1. What are fine bubbles?

Fine Bubbles (FBs) are bubbles smaller than 100 micrometers in diameter

	Ultrafine Bubble (UFB) (<1μm)	Micro-Bubble (1~100μm)	Sub-milli Bubble (100μm~1mm)
Water not saturated with gas	Disappear (dissolve)	Rise slowly and shrink	Break at the surface; Rise quickly
Water saturated with gas	Stable for weeks to months; Brownian Motion	Rise slowly	

The small size, high stability and high surface area of FBs give them unique features

Rising speed of a bubble with a diameter of;
300μm → few meters per minute
10μm → few millimeters per minute
0.1μm → does not rise (Brownian Motion)

APEC Workshop I

FBIA

b)18:10-18:40

"Standardization and certification as technical platform of fine bubble technology"

Mr. Takeyuki FUSE and Dr. MitsuruTANAKA,
Fine Bubble Industries Association (FBIA)
Japan

January 19, 2021

○"Standardization and certification as technical platform of FBT"

0.5 h (Mr.FUSE & Dr.TANAKA)

Basics of conformity assessment and Introduction of an example of conformity assessment

ABSTRACT:

Technical committee "ISO TC 281 "Fine bubble technology"" was established in order to support sound market formation by developing standards. Delegates from many economies in APEC area are actively participating the discussion. So far, 9 International Standards, 2 Technical Specifications and 1 Technical Report have been published and 7 standards are under development. The standardization is also necessary for objective evaluation of R&D fine bubble technology. The progresses of the role of standardization in the TC 281 will be introduced.

The products on market and technology for R&D with objective evidence and the establishing the infrastructure for the evaluation will be necessary. Internationally agreed conformity assessment will be the final goal for guaranteeing the confidence of the evaluation for mature technology. Currently, in fine bubble products area the technology is evolving, although rapidly, and the market is just growing. An example of conformity assessment system accommodating with current stage of the evolution of the technology will be introduced.

FBIA Marking System

Fine Bubble Industries Association (FBIA)
helps F-B industry by Transferring Confidence
on its Products/Services to their Users and Consumers

FBIA Marking system

- Product Registration
- Product Certification
- Testing Designation
  - Test Labs
  - Maker
- Domestic

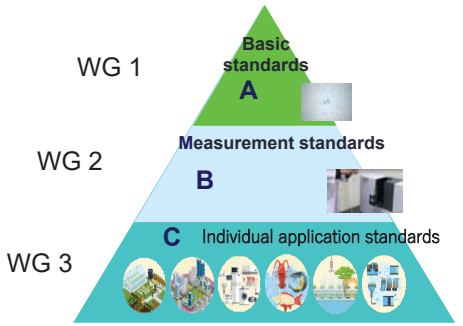
Supporting Self-Declaration

FBIA

By Marking

3. Three-layer configurations in ISO/TC281

Developing ISO standards on Fine Bubble Technology through three-layer configurations



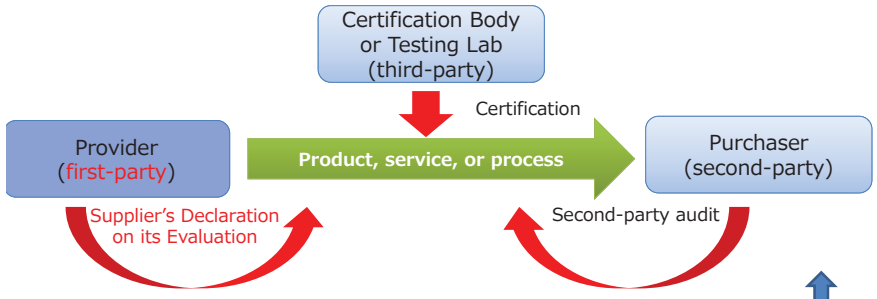
A The **first layer (basic standards)** covers common terminology, basic concepts, and principles for measurement and usage

B The **second layer (measurement standards)** covers various measurement methodologies for characterization

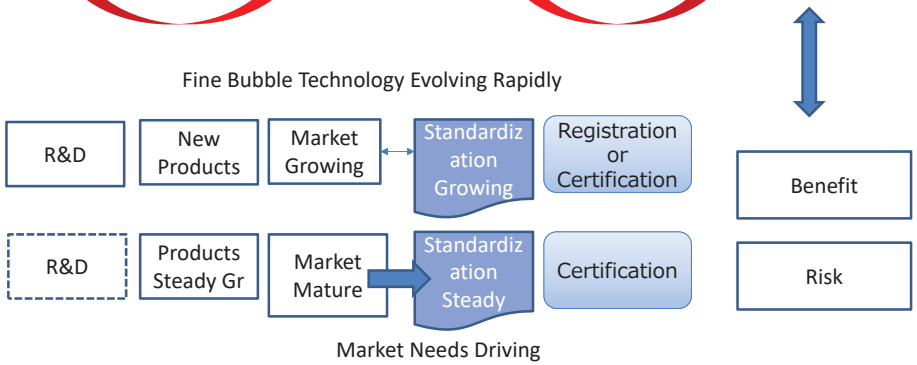
C The **third layer (individual application standards)** covers individual applications

12 PUBLISHED ISO STANDARDS under the direct responsibility of ISO/TC 281

9 ISO STANDARDS UNDER DEVELOPMENT under the direct responsibility of ISO/TC 281



Fine Bubble Technology Evolving Rapidly



Market Needs Driving

Stable Technology

4. Fine bubble standards in ISO/TC 281 (Red:AAWT)

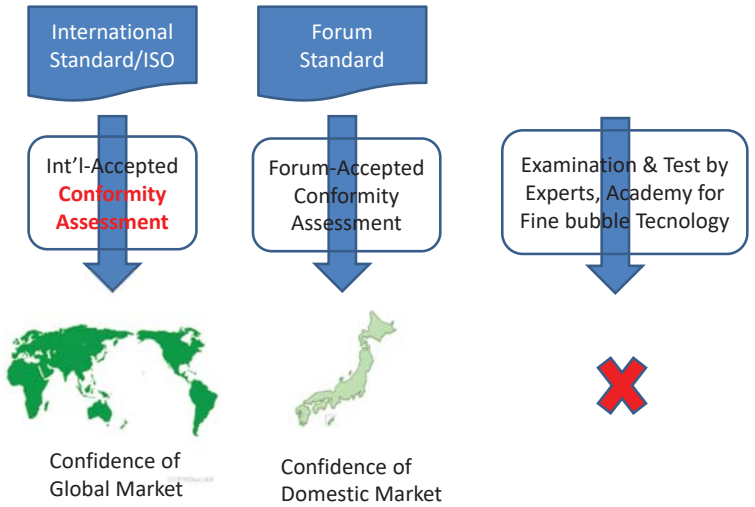
Published standards

- ISO 20480-1:2017 General principles for usage and measurement of fine bubbles -- Part 1: Terminology
- ISO 20480-2 General principles for usage and measurement of fine bubbles -- Part 2: Categorization of the attributes of fine bubbles
- ISO 20298-1 Sampling and sample preparation for measurement -- Part 1: Ultrafine bubble dispersion in water
- ISO 21255 Storage and transportation of ultrafine bubble dispersion in water
- ISO/TR 23015 Measurement technique matrix for the characterization of fine bubbles
- ISO 21910-1 Characterization of microbubbles -- Part 1: Off-line evaluation of size index
- ISO 24261-1:2020 Fine bubble technology -- Elimination method for sample characterization -- Part 1: Evaluation procedure
- ISO/TS 21256-1 Cleaning applications -- Part 1Test method for cleaning salt (NaCl)-stained surfaces
- ISO 21256-2 Cleaning applications -- Part 2: Test method for cleaning machine-oil stained surfaces of machined metal parts
- ISO/TS 23016-1 Agricultural applications -- Part1Test method for evaluating the growth promotion of hydroponically grown lettuce
- ISO 23016-2 Agricultural applications -- Part 2: Test method for evaluating the promotion of the germination of barley seeds
- ISO 20304-1 Water treatment applications -- Part 2: Test method for evaluating decolorization performance of ozone fine bubble water generating syst

How to use the mark?

On the surface of the products
On the package
On the catalogue
On the web-site
On the name card

FBIA Web-site & List



IDEC ultrafine Galf

Product
UFB Generator

Mark at Front Panel

Format of Marks

Registered FBIA Mark

Additional note

RUFB2004001
C1AUFB8b2004001
C1BUFB8b2004001

"R": Registration
"C": Certification
UFB: Ultrafine Bubble
MB: Micro Bubble

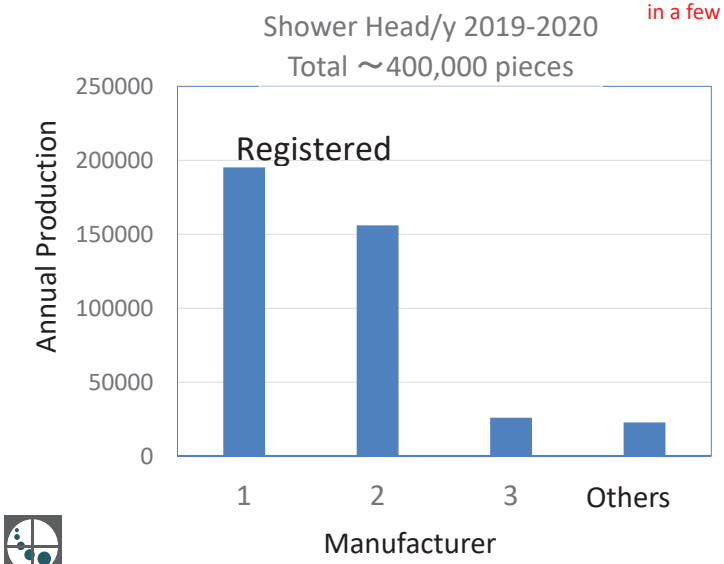
1A: Certification Level 1A
1B: Certification Level 1B

"8B": Category of FB Char

2004001
: Issued in April 2020, the first in the month

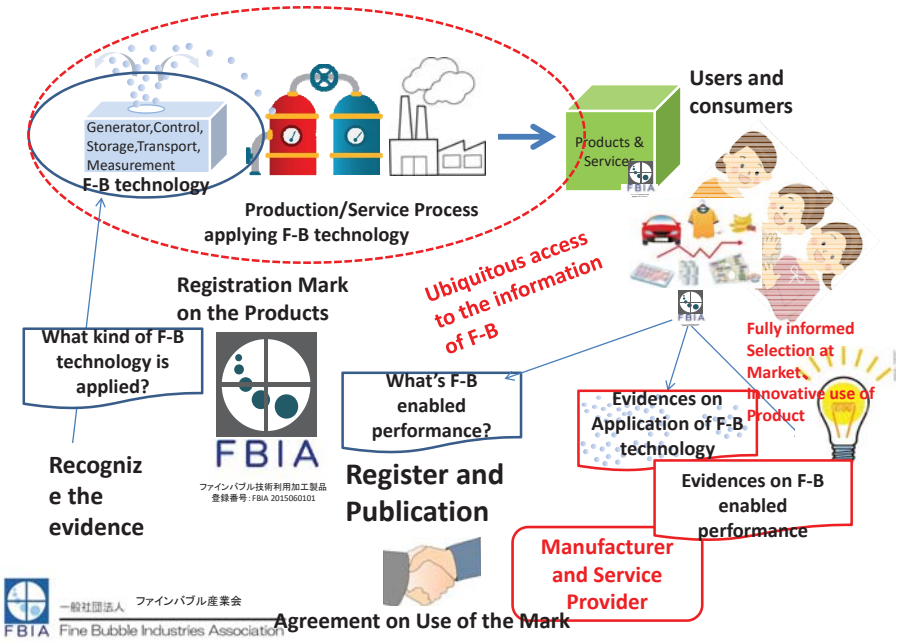
Explanation on the Mark :
FBIA certifies the fine bubble characteristics of this product is of the level 8B of ultrafine bubble in FBIA category.

Market Needs grown in a few years



FBIA
ファインバブル技術利用加工製品
登録番号：FBIA 2015060101

How to Examine



一般社団法人 ファインバブル産業会
FBIA Fine Bubble Industries Association

FBIA Registration Intension

To Register after examining sound use of "Fine Bubble" and "Ultra Fine Bubble", "Number concentration" as ISO TC 229 standard.

3.2
fine bubble
bubble (3.1) with a *volume equivalent diameter* (3.8) of less than 100 μm

Note 1 to entry: 100 μm is also represented as 1×10^{-4} m.

Note 2 to entry: Annex A provides further information on the use of terms "fine bubble" or "*ultrafine bubble*" (3.3), instead of "nanobubble".

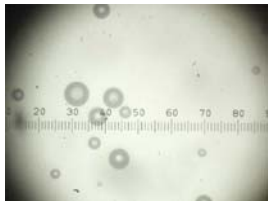
3.3
ultrafine bubble
Fine bubble (3.2) with a *volume equivalent diameter* (3.8) of less than 1 μm

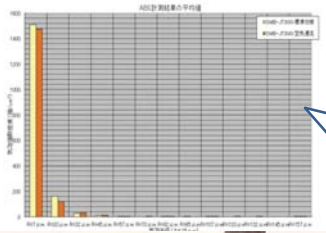
Note 1 to entry: Measured examples of ultrafine bubbles in water by particle characterization methods, in practical application fields, mostly range between 100 nm and 200 nm. The measured results can include contaminants, as well as ultrafine bubbles. (See 3)

3.7
bubble number concentration
number of *bubbles* (3.1) per unit volume of medium

Note 1 to entry: The medium can be *solid medium* (3.5) or *liquid medium* (3.6).

