
Sarcopenia Target

CJ (Biodegradable PHA)



→ Solvent-free Emulsion & Powderization

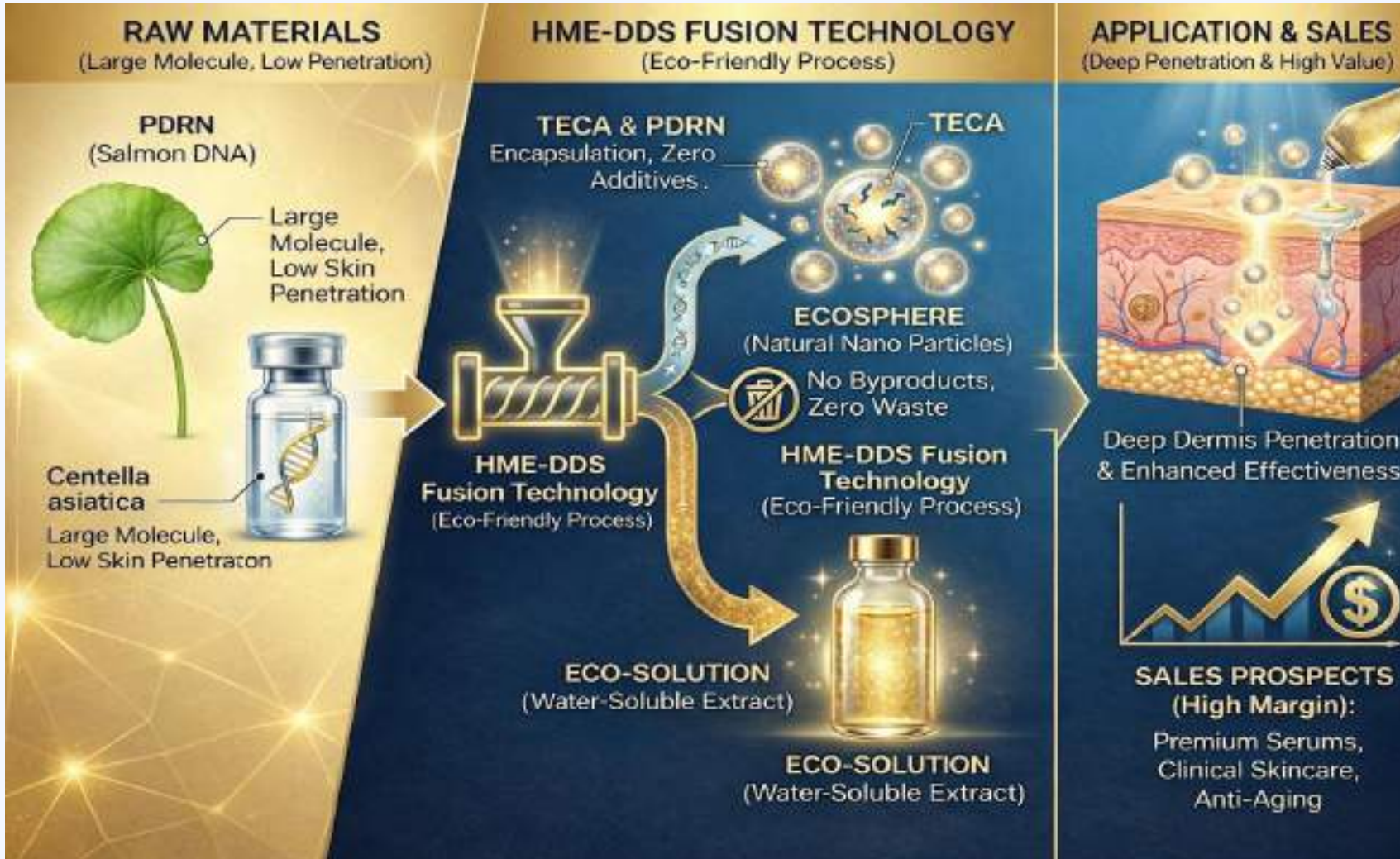
JEJU & HWANGONG FISHCAKE (Fish By-products)



→ By-product Utilization

Non-fried Fishcake
Development



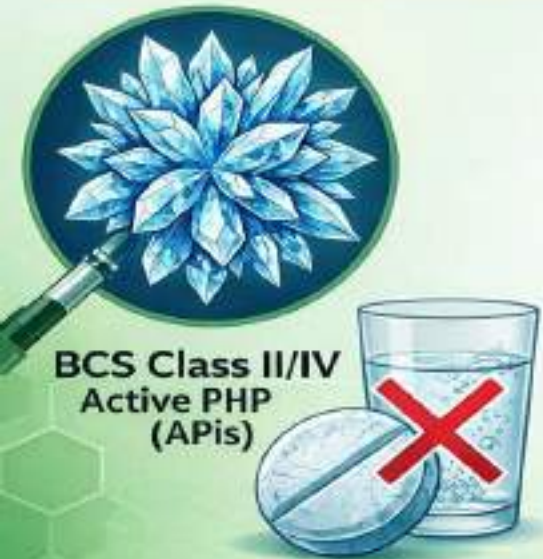


HME-DDS™ Platform Differentiators

- Absorption rate improved by **up to 3 to 5 times**
- Powderable**
→ Improved storage capacity & reduced distribution costs
- Minimize** the use of surfactants and synthetic polymers
- Use of carbon-neutral raw materials
→ **All ingredients used, no by-products**
- Up to 500% improvement** in extraction efficiency