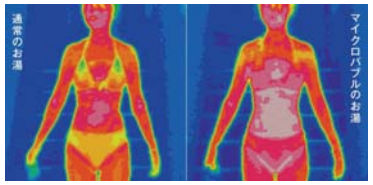
Example of Evidences

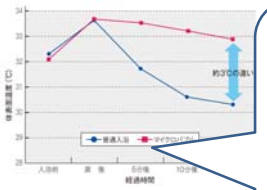




Application of F-B technology Size index of Micro bubbles

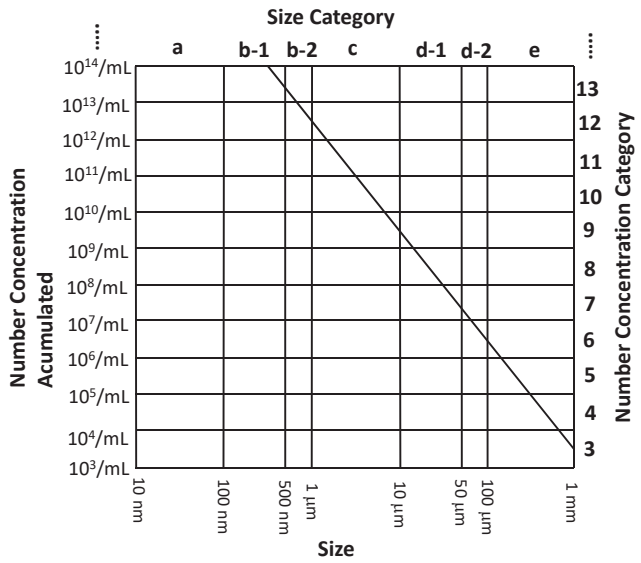
F-B enhanced performance Cleaning on bathed body





F-B enhanced performance Warming on bathed body

FBIA Category of Fine Bubble Characteristic



Examination & Evidences

Menu

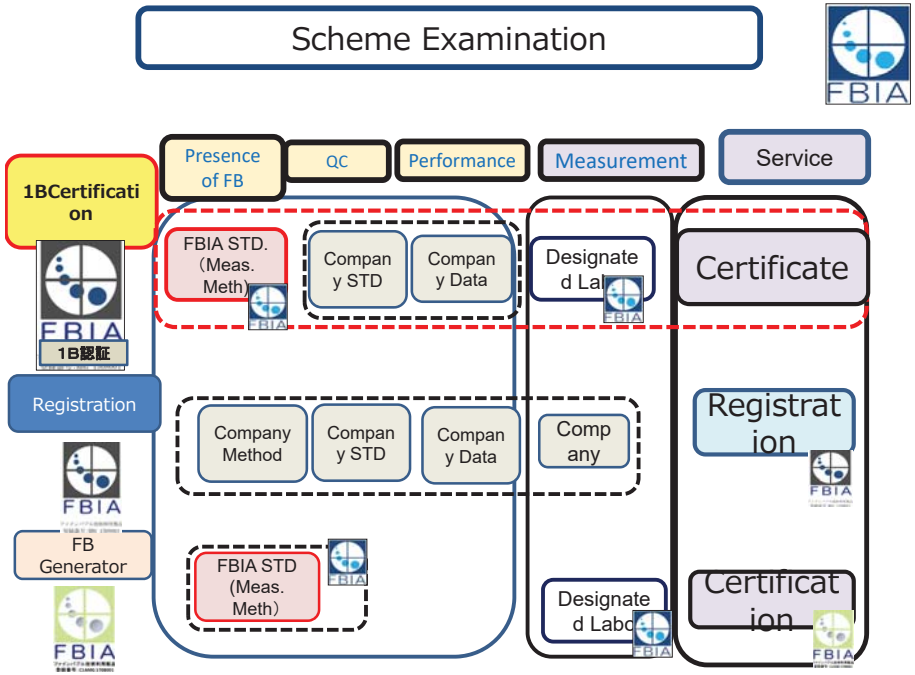
Proficiency test is necessary. QC on measurement service. For FB measurement lab.

Registration	1A certification	1B certification	Designation on Testing Lab.
1.Use of FB, 2.QC, 3.Sound Use of Mark are necessary. All evidences can be self declaration. Mark on All Products. Just presence of FB recognized. For consumer products.	1.Use of FB, 3.Sound Use of Mark are necessary. Certificate of Designated Lab is necessary. Mark just on a sample. For generator. FB characteristic is classified	1.Use of FB, 2. QC, 3.Sound Use of Mark are necessary. Certificate of Designated Lab is necessary. Mark just on All Products. FB characteristic is classified and needs QC. Standardization needed	

Registration Mark(1)

Reg. No.	Applicant	Initial Reg. Date	Registration Mark	Expiration Date	Appl. Field	Applied FB Technology	Information of Applicant
RBG 150 800 1	Science	2015 /10/3 0	FBIA	2020 /10/ 29	Cleaning, Home Use	Bath Water supply using FBs by Pressurizing Dissociation & Mechanical Shear	Homepage URL
RFG 170 400 1	IDEC	2017 /06/0 1	FBIA	2021 /05/ 31	UFB Generator	Multi purpose generator by Pressurizing Dissociation	Homepage URL
RAF 170 400 1	IDEC	2017 /06/0 1	FBIA	2021 /05/ 31	Agri-, Foods, Vegetable	UFB grown Tomates & their Juice	Homepage URL

Scheme Examination



1A Certification Mark

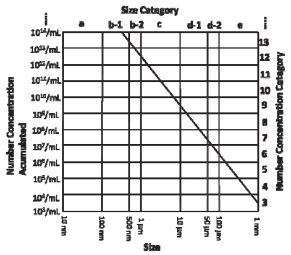
Reg. No.	Applicant	Initial Reg. Date	Certification Mark	Range of FB	Product	Information of applicant
C1AMG1708001	Nitto-Seiko	2017/08/25		Micro Bubble	Generator, Multi purpose	Homepage URL
C1AMG1709001	Science	2017/11/29		Micro Bubble	Generator, For Bath adapter	Homepage URL
C1AUG1903001	Aqua Solutions	C1AUG1903001		Ultrafine Bubble	Generator, Multi purpose	Homepage URL
C1AUG1907001	Hatano	2019/08/30		Ultrafine Bubble	Generator, For Bath adapter	Homepage URL
C1AUG1907002	Hatano	2019/08/30		Ultrafine Bubble	Generator, For Bath adapter	Homepage URL

Registration Mark(2)

RWG1705001	Toshiba Life Style	2017/06/23		2021/06/22	Home, Washing	Washing Machine, Drying Machine. UFB generated by cavitation	Home page URL
RFM1712001	Ligaric	2019/01/15		2021/01/14	UFB Generator	Multi purpose generator by Gas-Liquid Mixing and Shearing	Homepage URL
RWT1712001	Ligaric	2019/01/15		2021/01/14	Building, Washing	Service, by UFB water for sanitary facilities	Homepage URL
RFS19030001	MTG	2019/08/30		2021/08/29	Cleaning, Beauty	Shower-head, UFB by Pressuring Dissociation and Cavitation	Homepage URL
RUN1907001	Hatano	2019/10/31		2020/10/30	Cleaning, Home	Bath Adapter, by UFB water	Homepage URL

1B Certification Mark

Reg. No.	Applicant	Initial Reg. Date	Certification Mark	End Valid Term	Application field	FB Technology	Information of applicant
C1BUFB7ab	Science	2019/10/04		2021/10/03	Ultrafine Bubble Shower Head	Generation Method Changeable	Home Page URL



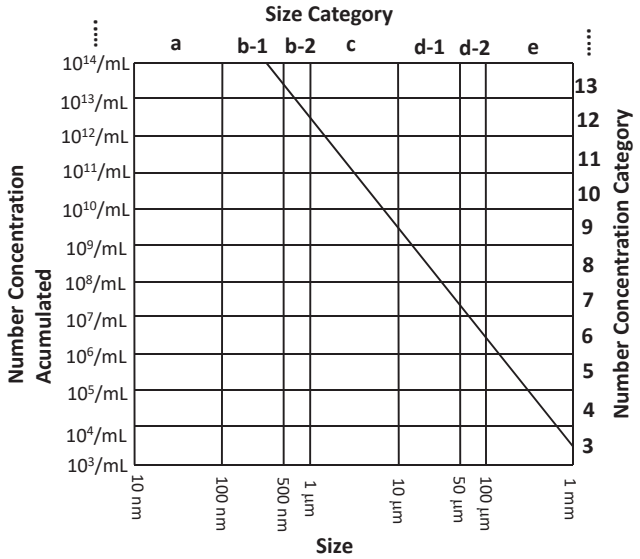
Registration Mark(3)

RUFBMB200601	Rinnai	2020/06/01		2021/05/31	Cleaning, Home	Bath Supply for MB water	Homepage URL
RUFBMB200101	MTG	2020/06/30		2021/06/29	Cleaning, Beauty	Shower-head, UFB by Pressuring Dissociation and Cavitation	Homepage URL
RUFB2003001	White Essence	2020/09/18		2021/09/17	Medical, Professional	Dental Care UFB generator by Pressurized Dissociation	Homepage URL
	SANEI						
	DAINICHI						

Designation Mark for Testing Laboratories

Reg. No.	Test Laboratory	Initial Reg. Date	Designation Mark	End Valid Term	Test Performance	Test Objects	Information on Applicant
DTU1705001	IDEC	2017/06/05	FBIA	2021/06/04	Size & Number Concentration	UFBs in Water	Homepage URL
DTU1712001	Izumi Tech	2017/12/20	FBIA	2020/12/19	Size & Number Concentration	UFBs in Water	Homepage URL
DTU1801001	Green Blue	2018/05/07	FBIA	2021/05/06	Size & Number Concentration	UFBs in Water	Homepage URL

FBIA Category of Fine Bubble Characteristic



FBIA registers or certifies the claimed statements of applicant on:

1. Use of Fine Bubble Technology
2. Fine Bubble-Enabled Performance
3. Quality control with respect to Fine Bubble Technology
4. Sound use of marks and outcome of the registration or certification

based on the its technical examinations on the submitted evidences including audit.

Examples of evidences are;

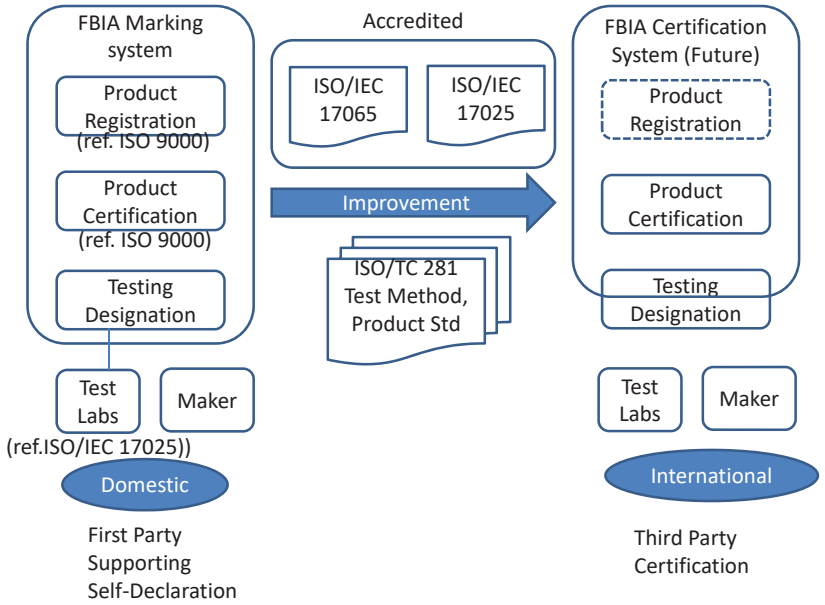
1. size and number concentration of fine bubbles
2. change in performance parameters due to presence of fine bubble
3. standardization on quality control of the product
4. practical use of marks in the advertisement

Type of evidences are:

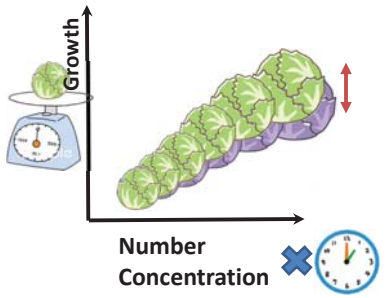
1. Self declaration (Company standard)
2. Third party declaration (ISO/IEC 9000, FBIA designated lab.,)

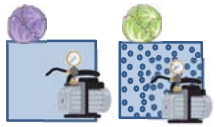
Reference of evidences are:
Company standard, FBIA standard, JIS, ISO/IEC

Future of FBIA Marking System



Performance Testing
Evaluation parameter
(Increase in) Mass of product
Number Concentration of FB (Applied)





Without FB With FB

FBIA Examination Item

1A Certification=

1. Use of Fine Bubble Technology
- Size & Number Concentration Data
- Sampling

4. Sound use of Mark
- Explanation of Mark in advertisement
- Internal Mark control rule

Refer to Designated Test Labo.

FBIA Examination Item

Registration=

1. Use of Fine Bubble Technology
- Size & Number Concentration Data
- Measuring Instrument
- Sampling

2. Fine Bubble-Enabled Performance
- Performance Indicator with data
- Measuring Instrument
- Application of FB

3. Quality control in production
- Documentation, Personnel
- Internal Testing & Control
- FB characteristic Indicator

4. Sound use of Mark
- Explanation of Mark in advertisement
- Internal Mark control rule

FBIA Examination Item

1B Certification=

1. Use of Fine Bubble Technology
- Size & Number Concentration Data
- Sampling

2. Fine Bubble-Enabled Performance
- Performance Indicator with Data
- Measuring Instrument
- Application of FB

3. Quality control in production
- Documentation, Personnel
- Internal Testing & Control
- FB Characteristic Indicator &

4. Sound use of Mark
- Explanation of Mark in advertisement
- Internal Mark control rule

Refer to Designated Test Labo.

FBIA Examination Item

Designation on Testing Laboratory=

Measurement Capability (Size & Number Concentration)

- Measurement Method
- Proficiency Test Result
- Measurement Procedure & Instrument

Quality control in Service

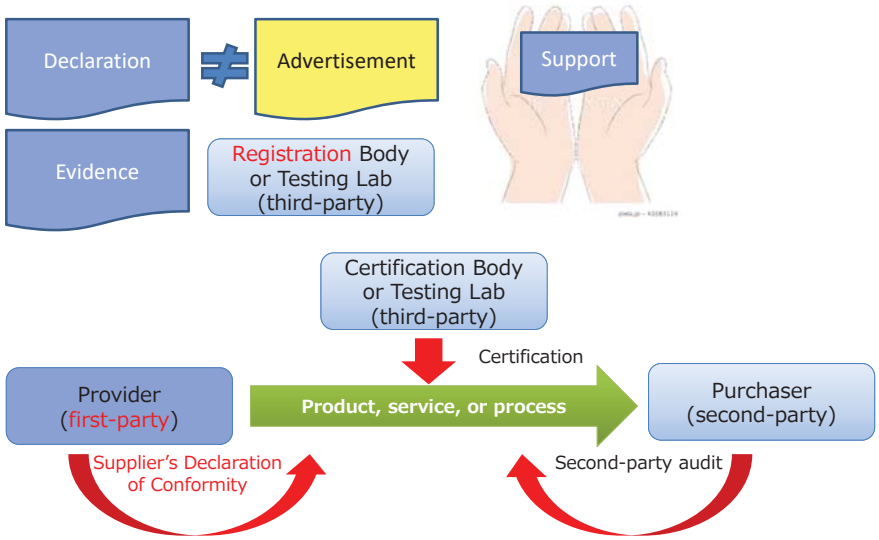
- Take note to ISO/IEC 17025
- Personnel
- Environment

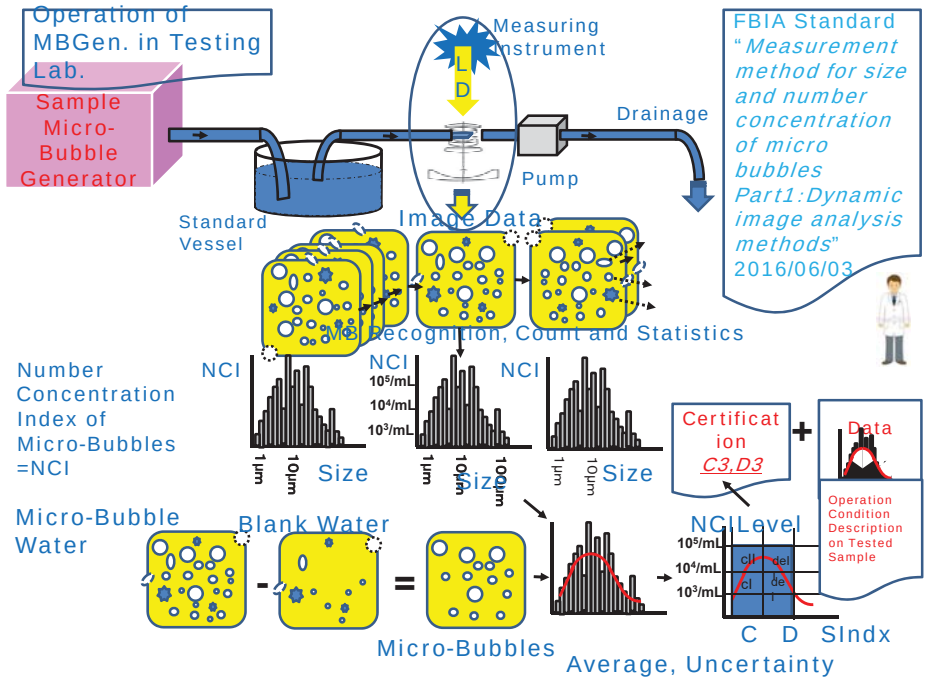
Measurement Method

ISO TC 281 standards or FBIA standards
Microbubble, Ultrafine Bubble measurement

Proficiency Test Result

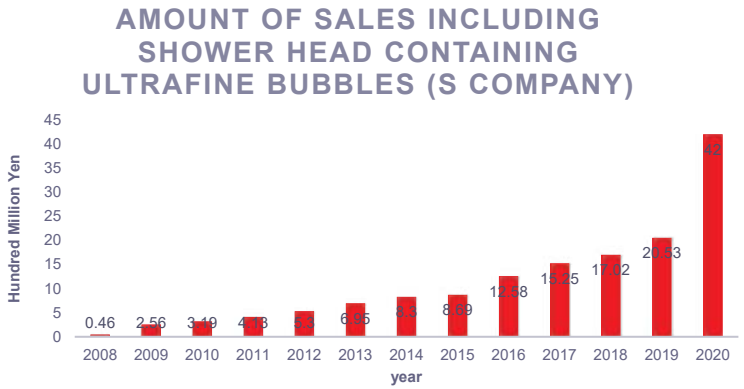
Comparison of measurement result with other designated laboratory on identical sample





1．Large Development of Actual Commercialization of Fine Bubble Technology

- Actual Commercialization of Fine Bubble Technology has been developed largely mainly for the application to consumer equipment including shower head.
- Further development can be expected worldwide.



APEC Workshop I

c)18:40-19:10

Current status of Fine Bubble Technology

Akira YABE, Dr. Eng.
Special Advisor & Researcher Emeritus,
National Institute of Advanced Industrial Science and Technology (AIST)
Japan

January 19, 2021

2. Recent Scientific Progress for Ultrafine Bubbles

Many scientific publications have been published from several years ago related to fine bubble technology, especially ultrafine bubble technology. (2015-2018)

The mechanism of longlife duration (nearly stable) of ultrafine bubble (less than 1000nm) has been tried to be cleared by the interaction between liquid-gas surface and the hydrophobic substances. Electron microscope measurements (TEM) have contributed largely.

Current Status of Fine Bubble Technology

Akira YABE
Special Advisor & Researcher Emeritus
National Institute of Advanced Industrial Science and Technology (AIST) Japan
Fellow, Technology Strategy Center,
New Energy and Industrial Technology Development Organization (NEDO) Japan
Trustee, Fine Bubble Industries Association (FBIA) JAPAN

Calculated radius of stable bulk ultra fine bubble

100% of gas saturation
1 atm
estimate
d=100nm
5% of surface covered by hydrophobic material
situation

d=100nm

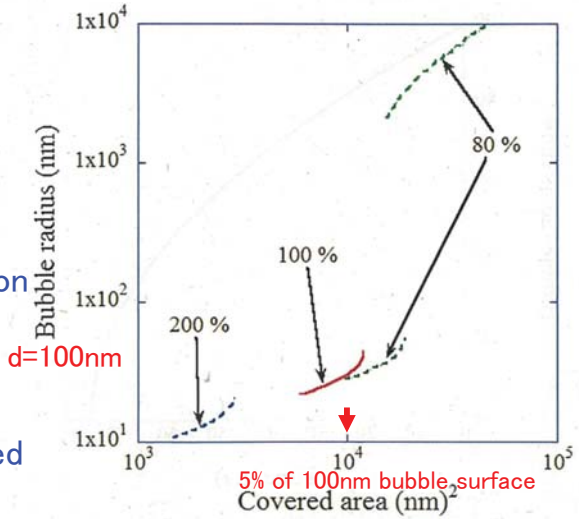


Fig. 8. Calculated radius of a stable bulk nanobubble as a function of the area covered with a hydrophobic material for various degrees of gas saturation in liquid water (80, 100, and 200%). The ambient liquid pressure is $p_0 = 1$ atm. The temperature is 20 °C. Reprinted with permission from K. Yasui, T. Tuziuti, W. Kanematsu, K. Kato, Dynamic equilibrium model for a bulk nanobubble and a microbubble partly covered with hydrophobic material, Langmuir 32 (2016) 11101–11110. Copyright (2016) American Chemical Society.

TEM Images of Organic Material(hydrophobic material) on the surface of ultra fine bubble
(Sugano K., Miyoshi. Y, Inazato S. 2017)
Transmission Electron Microscope (TEM)
500nm liquid phase sample without freezing
Diameter is 173nm.

Fig. 9. TEM images of a bulk nanobubble in aqueous solution without freezing [1]. (a) In aqueous oleic-acid solution, (b) in aqueous α-tocopherol solution. The diameters are 105 nm and 173 nm in (a) and (b), respectively. Courtesy of Panasonic corporation, Japan. Reprinted with permission from K. Sugano, Y. Miyoshi, S. Inazato, Study of ultrafine bubble stabilization by organic material adhesion, Jpn. J. Multiphase Flow 31 (2017) 299–306.

Various kinds of application technology utilizing ultra fine bubble have been experimented basically. (New data and Characteristics Investigation: Toilet Cleaning, Semi-conductor Cleaning, Ultra fine bubble measurement in cultivated water etc.)

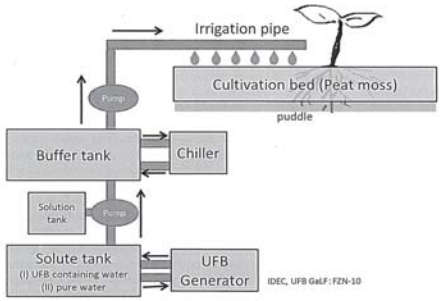


Figure 8. The plant factory with ultra-fine bubbles (UFB)-added medium supply system. A second line system, identical except with pure water as a solute without UFB generator, is used for the control case.

Mechanism of Long Lifespan of Ultra Fine Bubble
(Yasui K. et al. 2016,2018)

Dynamic equilibrium model based on the effect of hydrophobic material on the surface of ultra fine bubble.

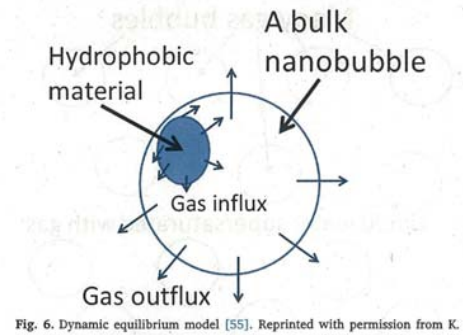
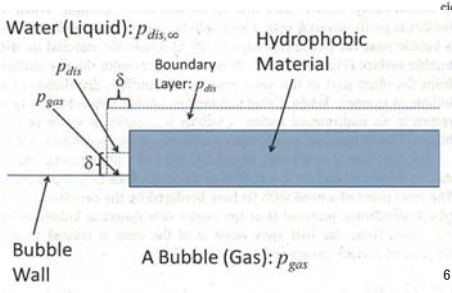
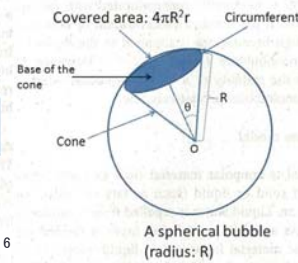


Fig. 6. Dynamic equilibrium model [55]. Reprinted with permission from K. Yasui, T. Tuziuti, W. Kanematsu, K. Kato, Dynamic equilibrium model for a bulk nanobubble and a microbubble partly covered with hydrophobic material, Langmuir 32 (2016) 11101–11110. Copyright (2016) American Chemical Society.





Scale can be removed easily by the ultrasound application with ultrafine bubble application (weaker structure containing bubbles)

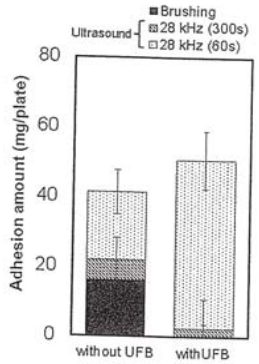


Fig. 3 Amount of scale removed at each strength (Series 1).

Table 2 Composition of scale (Series 1).

(%)	without UFB	with UFB
Ca	36	36
P	21	22
Si	31	32
others	12	10

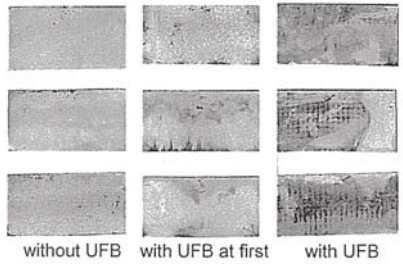


Photo 2 Scanning image (W/B) of residual scale on plate after each washings (Series 2).

Table 3 Percentage of residual scale on plate after each washings with ultrasound (Series 2).

	Area removed (%)	SD
without UFB	7.1	5.7
with UFB at first 30 days	7.4	3.6
with UFB	57.1	17.0

Red Line were the cases with ultra fine bubbles

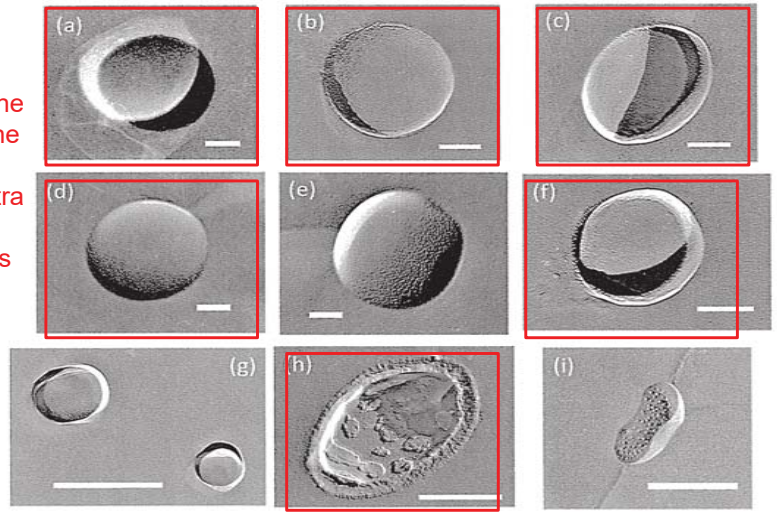


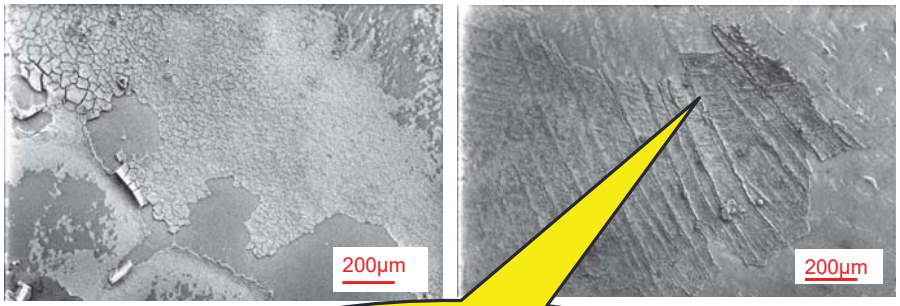
Figure 1. Typical TEM images of UFBs in each solution. **(a) I-W, (b) I-BT,** and **(c) II-BT** as initial conditions, **(d) I-P** and **(e) II-P** as transporting conditions, **(f) I-R** and **(g) II-R** as near-plant conditions. Each symbol shows the following: I = prepared with UFB generator, II = control water without UFB generator. The other symbols indicate location: BT = buffer tank; P = irrigation pipe; and R = rhizosphere. **I-W** is the tap water before entering the UFB generator. **(h)** A unique UFB from **I-R** solution that had accumulated much impurity. (i) Impurity masses observed independently of UFBs in **II-R** solution. Each scale shows 100 nm except for those in (g–i), which show 500 nm.

Cleaning with rotating UFB water

Comparison of cleaning samples' SEM images after cleaning

UFB Free water

UFB water



Stripes signatures were observed on the surface of the sample after cleaning by UFB water

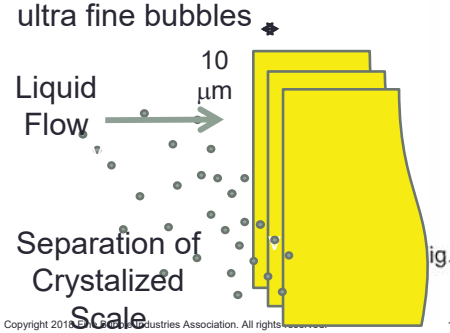
Effect of Ultra Fine Bubble onto Accumulation and Structure of Urinary Calculus (Toilet Cleaning) (Okuda T, Nishijima W. etc, 2018)

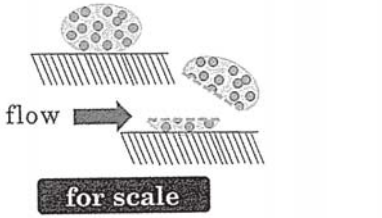
Fundamental Research on the mechanism of Scale Removal

Assumptions

1.Separation & Removal of the scale by the effect of immersed ultra fine bubbles between scale and the surface

2.Characteristics of scale become weaker structure containing ultra fine bubbles





ig. 1 Three assumptions about the effect of UFB onto scale production.