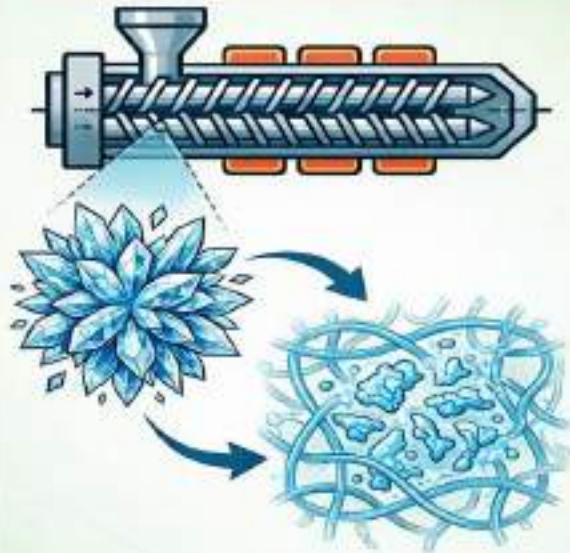


Challenge: Poorly Soluble Drugs



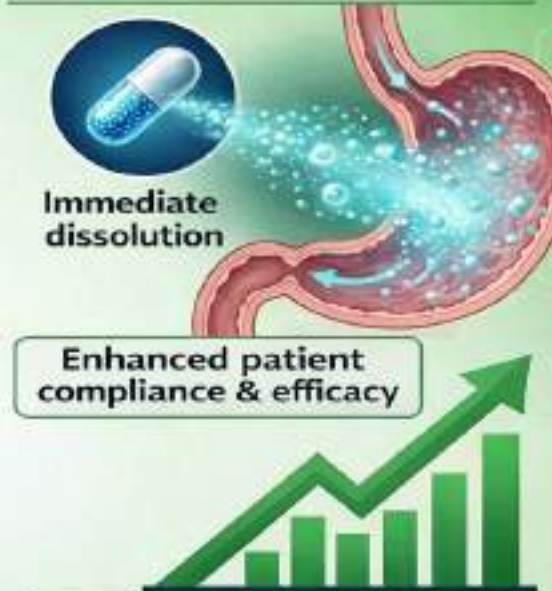
- Low bioavailability
- Poor patient compliance

HME-DDS Solution (Amorphous Solid Dispersion)



- Rapid dissolution
- Improved solubility
- Stable formulation

Results & Growth: Innovation & Success



- Sales prospects (tech transfer/reformulation)
- New drug delivery, improved drugs
- Sales prospects (tech transfer/reformulation)

HME-DDS™ Platform Differentiators

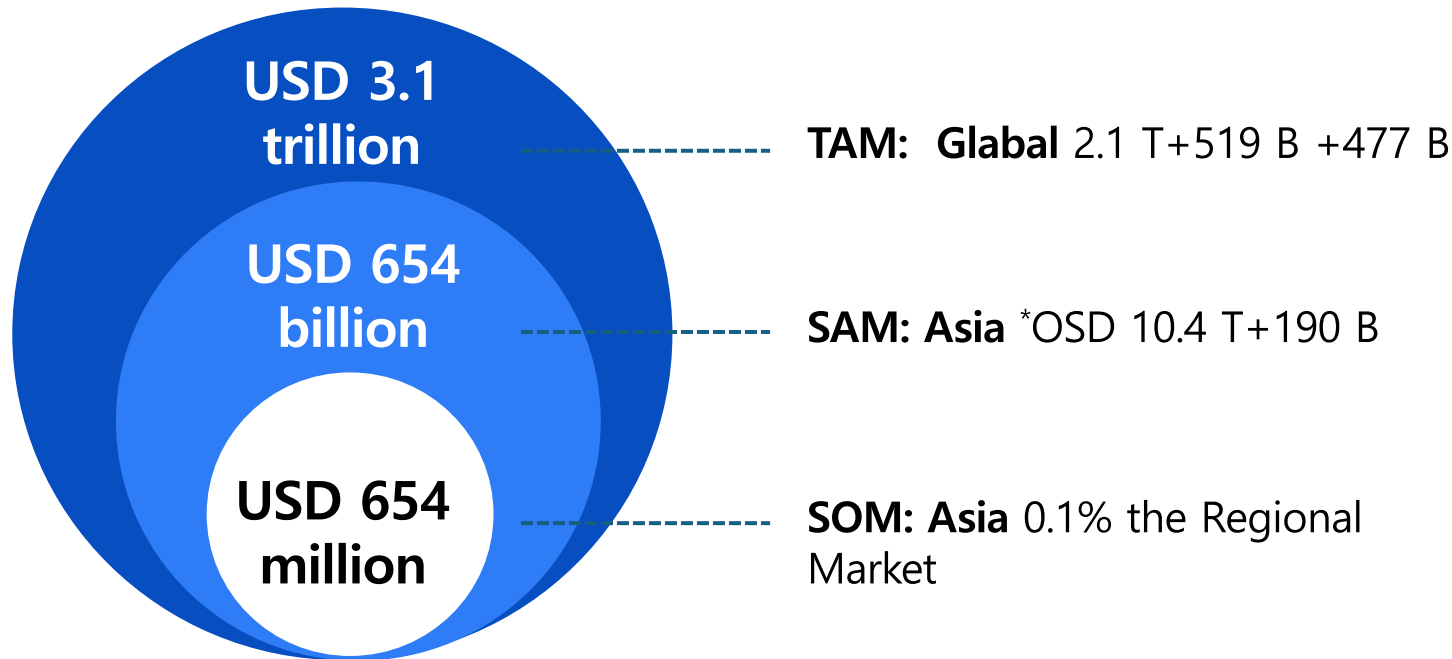
- Customized production available from **1kg to 1 ton**
- Reduction in formulation size and weight
- Minimize excipient content (0-30%)
- Take once a day and reduce dosage
- Application of HME-DDS-3DP technology
- API Separate Loading and Release Pattern Optimization