Application Fields of Fine Bubble Technology

1.Engineering Application

2.Environmental Application

3.Agricultural and Food Application

4.Medical and Cosmetic Application

Recent Scientific Publications related to Fine Bubble Technology(2015-)

(1) H. Kobayashi, S. Maeda, M. Kashiwa and T. Fujita, "Measurement and Identification of Ultrafine Bubbles by Resonant Mass Measurement Method", Proc. SPIE 9232, International Conference on Optical Particle Characterization (OPC 2014), 92320S (2014)
(2) T. Uchida, H. Nishikawa, N. Sakurai, M. Asano and N. Noda, "Ultra-Fine Bubble Distribution in a Plant Factory Observed by Transmission Electron Microscope with a Freeze-Fracture Replica Technique", Nanomaterial, Vo.8, No.152, pp.1-12(2018)
(3) K. Yasui, T. Tuziuti, W. Kanematsu and K. Kato, "Dynamic Equilibrium Model for a Bulk Nanobubble and a Microbubble Partly Covered with Hydrophobic Material", Langumuir DOI10.1021/5B04703 (2016)
(4) K. Yasui, "Mechanism for Stability of Ultrafine Bubbles", Japanese J. Multiphase Flow, Vol.30, No.1, pp.19-26 (2016)
(5) K. Sugano, Y. Miyoshi and S. Inazato, "Study of Ultrafine Bubble Stabilization by Organic Material Adhesion", Japanese J. Multiphase Flow, Vol.31, No.3, pp.299-306 (2017)
(6) A. Sonoda, "Measurement of Ultra Fine Bubble Using Laser Diffraction Method" Journal of Society of Powder Technology Japan, Vol.54, No.9, pp590-595 (2017)
(7) K. Takahashi, S. Ohuchi, K. Saito, M. Hirasawa and H. Sakurai, "Simultaneous Determination of the Size and Concentration of Fine Bubbles in Water by Laser-light Scattering" Applied Optics, Vol.57, No.2, pp.225-229 (2018)

Classification of Effective Functions of Fine Bubbles (Fine Bubbles and Ultrafine Bubbles)

A.Cleaning Effects:
- Toilet Cleaning,
- Removal of Salt from the Bridges,
- Cleaning of Vegetables
- Removal of Contaminants on the Semiconductor Wafers,
- Cleaning inside of Mouth, Cleaning of Ceramic membrane

B.Water Treatment (including Soil Treatment):
- Dissolution of Oxygen Lack of Ponds and Lakes
- Floatation Mining of Minerals
- Water Treatment of Disposed and Contaminated Water (Minimizing the total amount of disposal in Isolated Area Promoting the Growth of Bacterium for Disposal Treatment),
- Removal of Radioactive Substances from the Soil

C. Sterilizing Promotion Effect:
- Minimize the Total Usage Amount of Ozone,
- Maximize the Effect of Sterilizing Liquid by Changing the PH,

(8) T. Okuda, K. Matsui, K. Hashimoto, Y. Ueda, S. Nakai and W. Nishijima, "Effect of Ultrafine Bubble onto Accumulation and Structure of Urinary Calculas", Japanese J. Multiphase Flow Vol.32, No.1 pp.12-18 (2018)
(9) P. Klintham, S. Tongchitpakdee, W. Clinsirikul and W. Mahakarnchanakul, "Combination of microbubbles with oxidizing sanitizers to eliminate Escherichia coli and Saimonella Typhimurium on Thai leafy vegetables", Food Control Vol.77, pp.260-269 (2017)
(10) A. Ghadimkhani, W. Zhang and T. Marhaba, "Ceramic Membrane Defouling (Cleaning) by Air Nano Bubbles", Chemosphere Vol.146, pp.379-384 (2016)
(11) S. Hamamoto, "Fine Bubble Transport in Porous Media towards Application for Soil Remediation", Japanese J. Multiphase Flow, Vol.32, No.1, pp.19-25 (2018)
(12) S. Liu, S. Oshita, Y. Makino, Q. Wang, Y. Kawagoe and T. Uchida, "Oxidative Capacity of Nanobubbles and Its Effect on Seed Germination", ACS Sustainable Chem. Eng. Vol.4, pp.1347-1353 (2016)
(13) K. Onoe, Y. Wada, M. Matsumoto, "Fascination and Engineering Application of Reaction Field Utilizing Fine Bubbles", Jap. J. Multiphase Flow, 30, 1, pp.27-36 (2016)
(14) S. Liu, Y. Kawagoe, Y. Makino and S. Oshita, "Effects of Nanobabbles on the Physicochemical Properties of Water: The Basis for Peculiar Properties of Water Containing Nanobabbles", Chemical Engineering Sciences, Vol.93, pp.250-256 (2013)
(15) M. Kashiwa, T. Fujita, H. Yamazaki and T. Fushiki, "Introduction of Sansho-pepper Flavor to Water by Using Nano-bubbles Generator and Its Application to the Field of Food Manufacturing", Annual Meeting of Japanese Society of Multiphase Flow, (2012)

Application Fields of Fine Bubble Technology

1.Engineering Application

- Removal of Contaminants on the Semiconductor Wafers(A)
- Cleaning of Ceramic Membrane(A),
- Floatation Mining of Minerals(B)
- Minimize the Total Usage Amount of Ozone(C)
- Maximize the Effect of Sterilizing Liquid by Changing the PH(C)
- Lubrication of Semiconductor Wafer Transportation(E)
- Control the Limiting Transport Phenomena(F)

2.Environmental Application

- Toilet Cleaning(A),
- Removal of Salt from the Bridges(A),
- Dissolution of Oxygen Lack of Ponds and Lakes(B)
- Water Treatment of Disposed and Contaminated Water(B)
- Removal of Radioactive Substances from the Soil(B)
- Minimize the Total Usage Amount of Ozone(C)
- Application of Cell Cultivation(D)

D.Growth Promotion:

- Growth Promotion of Vegetables (Leaves such as Lettuce, Increase of Total Harvest and Quality of Tomato)
- Germination Promotion,
- Application of Cell Cultivation
- Growth Promotion of Fishes
- Prevention of Oxygen Lack of Fishes in Aquaculture

E.Lubrication Effect:

- Lubrication of Semiconductor Wafer Transportation

F.Promotion & Control of Chemical Reaction,

- Control the Limiting Transport Phenomena

G.Quality Control of Food

- Control of Calorie of Mayonnaise
- Freshness Keeping of Fishes
- Fragrance Addition

3.Agricultural and Food Application

- Cleaning of Vegetables(A)
- Water Treatment of Disposed and Contaminated Water(B)
- Minimize the Total Usage Amount of Ozone(C)
- Growth Promotion of Vegetables(D)
- Germination Promotion(D),
- Application of Cell Cultivation(D)
- Growth Promotion of Fishes(D)
- Prevention of Oxygen Lack of Fishes in Aquaculture(D)
- Control of Calorie of Mayonnaise(G)
- Freshness Keeping of Fishes(G)
- Fragrance Addition(G)

4.Medical and Cosmetic Application

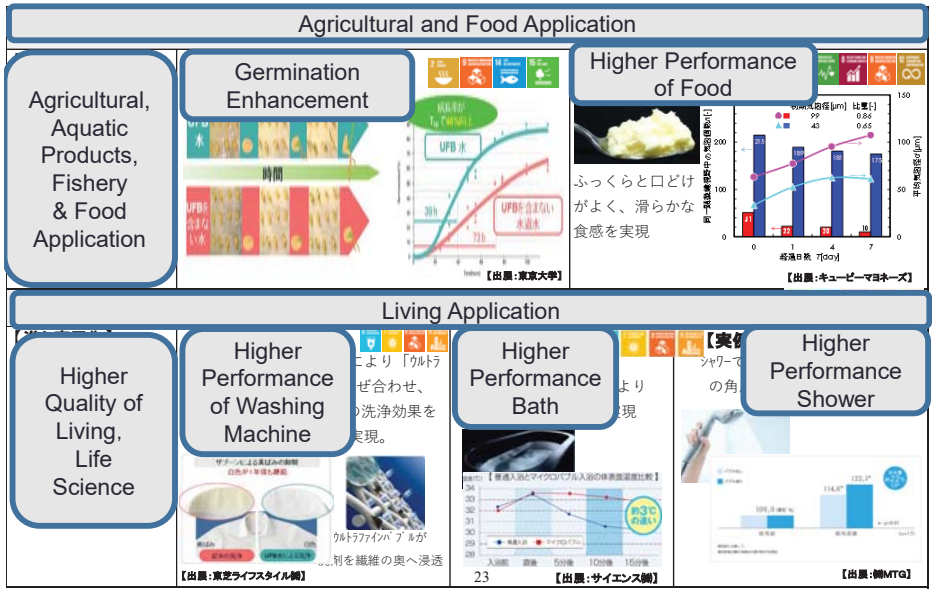
- Cleaning inside of Mouth(A)
- Minimize the Total Usage Amount of Ozone(C)

Systematic View of "Application of Fine Bubble Technology"

		Effective Functions						
		Cleaning Effect	Water Treatment	Sterilizing Promotion Effect	Growth Promotion	Lubrication Effect	Control of Chemical Reaction	Quality Control of Food
	Application Fields	A	B	C	D	E	F	G
1	Engineering Application	○	○	○		○	○	
2	Environmental Application	○	○	○	○			
3	Agricultural and Food Application	○	○	○	○			○
4	Medical and Cosmetic Application	○		○				

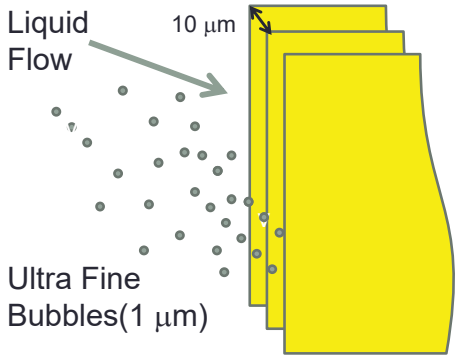
○:Application Technology Existed(Researched or Developed or Actually Utilized or Commercialized)

Food & Living Application



Movement & Effect of Ultra Fine Bubble

Ultra Fine Bubbles (have the diameter smaller than 1μm) move along the Streamline of Liquid Flow without the Effect of Buoyancy.
Easy to Enter the Narrow Space



Create the Separation Effect of Plates and Scale and Lubrication Effect for Plates
Enter into the Narrow Space of Fine Roots of Vegetables for Growth Promotion

Agricultural Application

Agricultural and Aquatic Application Fields — Agricultural, Fishery and Food Application

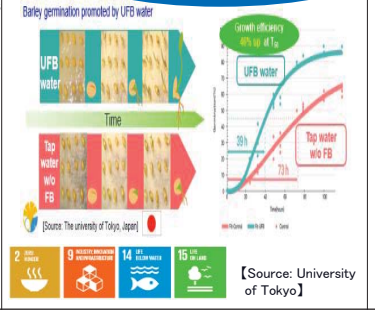
【Application Fields】

Agricultural Application:
- ＊Cleaning of Agricultural Products
- ＊Growth Promotion of Vegetables and Fruits

Aqua and Fishery Application :
- ＊Aqua Products Cleaning & Sterlization
- ＊Growth Promotion of Aqua Products, Food Manufacturing

【Application1】 Germination Promotion of Bareley Seeds

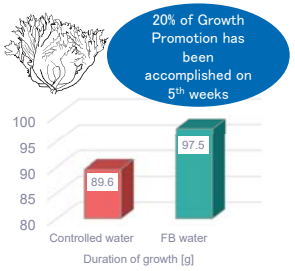
46% of Germination Promotion has been attained at T50 for Bareley Seeds



【Source: University of Tokyo】

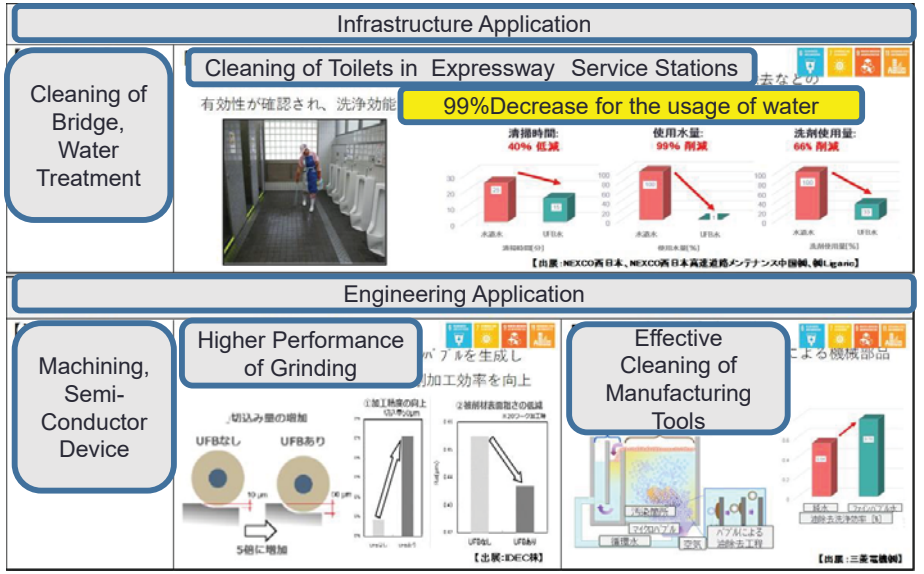
【Application2】 Growth Promotion of Lettuce

20% of Growth Promotion has been accomplished on 5th weeks



【Source: AIST ISO/TS 23016-1】

Infrastructure and Engineering Application



Topics

1. Terminology
2. Categorization
3. Physical Properties of Ultrafine Bubbles
4. Sampling and Sample Preparation
5. Storage and Transportation
6. Evaluation Method of Ultrafine Bubbles
7. Physical Properties of Microbubbles
8. Evaluation Method of Microbubbles

CONCLUSIONS

1. Current Status of fine bubble technology has been explained from viewpoints of commercialized technologies and the scientific investigations conducted so far.

2. For realizing the systematic view of “Application of Fine Bubble Technology”, several kinds of viewpoint of functional effects would be very important to be understood and should be reviewed constantly for making wider application targets.

1. Terminology

APEC Workshop I

d)19:10-20:10

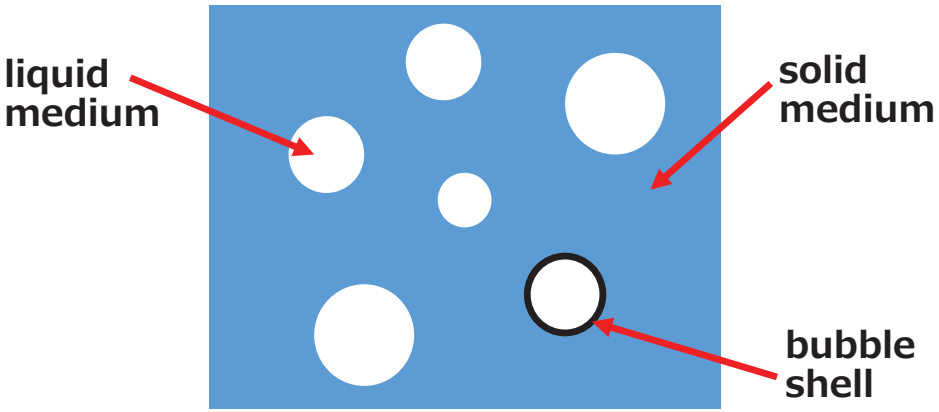
"Standards for basic principle and measurement of fine bubbles"

Ms. Hirona KOBAYASHI and Ms. Seika OHUCHI,
National Institute of Technology and Evaluation(NITE)
Japan

January 19, 2021

What are Fine Bubbles

nite



ISO

TC > ISO/TC 281

ISO 20480-1:2017

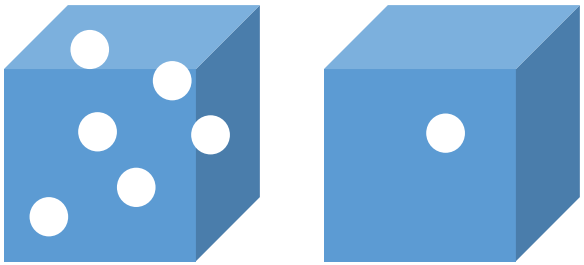
Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 1: Terminology

This document specifies terminology and definitions used in the area of fine bubble technology. Terminology in this document covers general principles, measurements, and individual applications of fine bubble technology.