14 Market Opportunity

As demand for high-performance products expands, nanotechnology is being applied to a wide range of products, including **food, cosmetics, and pharmaceuticals.**

Global Market

Pharma Drug Delivery + Cosmetics + Functional Supplements



Why now?

Government Policy: Strengthened ESG & Eco-Friendly Process Support

- 2023: Enforcement of the Carbon Neutrality Framework Act
- Promotion of green industries and ESG certification expansion
- Establishment of eco-friendly process R&D support programs (2024)

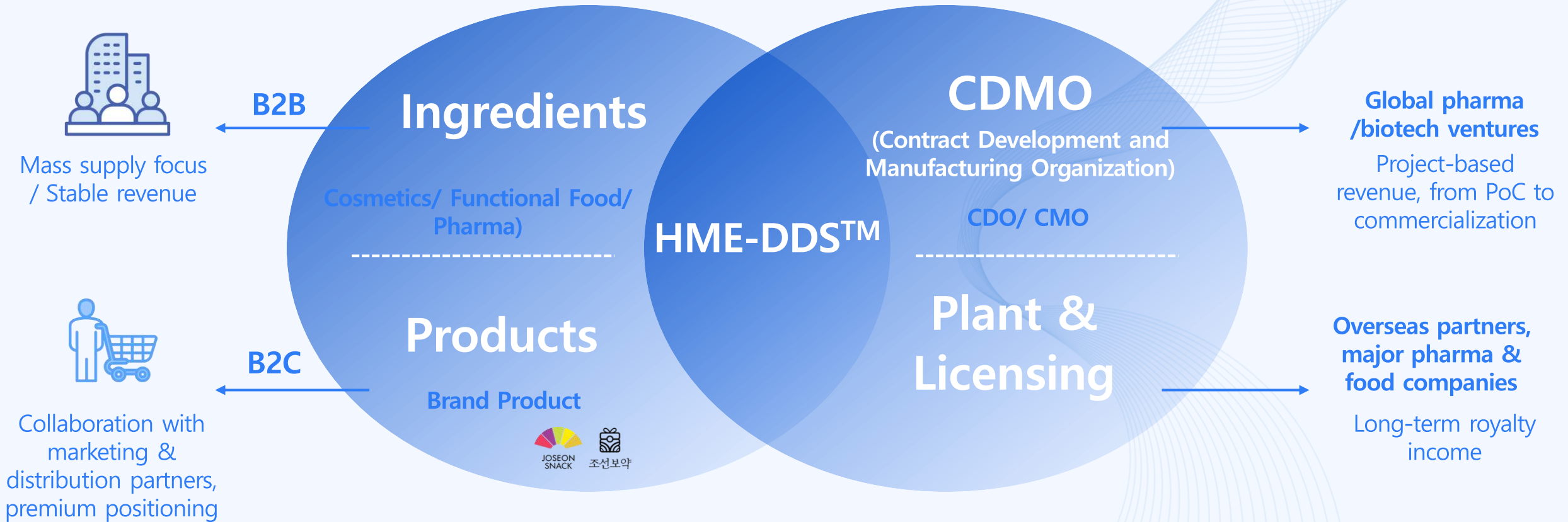
Global Regulatory Changes

- EU CBAM (Carbon Border Adjustment Mechanism): full implementation by 2026
- U.S. & EU ESG supply chain audit requirements expanding (from 2024)
- Accelerating transition of global cosmetics and food brands to low-carbon materials

Regulatory relaxation in Korea + tightening global regulations = A prime opportunity for companies with eco-friendly process technologies

*Oral Solid Drug

“From Platform to Product: Creating Scalable Value through HME-DDS™”



Beyond CMO for natural and synthetic materials, expanding into CDO to establish an integrated CDMO business model

1. One-Stop CDMO Service



CDO: R&D Area

5-batch/day
Production
Capacity



CMO: Scale-Up/
Initial Production

End-to-End Support from
Research to Production

2. Technology Platform Licensing



Customized HME-DDS
Equipment



Patent Technology
Transfer
(License-out)



Equipment
Sales +
Licensing
Fees

Integrated Equipment &
IP Package Offering

3. Sustainable Royalty Revenue



Client Mass-Production
Products



BNBL Royalty
Revenue

Volume-Linked Running
Royalty Secured

17 Traction & Validation

Academic Validation

17 domestic patents, 13 pending, 100+ SCI papers

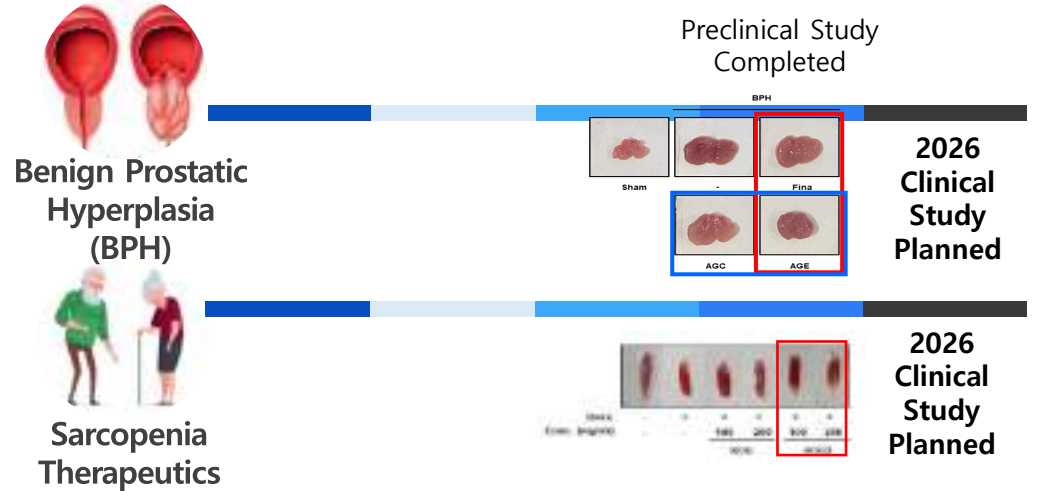
Partnerships

 Food Technology Transfer Discussions	 Cosmetics AMORE PACIFIC Cosmetic Contract Signed	 Pharma Device Purchase Agreement (Post-PoC, In Progress)
 MOU for Co-Development (25.03~)	 NDA/PoC (25.08~)	

Main Pipeline

Individually Approved Type

2026 Clinical Study Planned



Pharma 2026 Preclinical Study Planned

대웅제약
 GLP-1 Oral Formulation

Cosmetic Materials

AMORE PACIFIC
 ECOSOLUTION ECOSPHERE

18 Our Team

An optimized team leading the development and global commercialization of innovative healthcare solutions

CEO&Founder

Jong-Suep Baek CEO



- PhD of Pharmacy (Pharmaceutics)
- Assistant Professor, Kangwon National University
- Received 5 Billion Won in Government projects
- Published 70 SCI Papers

CTO

Hyo-Jin An



- PhD of Oriental Medicine (Pharmacology)
- **Professor, College of Pharmacy, Kyung Hee University**

Head of Manufacturing

Man-Seop Shim



- M.S. of Agriculture (Animal Resources)
- **Over 35 Years of Practical Experience** in the Green Cross Veterinary Medicine Field

Technical Sales Director

Moonkyu Kang



- Ph.D. in Pharmacology and Toxicology
- **Global Network & BD Expertise**

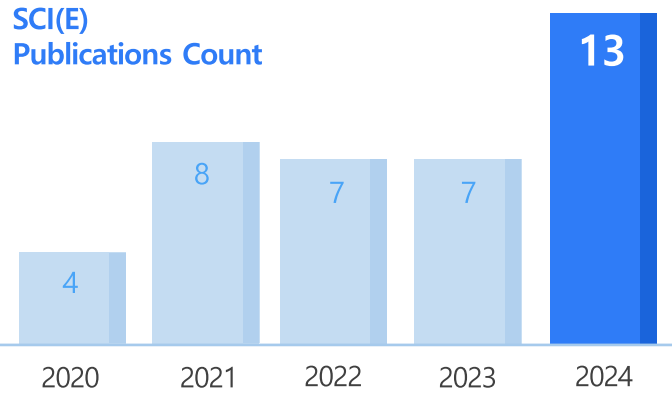
2 Professors + 80 years industry experiences

19 Key Achievements

SCI Publications Overview

HME-DDS™	18 cases
Natural product formulation	40 cases
Disease targeting	6 cases
etc	49 cases

Research growth trend



Patent Registration and Application Status

Domestic Registrations	17	Domestic Applications	10	PCT Applications	3
Cosmetics	2	Pharmaceuticals	2	Foods	12

Awards



2021 D-Startup Solution Platform Finalist (Excellence Award)



Uni-Tec Demo Day (Grand Prize)