(Reference) https://www.iso.org/standard/68187.html?browse=tc

What are Fine Bubbles

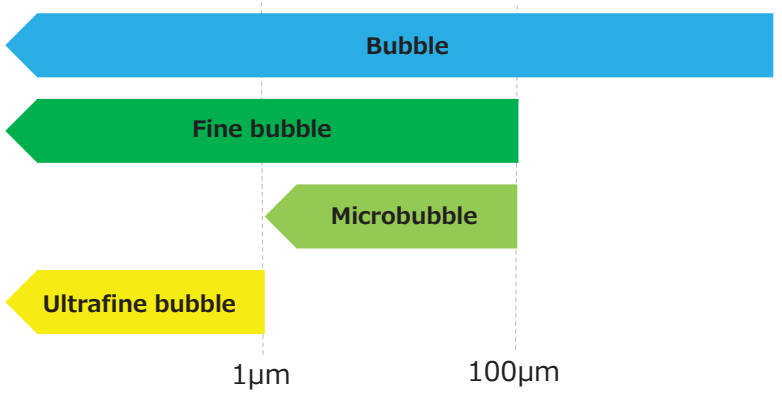
nite



bubble number concentration
: number of bubbles per unit volume

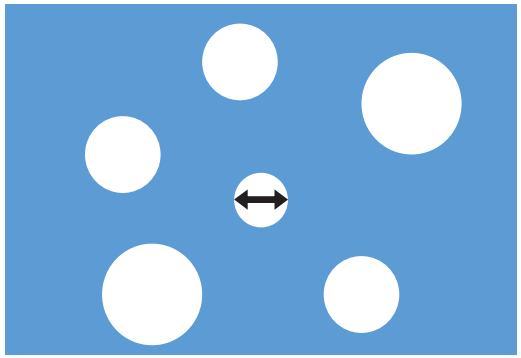
What are Fine Bubbles

nite



2. Categorization

What are Fine Bubbles



volume equivalent diameter $d_{eq} = \sqrt[3]{\frac{6}{\pi} V_{bubble}}$

TC > ISO/TC 281

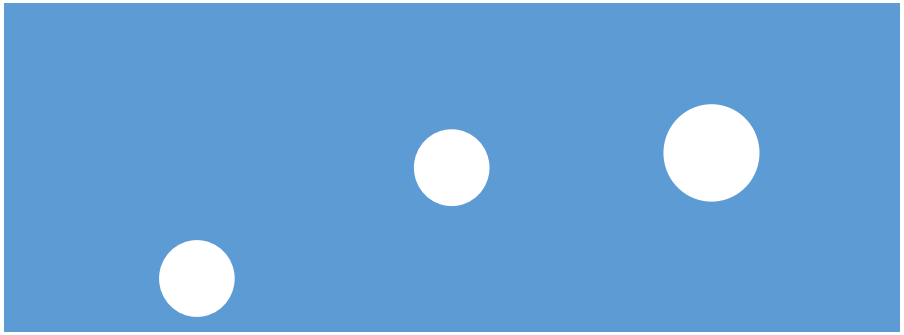
ISO 20480-2:2018

Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 2: Categorization of the attributes of fine bubbles

This document establishes the general principles and descriptors to allow users to describe the quality of the liquid media and the size and concentration of fine bubbles. It is also intended to allow users to classify fine bubbles by rise velocity.

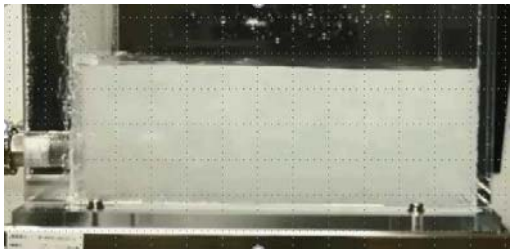
(Reference) https://www.iso.org/standard/70763.html?browse=tc

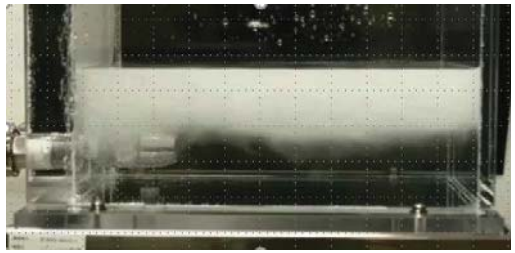
What are Fine Bubbles



Floatation **Shrinkage** **Coalescence**

Floatation of Microbubbles





Size index and Concentration index

The terms **“size index”** and **“number concentration index”** should be used.

Rise Velocity

a very low rise velocity

a high rise velocity

Size index and Concentration index

Stability

(Reference) Shunya Tanaka et al, Generation and Long-Term Stability of Ultrafine Bubbles in Water - Chemie Ingenieur Technik

Attributes of Fine Bubbles by Rise Velocity

Zeta Potential

(Reference) Shunya Tanaka et al, Destabilization of ultrafine bubbles in water using indirect ultrasonic irradiation - Ultrasonics Sonochemistry

3. Physical Properties of Ultrafine Bubbles

4. Sampling and Sample Preparation

Zeta Potential

(Reference) Shunya Tanaka et al, Destabilization of ultrafine bubbles in water using indirect ultrasonic irradiation - Ultrasonics Sonochemistry

TC › ISO/TC 281

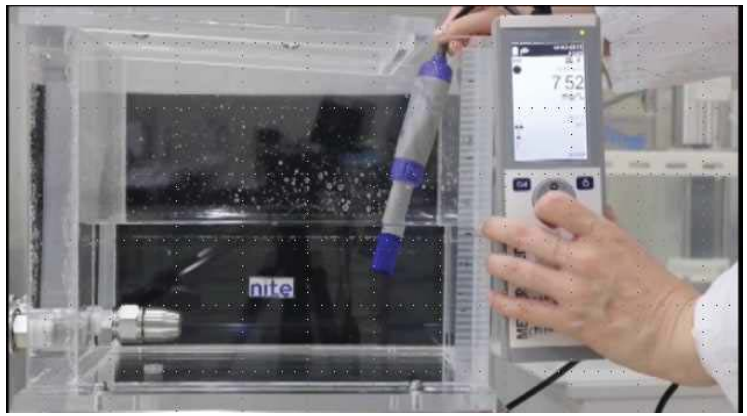
ISO 20298-1:2018

FINE BUBBLE TECHNOLOGY — SAMPLING AND SAMPLE PREPARATION FOR MEASUREMENT — PART 1: ULTRAFINE BUBBLE DISPERSION IN WATER

This document specifies procedures and requirements for sampling and sample preparation of ultrafine bubble dispersions in water.
This document is applicable to relatively stable dispersions where the size and number of bubbles are relatively constant for the duration of the sampling, sample preparation and measurement.
This document is not applicable to less stable fine bubble dispersions or microbubble dispersions.

(Reference) https://www.iso.org/standard/67588.html?browse=tc

Dissolved Oxygen

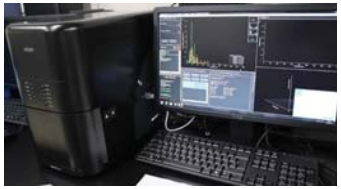


Homogenization

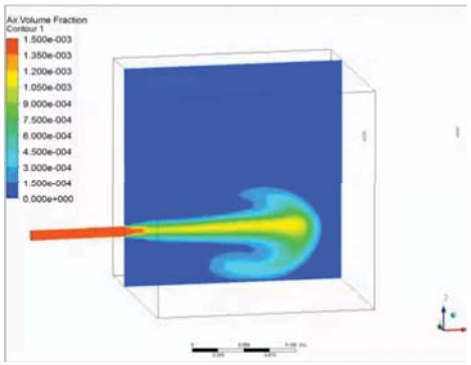
Introduction

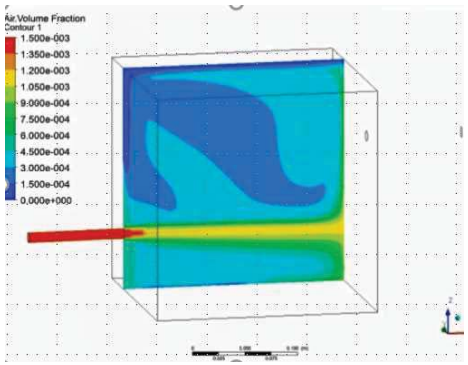
Generation

Measurement



Homogenization





Introduction

Generation

Sampling

Storage

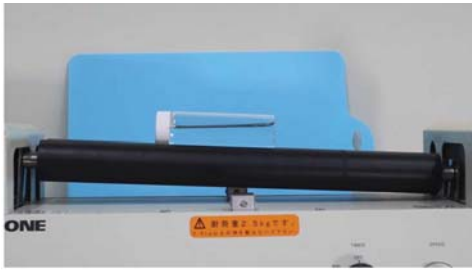
Transportation

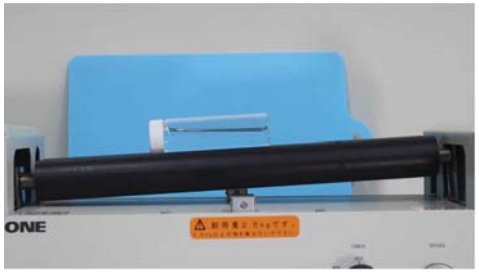
Sample preparation

Measurement

Homogenization

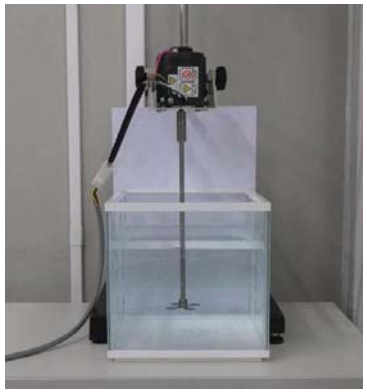
Homogenization using motor-driven drum roller





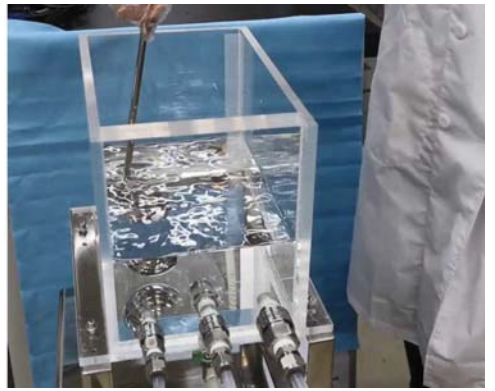
Homogenization

Homogenization using a motor-driven stirrer



Homogenization

Homogenization



Sample Preparation

Sampling using a pipette and slowly drawing it down

Homogenization

No Good

5. Storage and Transportation

Sample Preparation

Dilution using water diluent based on its mass or volume

Storage

Container: rigid and less gas-permeable material (e.g. glassware)

TC > ISO/TC 281

ISO 21255:2018

FINE BUBBLE TECHNOLOGY — STORAGE AND TRANSPORTATION OF ULTRAFINE BUBBLE DISPERSION IN WATER

This document describes the procedures and equipment for storage and transportation of ultrafine
bubble dispersions in water and specifies the related requirements in order to maintain such bubble
characteristics as size and number concentration.

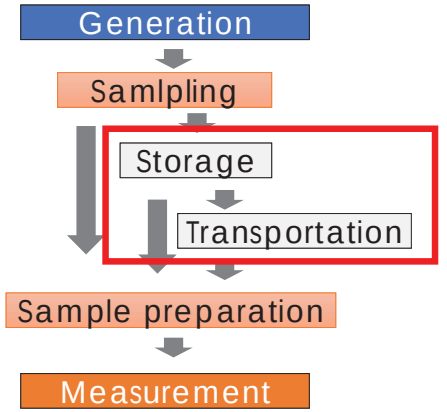
(Reference) https://www.iso.org/standard/70257.html?browse=tc

Storage

- Container is filled with full amount of water dispersing ultrafine bubbles.

- Environmental conditions such as temperature and pressure should be kept unchanged.
- Temperature should remain above 0℃.

Introduction



Transportation

- Minimize the effects of temperature, pressure and vibration.

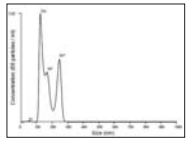
- Before transportation, the stability should be evaluated by test transportation.

6. Evaluation Method of Ultrafine Bubbles

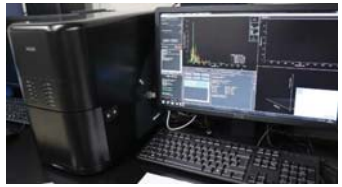
Particle Tracking Analysis

Visualization the movement by scattered light of particles

Tracking the movement of particles by Brownian motion



Calculation particle size from the Stokes-Einstein formula



Points of Measurement

- Distinguish ultrafine bubbles from contaminants

- Confirm lower limit

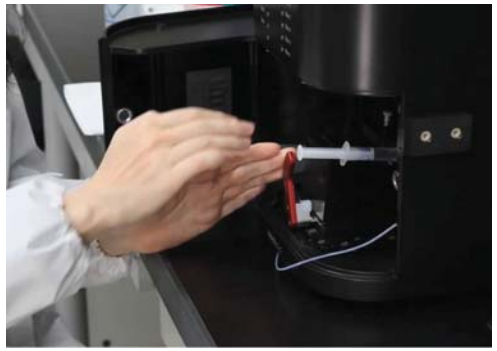
e.g. Concentration range 10^6 to 10^9 particles per mL

- Confirm reproducibility

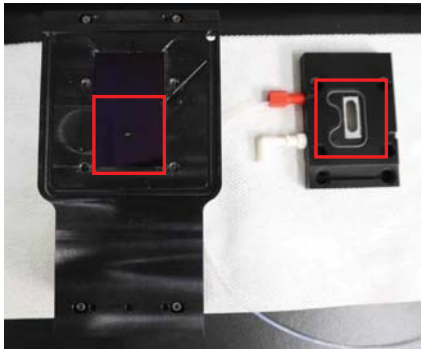
e.g.

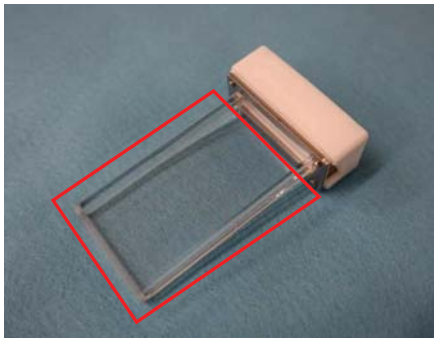
Concentration:	2.55e+008 +/- 4.56e+007 particles/ml
Mode:	154.9 +/- 14.2 nm