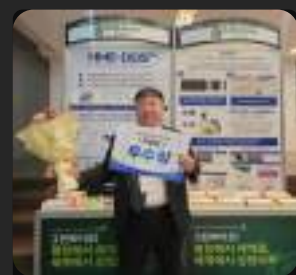


Recipient of the Governor of Gangwon Province Award



Grand Prize (Minister of SMEs and Startups Award, Korea)

Others



Intergreen CnA Partnering IR Pitch (Excellence Award)



Deep Tech TIPS Program



2024 TechCruch



BIO USA 2025



CES 2025

BeNatureBioLab Manufacturing Facility

STEP 01

Incorporation of BeNatureBioLab



STEP 02

Relocated to the 2nd plant at Chuncheon Technopark



STEP 03

Head office relocated to Kangwon National Univ



STEP 04

Completion of GMP Manufacturing Facility Construction



Maximum Daily Production Capacity | 5,000 Kg

Establishment of Company-Affiliated Research Institute

~2023. 11



Certified as a Venture Company

~ 2024. 02



Obtained HACCP Certification

~ 2024. 11



Issued Green Bio Company Registration Certificate

~ 2025. 04



Acquired New Technology Certification

~2025. 8



ISO 14001 Certification (Environmental Management System)

~2025. 12



ISO 9001 Certification (Quality Management System)

~2025. 12



ISO 22716 Certification (Cosmetic GMP)

~2025. 12



“A healthy and sustainable future where people and nature thrive together”

Boosted
bioavailability

**Eco-friendly
Process**
(Solvent Free)

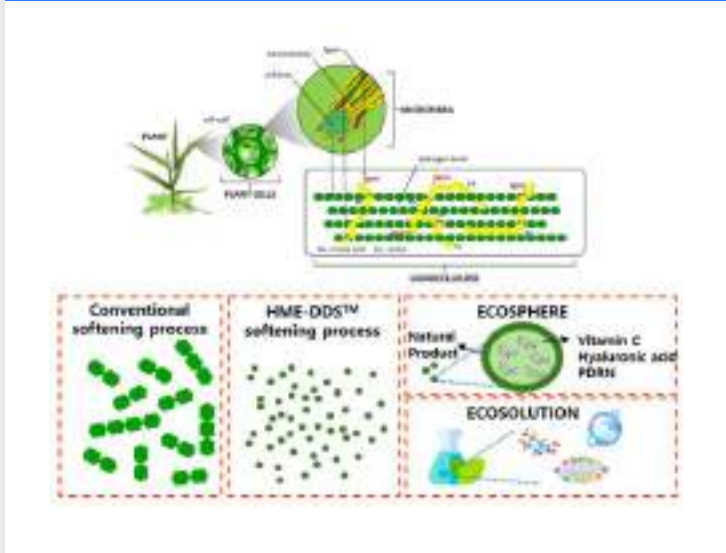
Integrated
continuous
process

Synthetic · Natural ·
hybrid formulations

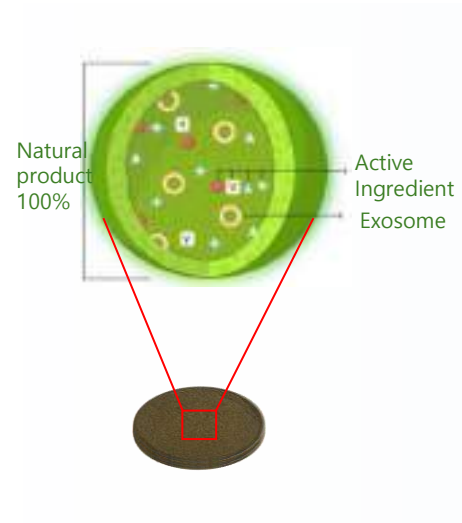
01 Appendix

B2B

Distinctive Features of HME-DDS™ Technology



ECOSPHERE



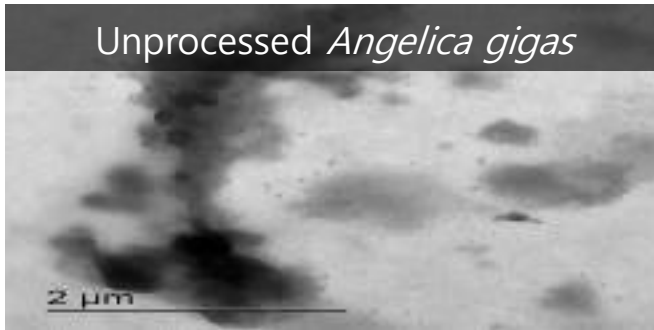
1. Plant-softened materials are dried into powder form, allowing **high versatility in formulations** such as serums.
2. The **structure remains stable in cosmetic formulations** but disappears upon application, enabling full skin absorption and maximizing visual impact.
3. **Improved water solubility and increased concentration** of active ingredients.

ECOSOLUTION



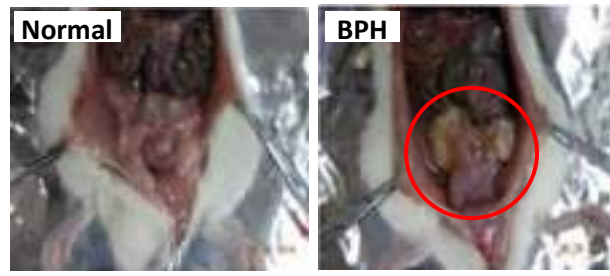
1. Filtered plant-softening extracts obtained during the manufacturing process show **high applicability in formulations** such as toners and ampoules.
2. Rich in active ingredients and exosomes, making it a **potent natural ingredient for high-performance cosmetics**.
3. Liquid form offers **excellent processability and formulation flexibility**.

Feature

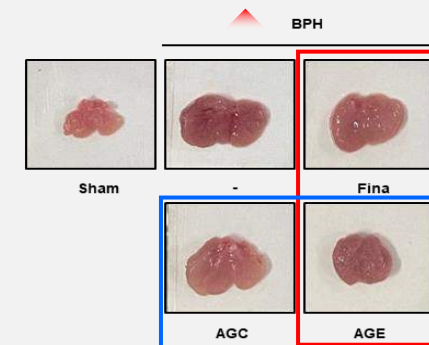
Unprocessed *Angelica gigas*HME-DDS™-processed *Angelica gigas*

Efficacy

Benign Prostatic Hyperplasia (BPH)-Induced Model



Demonstrated a higher inhibitory effect on **benign prostatic hyperplasia (BPH)** than **Finasteride**.



The conventional water extract of *Angelica gigas* (AGC) showed no inhibitory activity, whereas only the **HME-DDS™-processed extract (AGE)** demonstrated significant inhibition.

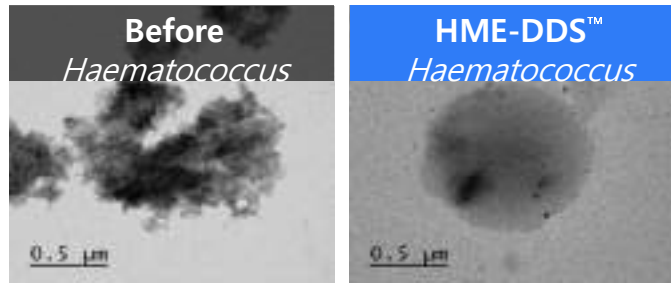
Patent Title A composition for preventing, alleviating, or treating benign prostatic hyperplasia, Comprising a hot-melt extruded extract of *Angelica gigas* as an active ingredient

Registration Date 2024.04.29 **Registration Number** 10-2024-0056896

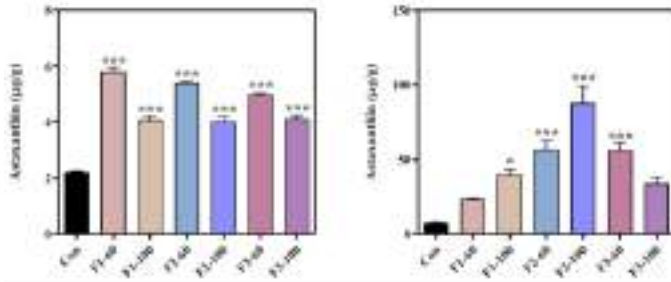
03 Appendix

B2B

Feature



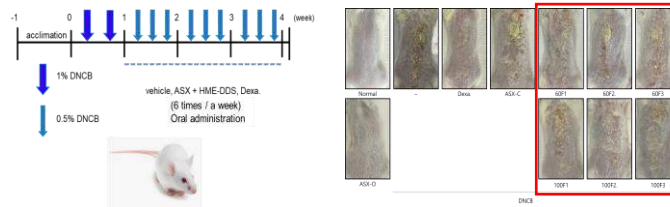
HME-DDS™-based nanoencapsulation of *Haematococcus pluvialis* powder



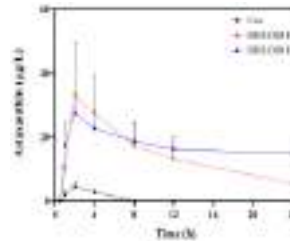
The HME-treated group showed a significantly higher astaxanthin content compared to the control group.

Patent Title Composition for prevention, improvement, or treatment of sepsis, comprising an extract of hot-melt extruded *Haematococcus pluvialis* as an active ingredient
Registration Date 2024.12.24 **Registration Number** 10-2747956

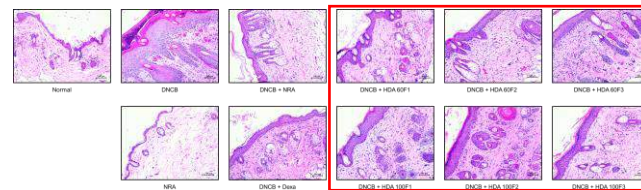
Efficacy



Compared to the control group, the HME-processed material significantly alleviated pathological conditions in skin tissue.



The HME-processed astaxanthin formulation showed more than a threefold increase in AUC compared to the control group, indicating significantly enhanced bioavailability and sustained systemic exposure.