Put the Module in the Device

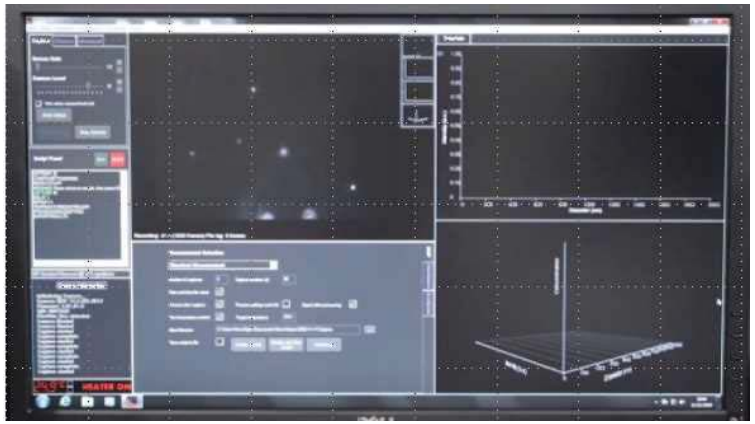


Check the Cell



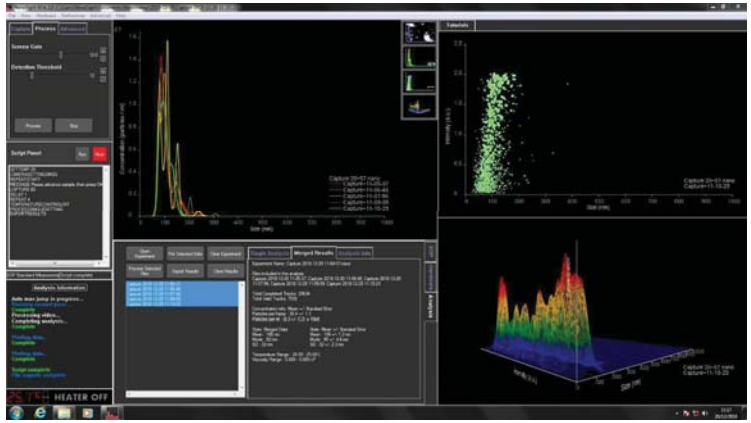


Set the Conditions

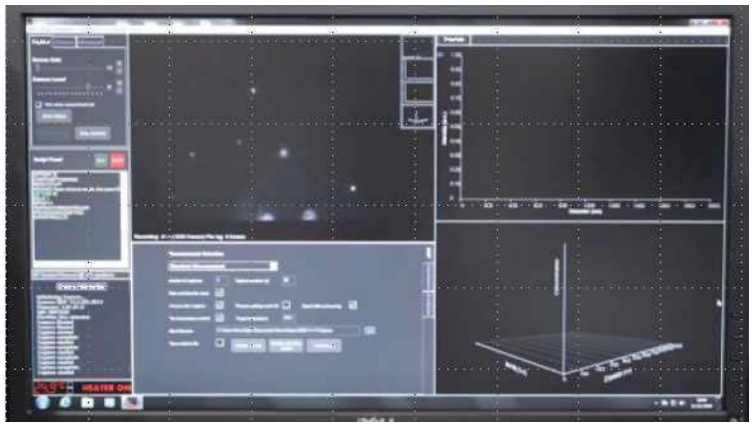


Inject Sample into the Cell

Data Analysis



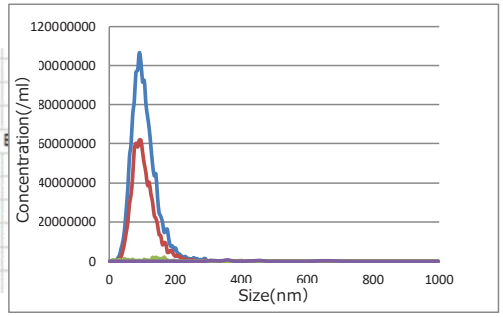
Measurement



Data Analysis

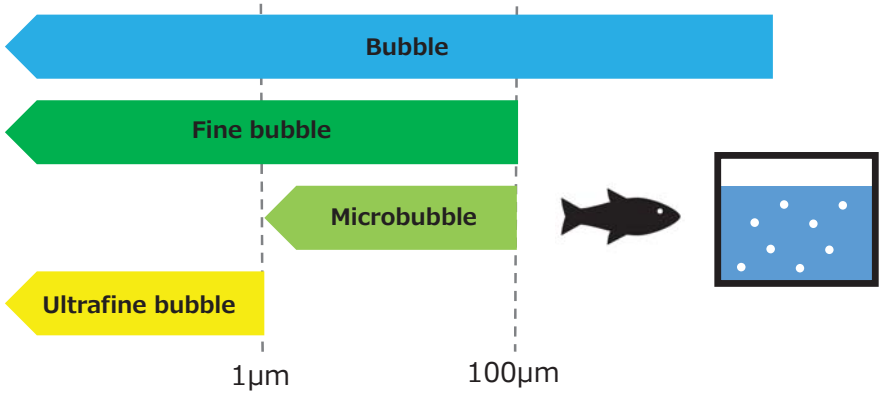
[Sice Data]
Analysis I FTLA
Weighting Number

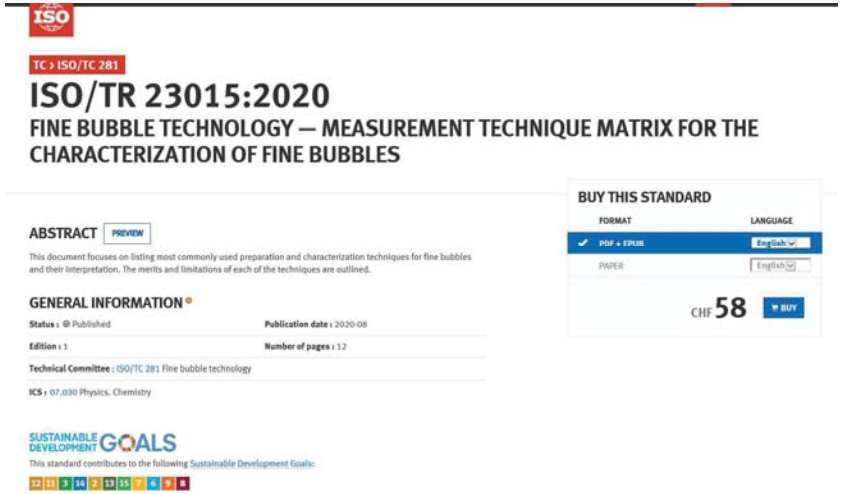
Filename	Capture 1	Capture 2	Capture 3	Capture 4	Capture 5	Average	Standard E
Mean	106.1	113	115.8	111	105.2	110.2	2
Mode	90.8	89.1	95.4	87.5	85.6	89.7	1.7
SD	39.4	33.9	32	25.4	22.6	30.6	3
D10	78.6	80.9	85.8	81.7	80.4	81.5	1.2
D50	97.1	98.5	103.7	108	97.9	101	2.1
D90	129.2	154.7	166.7	141.9	137.1	145.9	6.6



Data Analysis

What are Microbubbles?





TC > ISO/TC 281

ISO/TR 23015:2020

FINE BUBBLE TECHNOLOGY — MEASUREMENT TECHNIQUE MATRIX FOR THE CHARACTERIZATION OF FINE BUBBLES

BUY THIS STANDARD

FORMAT LANGUAGE

PDF + EPUB English

PAPER English

CHF 58 BUY

ABSTRACT PREVIEW

This document focuses on listing most commonly used preparation and characterization techniques for fine bubbles and their interpretation. The merits and limitations of each of the techniques are outlined.

GENERAL INFORMATION

Status : Published Publication date : 2020-08

Edition : 1 Number of pages : 12

Technical Committee : ISO/TC 281 Fine bubble technology

ICS : 07.030 Physics. Chemistry

SUSTAINABLE DEVELOPMENT GOALS

This standard contributes to the following Sustainable Development Goals:

(Reference) https://www.iso.org/standard/74323.html?browse=tc

Floatation of Microbubbles

7. Physical Properties of Microbubbles

Shrinkage of Microbubbles

nite

(Reference) Takahashi, M(AIST).et al. Free-Radical Generation from Collapsing Microbubbles in the Absence of a Dynamic Stimulus JOURNAL OF PHYSICAL CHEMISTRY B, 2007

Floatation of Microbubbles

nite

(Reference) Takahashi, M(AIST). The ζ Potential of Microbubbles in Aqueous Solutions - Electrical property of the gas-water interface -- JOURNAL OF PHYSICAL CHEMISTRY B, 2005

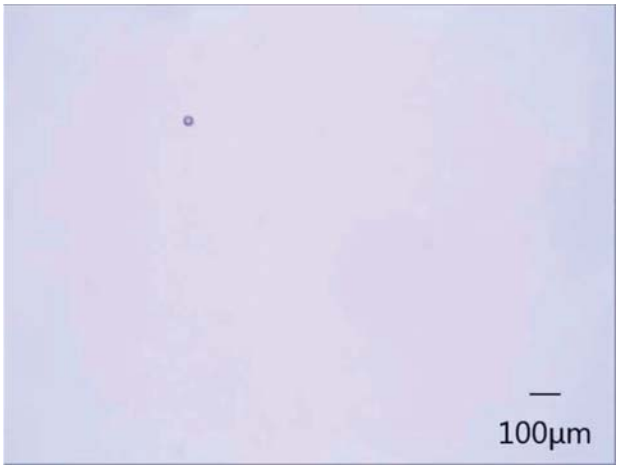
Zeta Potential of Microbubbles

nite

(Reference) Takahashi, M(AIST). The ζ Potential of Microbubbles in Aqueous Solutions - Electrical property of the gas-water interface -- JOURNAL OF PHYSICAL CHEMISTRY B, 2005

Shrinkage of Microbubbles

nite



8. Evaluation Method of Microbubbles

nite

ISO

TC > ISO/TC 281

ISO 21910-1:2020

Fine bubble technology — Characterization of microbubbles — Part 1: Off-line evaluation of size index

This document specifies the evaluation method for the size index of microbubbles in microbubble dispersion. It is only applicable to microbubbles with or without shell in water within the range from 1 μm to 100 μm. It describes the sampling methods from the point generating or dispersing microbubbles in the retention container to the detecting point of the measuring instruments.

(Reference) https://www.iso.org/standard/72151.html

Conventional Methods

nite

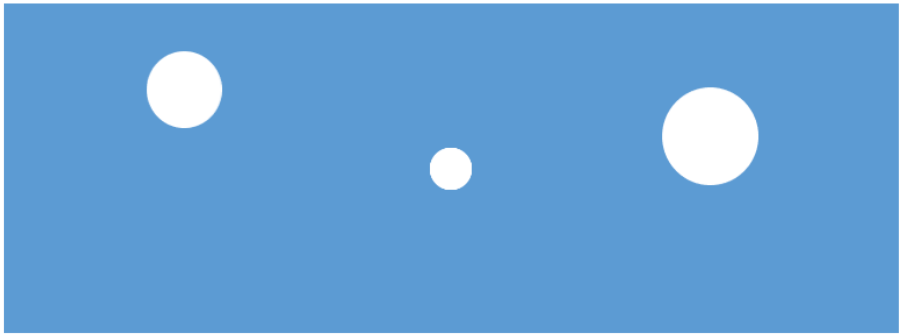
Turbidity

Dissolved oxygen

Microscope

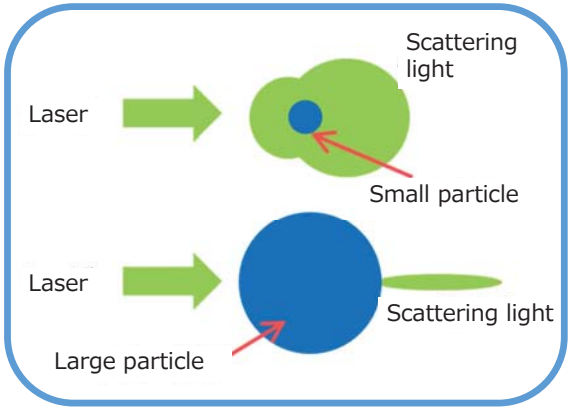
Properties of Microbubbles

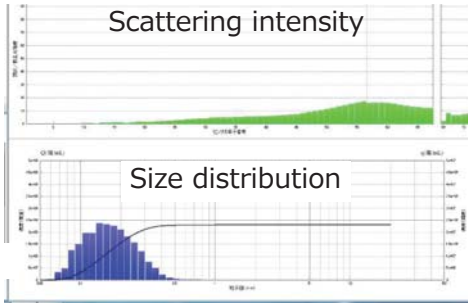
nite



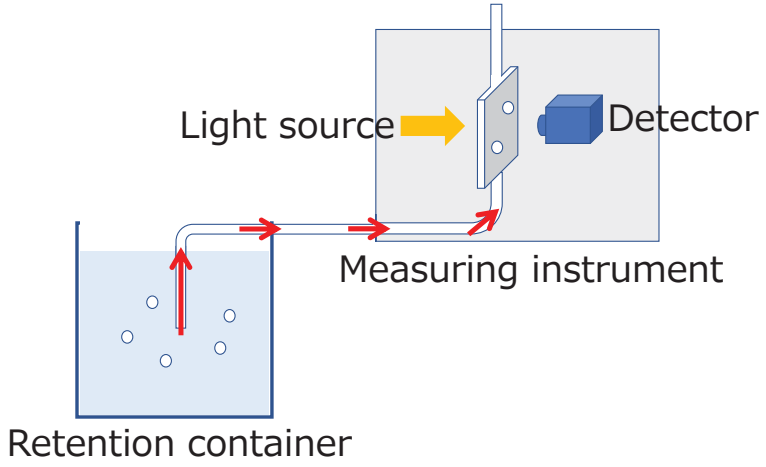
Floatation Shrinkage Coalescence

Laser Diffraction

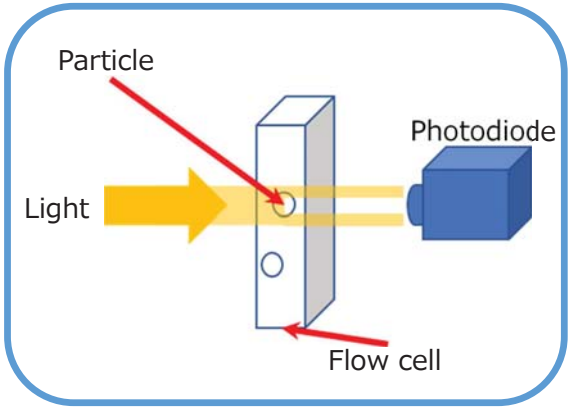


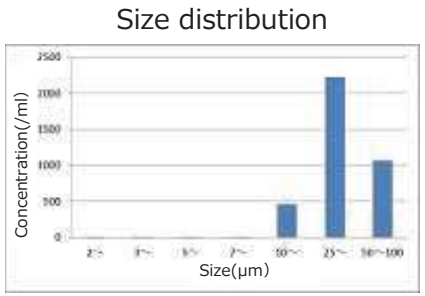


System Structure

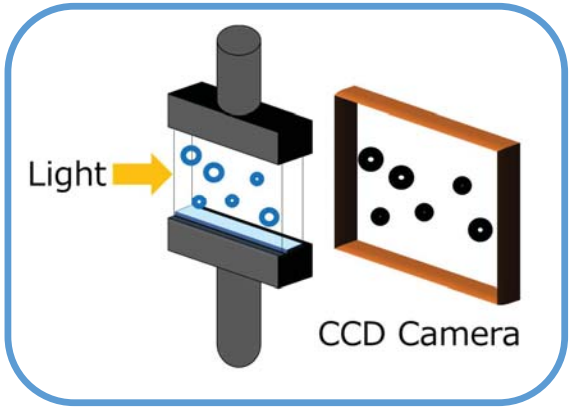


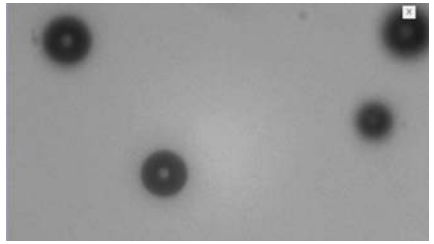
Light Extinction Liquid-borne Particle Counter