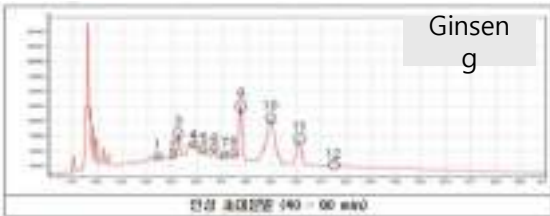
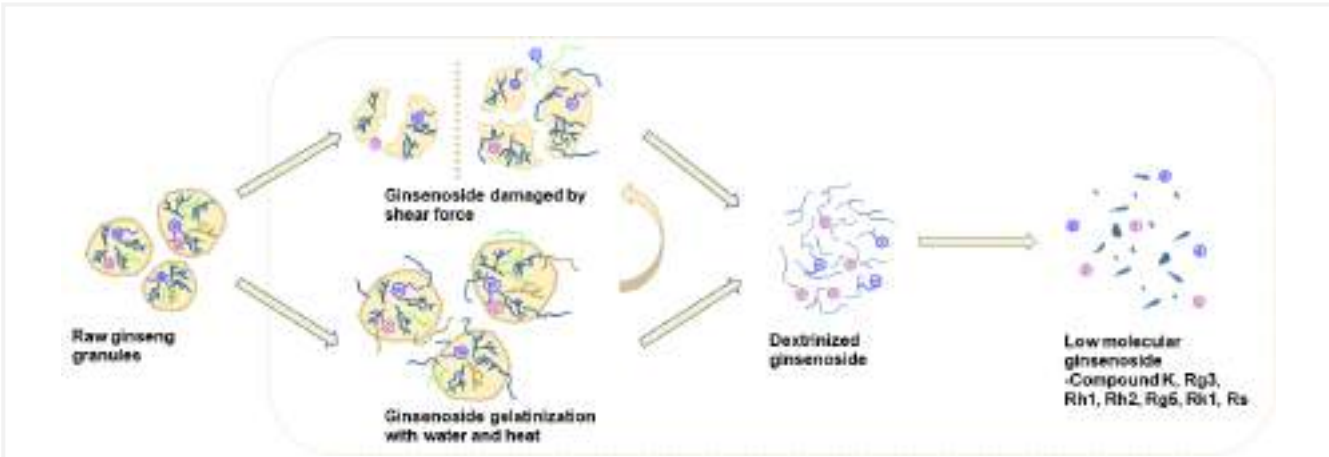


The HME-treated group exhibited a significant reduction in scratching behavior compared to the control group.

Patent Title Method for Manufacturing Multi-Walled Carbon Nanotubes Comprising Hot-Melt Extruded *Haematococcus pluvialis* and Use Thereof
Registration Date 2024.11.15 **Registration Number** 10-2024-0162708

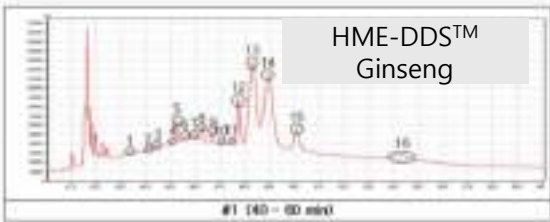
04 Appendix

B2B



Ginseng

Generation of **highly bioactive functional ginsenosides** such as Compound K, Rg3, Rh1, Rh2, Rg5, Rk1, and Rs — **with up to a 50-fold increase in content.**



HME-DDS™ Ginseng

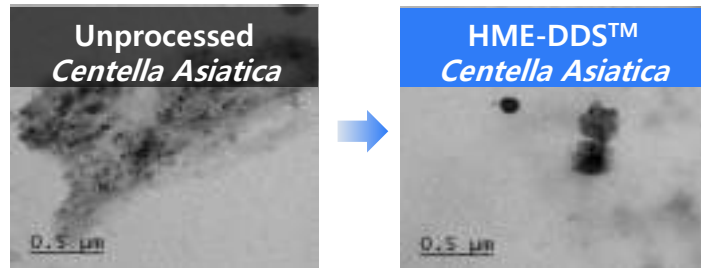
High bioavailability with distinct pharmacological efficacy compared to conventional ginseng and red ginseng.

➔ It was confirmed that ginseng's bioactive compounds are transformed through high-temperature, high-pressure ultrafine pulverization."

05 Appendix

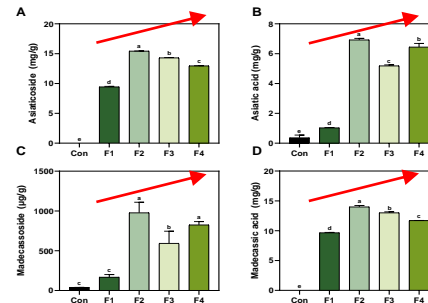
B2B

Characteristics

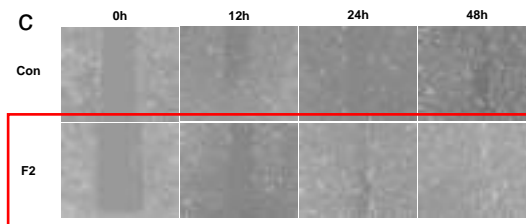


Nanoencapsulation of *Centella Asiatica* Powder via HME-DDS™ Processing

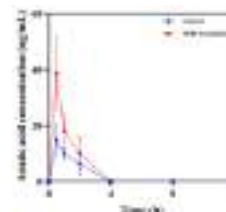
Efficacy



All HME-processed *Centella Asiatica* formulations showed increased levels of asiaticoside, madecassoside, asiatic acid, and madecassic acid compared to the control group.



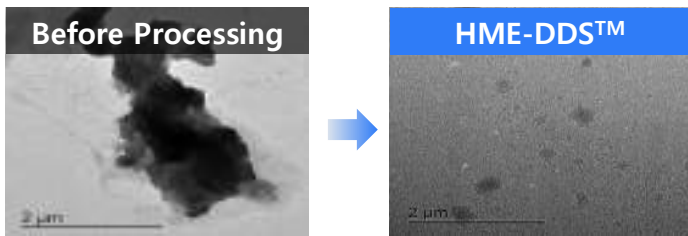
The skin regeneration effect of *Centella Asiatica* was further enhanced through HME processing.



Parameter	Con	HME-processed
T_{max} (hr)	0.50 ± 0.00	1.50 ± 0.00
C_{max} (μg/mL)	11.01 ± 1.40	30.30 ± 1.00
AUC_{0-12h} (μg·h/mL)	11.00 ± 1.40	30.30 ± 1.00
$AUC_{0-∞}$ (μg·h/mL)	21.40 ± 1.00	47.54 ± 11.17

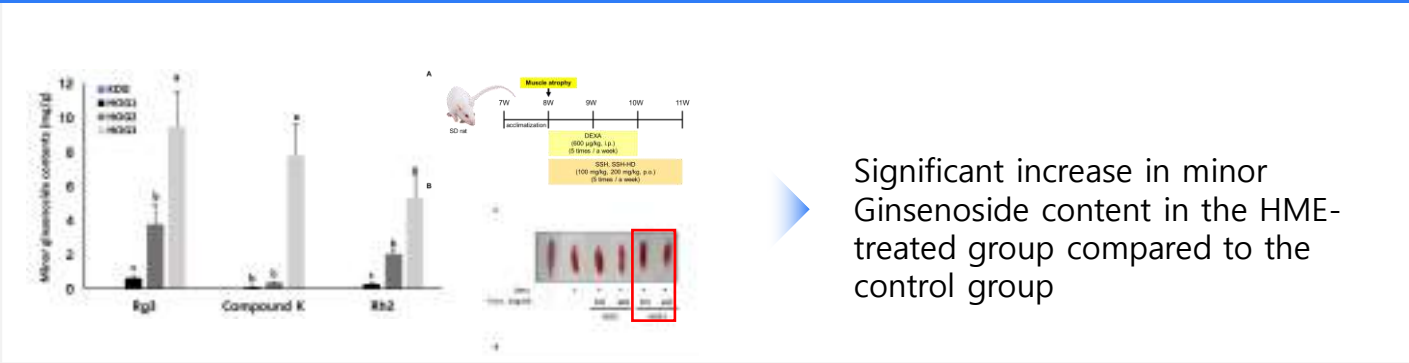
HME-processed *Centella Asiatica* formulations improved bioavailability and absorption, increasing the AUC value of asiatic acid by approximately 2.6 times and 2 times compared to the control group.

Characteristics



Nano-encapsulation of Kyungok-go through HME-DDS™ processing

Efficacy



Significant increase in minor Ginsenoside content in the HME-treated group compared to the control group



HME-Kyungok-go administration significantly improved muscle loss



Patent Title Processing method of Kyungok-go for enhancing the content of low-molecular-weight components, micro-colloid dispersion obtained thereby, and composition comprising the same

Registration Date 2025.04.28 **Registration Number** 10-2803249

Patent Title Processing method of Ssanghwa-tang for enhancing solubility of fat-soluble active ingredients, micro-colloid dispersion obtained thereby, and composition comprising the same

Registration Date 2025.04.28 **Registration Number** 10-2803249



<p>Sales Channels</p>	<p>1 Naver Smart Store, Brand-owned Online Store 2 Major Domestic and Global E-commerce Platforms 3 Overseas Export</p>	
<p>Core Technology</p>	<p>HME-DDS™ Technology Applied</p>	<p>1 Eco-friendly processing 2 Low molecular weight & microencapsulation 3 Improved bioavailability and sustained absorption</p>
<p>Product Features</p>	<ul style="list-style-type: none"> • 100% Natural Ingredients • Guaranteed content of functional compounds (Ginsenoside) • Free from harmful additives (No trans fats, artificial colorants, or synthetic additives) 	<ul style="list-style-type: none"> • Registered as a Health Functional Food • Preserves the original properties of natural substances • Free from harmful additives (No trans fats, artificial colorants, or synthetic additives)
<p>Reference Images</p>	 <p>Five types of Color Bites and Panax</p>	 <p>Joseon Herbal Remedy products scheduled for release in 2026</p>