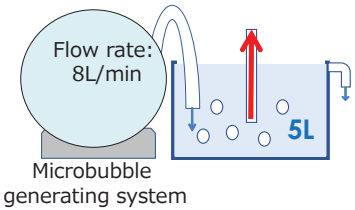


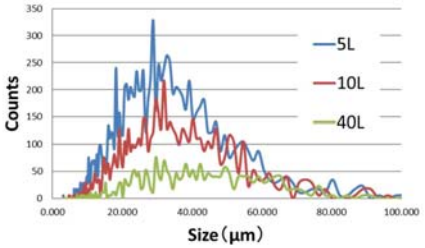
Dynamic Image Analysis

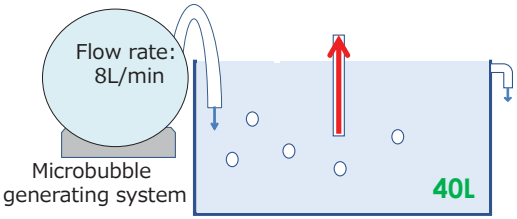




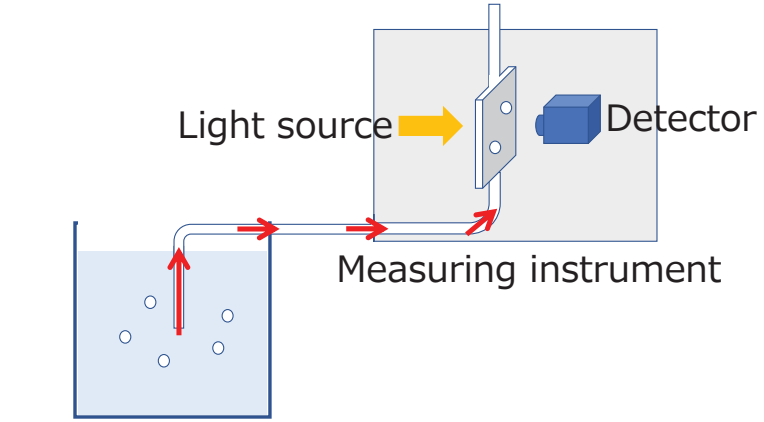
Retention Container



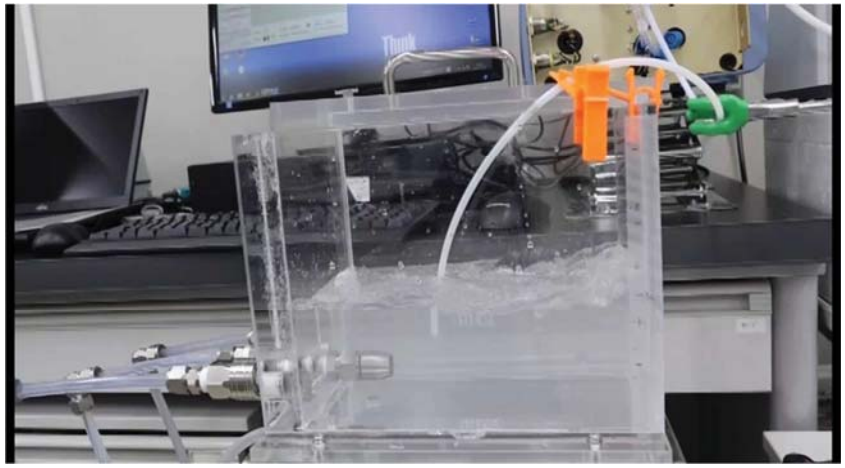




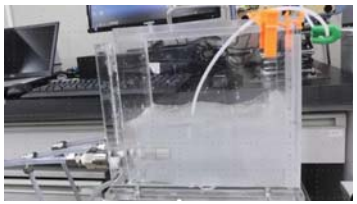
System Structure

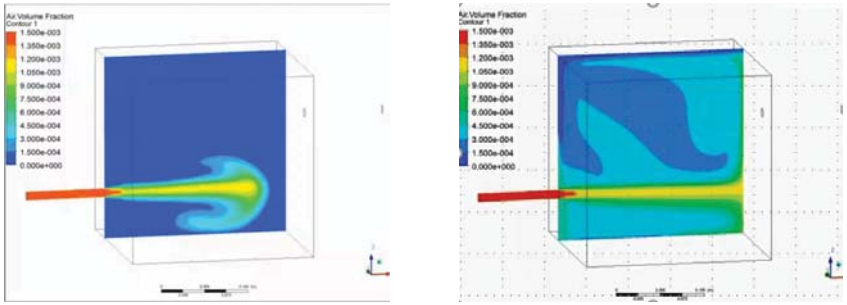


Retention Container



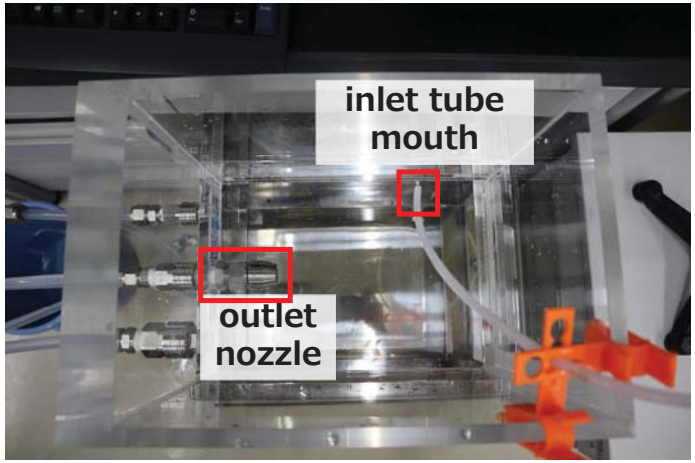
Sampling of Microbubbles





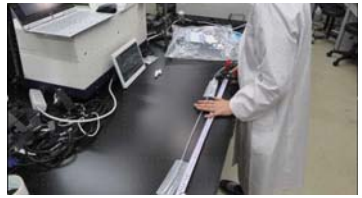
Retention Container

Position of Inlet Tube Mouth



Loading Tube

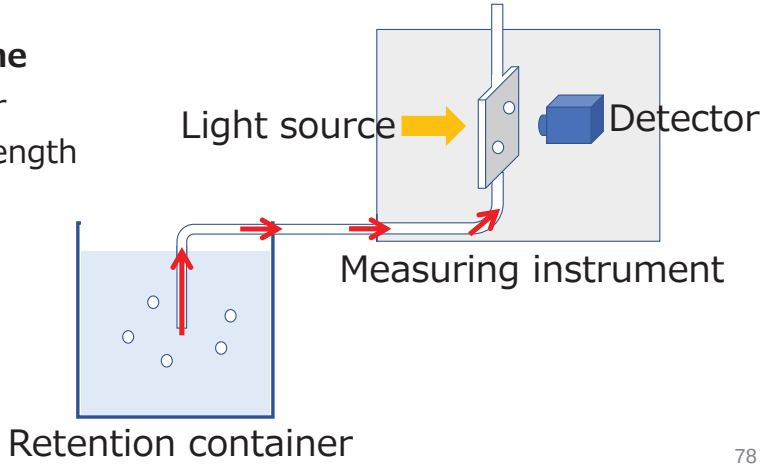
hydrophobic
not soft
not eluting
negatively charged



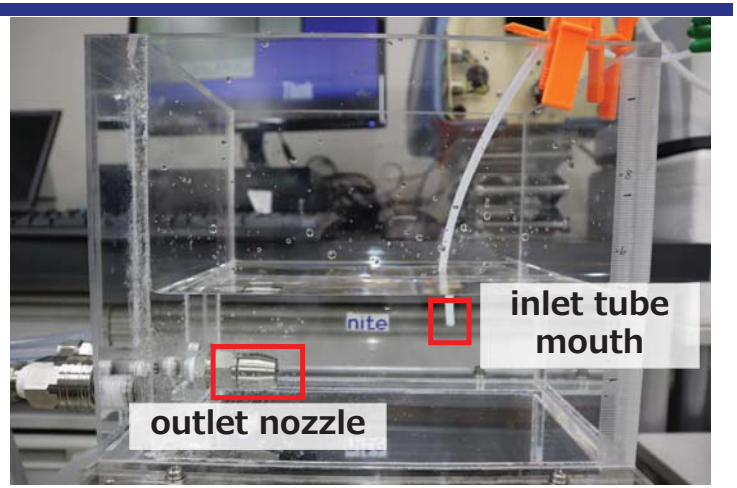
Retention Time

Retention time

inner diameter
loading tube length
cell volume
flow rate



Position of Inlet Tube Mouth

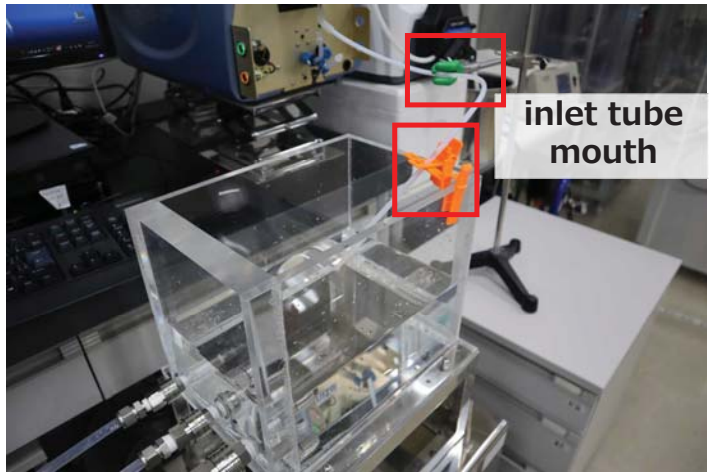


Retention Time

$$\text{Retention time} = \left(\pi \left(\frac{d}{2} \right)^2 \times l + V_c \right) / q$$

d : inner diameter
l : loading tube length
Vc : cell volume
q : flow rate

Position of Inlet Tube Mouth

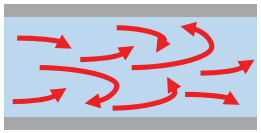


Reynolds Number

Reynolds number $= \dfrac{V \times d}{\nu}$

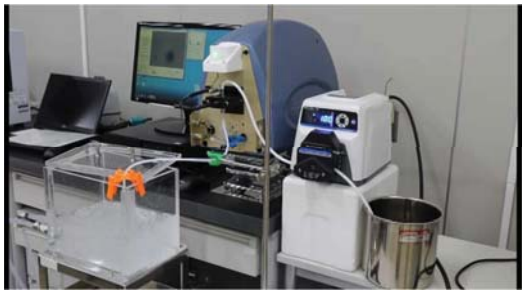
V : flow velocity
d : inner diameter
ν : kinetic viscosity

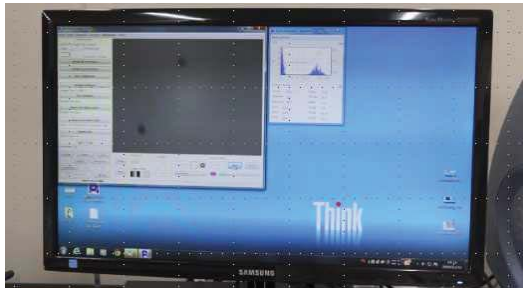
Laminar
Re≦2300



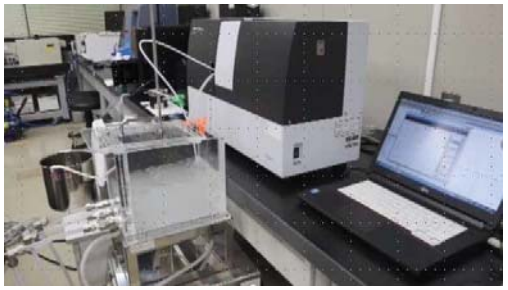
Turbulent
Re>2300

Dynamic Image Analysis

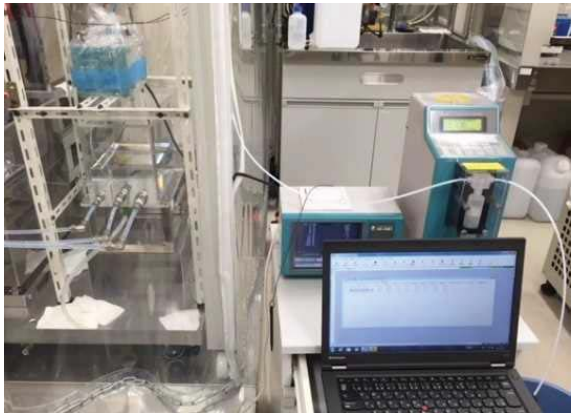




Laser Diffraction



Light Extinction Liquid-borne Particle Counter



"Role of inter-laboratory comparison"
0.5 h (Prof. OSHITA &Dr.TANAKA)
Reliable conformity based on inter-laboratory comparison will be introduced

ABSTRACT
In order to guarantee the confidence of evaluation, related measurement method, procedure, environment and personal competence must be sound. The typical evaluations currently of interest for fine bubble technology are fine bubble characteristics and fine bubble enhanced performances of applied fine bubble technology and its products. Evaluation of fine bubble characteristics, being typically size and number concentration, is still under evolving and needs to proceed to have objective evidence for the equivalence of measurement results. Similarly, the parameters measuring the performance must have equivalence, based on the deliberate choice of the parameter representing the performance.
Since different measurements on identical object should show equivalence, the practical evidences for the equivalence are supported by the results of comparison. With some examples, the presentation will show current status of process and result of inter laboratory comparison. It covers measurement on fine bubble characteristics of ultrafine bubble water and fine bubble-enabled enhancement of germination of barley seed. From the examples, participant will be aware of the current state of inter-laboratory and its importance. A proposal for another inter-laboratory comparison for the fine bubble characteristic in APEC area will be presented

Reference

nite

ISO 20480-1:2017
Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 1: Terminology

ISO 20480-2:2018
Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 2: Categorization of the attributes of fine bubbles

ISO 20298-1:2018
Fine bubble technology — Sampling and sample preparation for measurement — Part 1: Ultrafine bubble dispersion in water

ISO 21255:2018
Fine bubble technology — Storage and transportation of ultrafine bubble dispersion in water

ISO 21910-1:2020
Fine bubble technology — Characterization of microbubbles — Part 1: Off-line evaluation of size index

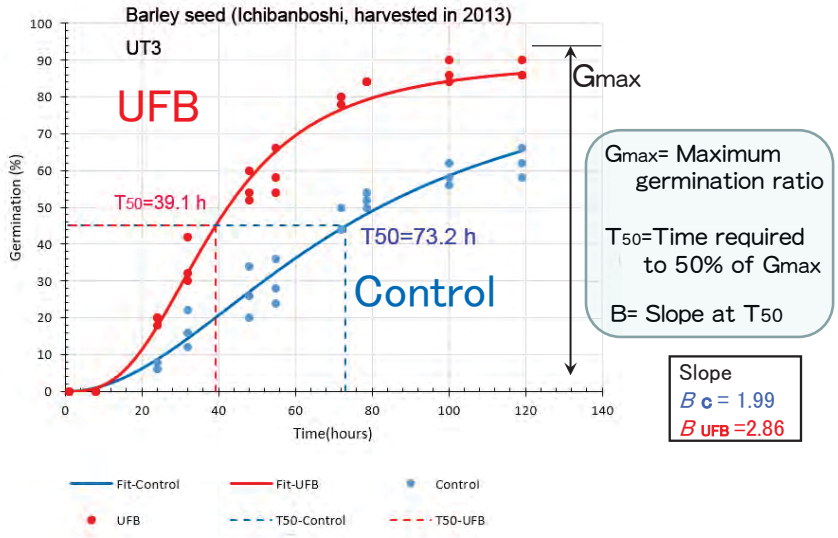
APEC
Capacity Building on Testing and Conformity Assessment of Fine Bubble Technologies for use in Agro-/Aqua-Culture and Water Treatment in the APEC Region
19th & 21st January 2021
1st Workshop, Virtual

Examples of inter-laboratory tests between Vietnam, Indonesia, Hawaii (USA) and Japan

Seiichi OSHITA,

Project Professor
Research Center for Food Safety
Graduate School of Agricultural and Life Sciences,
The University of Tokyo

$$\textit{Model Analysis } (s-\textit{haped model})$$
$$G = \frac{G_{max}}{1+\exp\{B\log(t_i)-\log(T_{50})\}}$$



Gmax= Maximum germination ratio

T50=Time required to 50% of Gmax

B= Slope at T50

Slope
B_C = 1.99
B_{UFB} =2.86

Contents

- What we found as an effect of UFB on seed germination
- Germination test in
  Hanoi (Viet Nam)
  Bogor (Indonesia),
  Hawaii (USA)
  and Chiang Mai (Thailand)
  - ✓ Preparation before visiting
  - ✓ Results in each country
- Conclusions

Inter-laboratory collaborative tests

Germination test at Hanoi University of Science

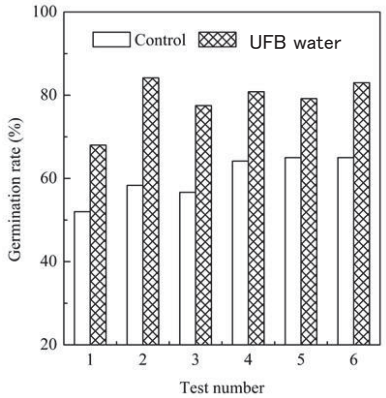
(Vietnam, 2017)

Germination test at Bogor Agricultural University

(Indonesia, 2017)

Promotion of barley seed germination

at the same DO (25°C, 20h)



DO: 9 mg L^{-1}
(Distilled water and Ultrafine bubble water)

Germination rate
Distilled water: **59%**
Fine bubble water: **78%**

S. Liu et al. (2013), *Chemical Engineering Science*

Germination test procedure

1. Select good seeds as shown in the left side of Figure 1.
   Good seeds (big and without visible defect) of 50 are collected and put into a net.
   Three nets are for submerged in UFB water and another tree nets are for distilled water as a control.

2. They are submerged in each water (UFB water and control) for germination, as shown in the center of Figure 1 and Figure 2, at the temperature of 25 °C (or at room temperature) in dark condition.
   Required water volume=1 seed/10 ml (10 ml water is required for 1 seed germination);
   50 seeds/1 bag x 3 plastic nets are for both distilled water and FB water.
   This means 1500 ml of water in one beaker for 3 nets for each UFB and Control water.

3. Water of both UFB and Control is required to change twice a day. A certain period (for example, around 12 h later, nets for UFB and Control are taken and seeds are arranged on a sufficiently wet filter papers as shown in Figure 3.
   Through magnifying viewer or with naked eyes, germinated seeds are counted up to score a germination rate at each submerging period.

Flow of germination test of seed

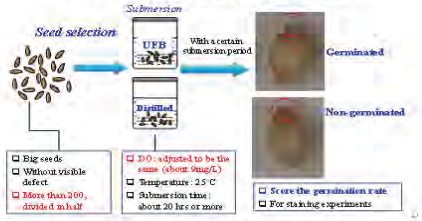


Figure 1 Overview of the flow of germination test

Inter-laboratory collaborative tests

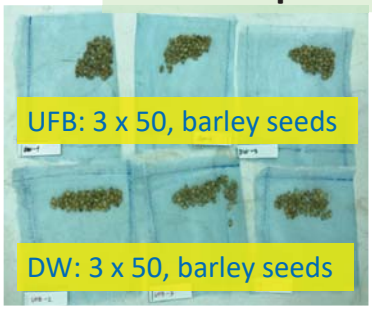
Germination test at MetroGrow Hawaii

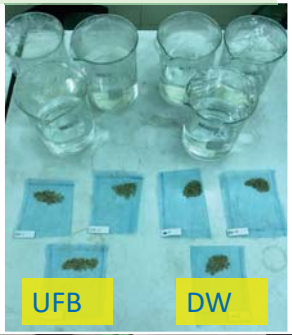
(USA, 2018)

Germination test at Rajamangala University of Technology Lanna

(Thailand, 2018)

Experimental procedure

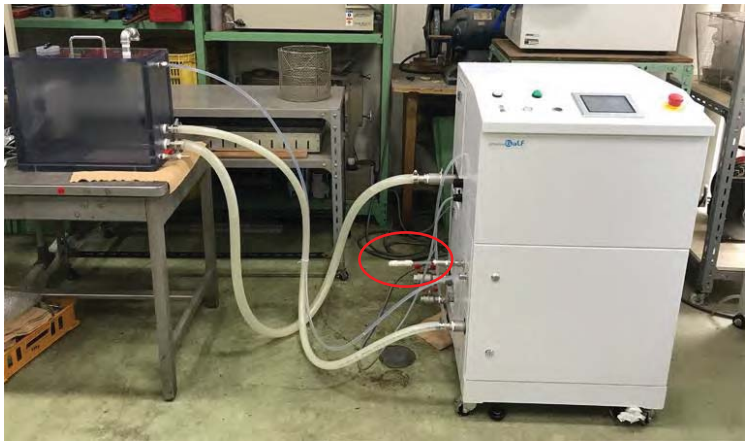




Time: June 05 18:50 (0 h)

Preparation before visiting

Ultra Fine Bubble generator
(The Univ. of Tokyo)



Ultrafine Galf

- Pressure: 0.3 MPa
- Water flow rate: 16.61 L/min
- FZ1N-10

Experimental procedure

5 x 2L- bottles
(Distilled water volume = 1.5 L)

5 x 2L- bottles
(Full of UFB water with no head space)

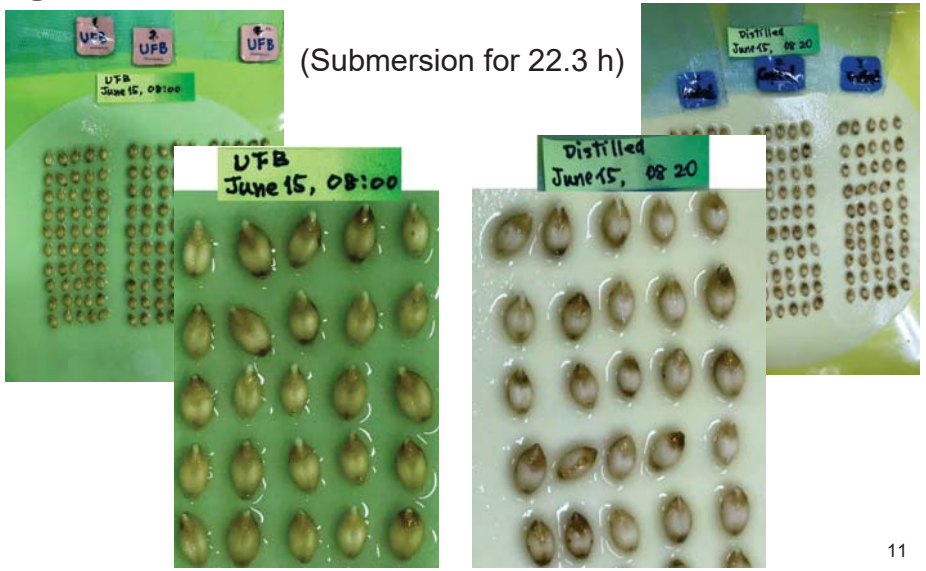
All the bottles were stored in a incubator at 23 ºC

Results in each economy

Count of germinated seeds (150 seeds for each)

UFB

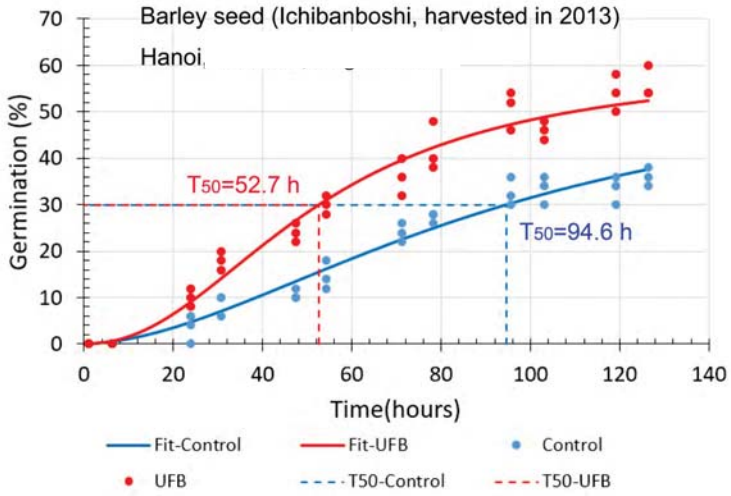
Control



(Submersion for 22.3 h)

Promotion of germination – Hanoi

Seeds harvested in 2013 (low quality)



Germination test in Hanoi

Viet Nam

June 4 to 9, 2017

Faculty of Chemistry at University of Science,
`Viet Nam Naional University

Counterpart

Dr. Thanh Son Le,
Dean of Faculty of Chemistry

Dr. Quang Trung Pham

Visitor

S. Oshita, D. Q. Thuyet (The Univ. of Tokyo)
S. Maeda (IDEC Corporation)

Germination test in Bogor (Indonesia)

July 4 to 10, 2017

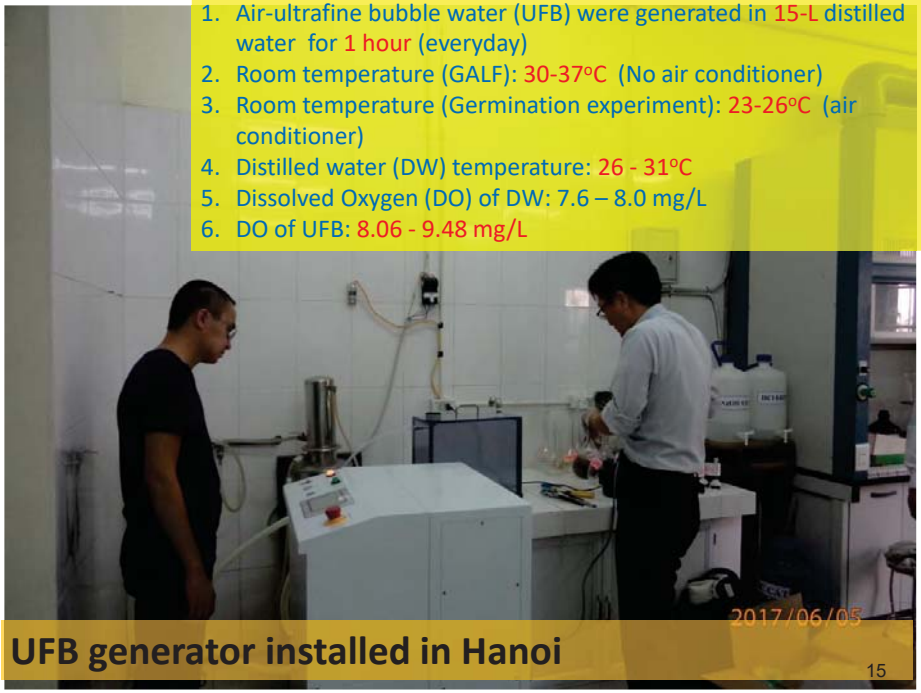
Dept. of Mechanical and Biosystem Engineering,
Faculty of Agricultural Technology,
Bogor Agricultural University

Counterpart

Dr. Y Aris Purwanto

Visitor

S. Oshita, D. Q. Thuyet (The Univ. of Tokyo)
Y. Kawagoe (Nihon University)
S. Maeda (IDEC Corporation)



1. Air-ultrafine bubble water (UFB) were generated in 15-L distilled water for 1 hour (everyday)
2. Room temperature (GALF): 30-37°C (No air conditioner)
3. Room temperature (Germination experiment): 23-26°C (air conditioner)
4. Distilled water (DW) temperature: 26 - 31°C
5. Dissolved Oxygen (DO) of DW: 7.6 – 8.0 mg/L
6. DO of UFB: 8.06 - 9.48 mg/L

UFB generator installed in Hanoi

Germination test in Hawaii (USA)

December 10 to 13, 2018

MetroGrow Hawaii
Vertical farm using aeroponics and hydroponics

Counterpart
Dr. Kerry Kakazu

Visitor
S. Oshita (The Univ. of Tokyo)
Leo Funaki (IDEC CORP.)

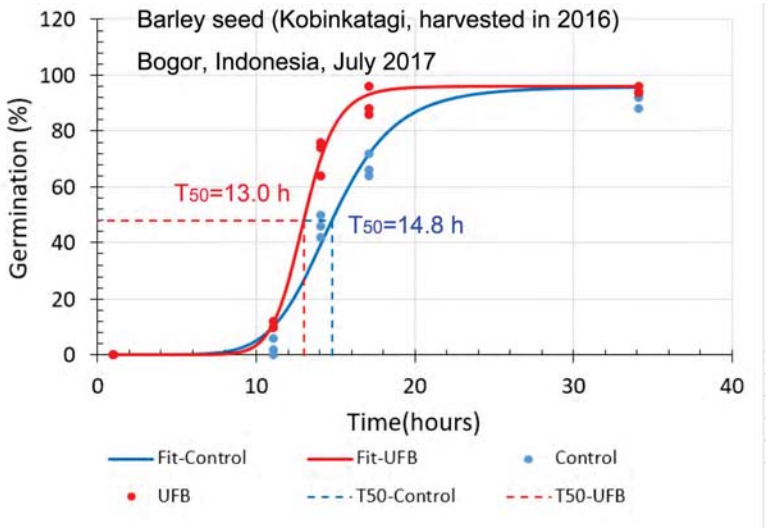
UFB generator installed in Bogor

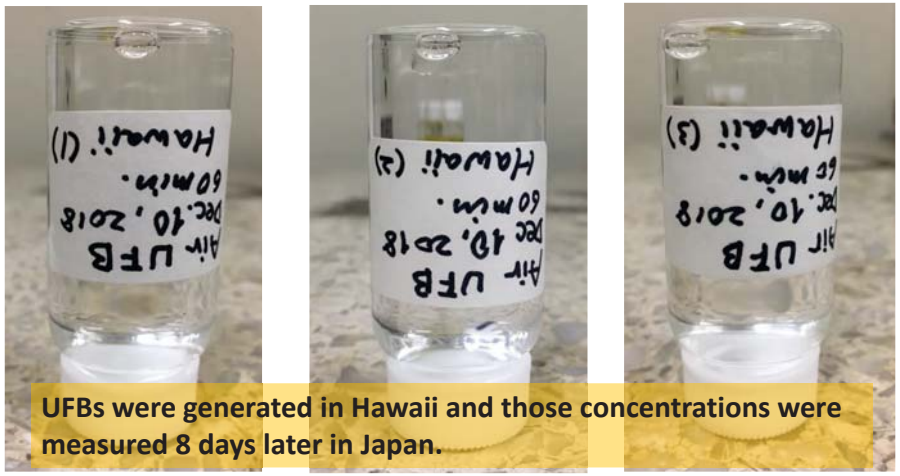
1. Air-ultrafine bubble water (UFB) were generated in 15-L distilled water for 1 hour (15:45 – 16:45)
2. Room temperature: 26°C (Air conditioner setting: 17°C)
3. Distilled water (DW) temperature: 26°C
4. Dissolved Oxygen (DO) of DW: 7.6 mg/L
5. DO of UFB: 10.77 mg/L

UFB generator installed in MetroGrow Hawaii

Promotion of germination – Bogor

Seeds harvested in 2016 (high quality)





UFBs were generated in Hawaii and those concentrations were measured 8 days later in Japan.

2.4×10^8/mL±2.6×10^7	2.5×10^8/mL±1.9×10^7	2.4×10^8/mL±1.5×10^7

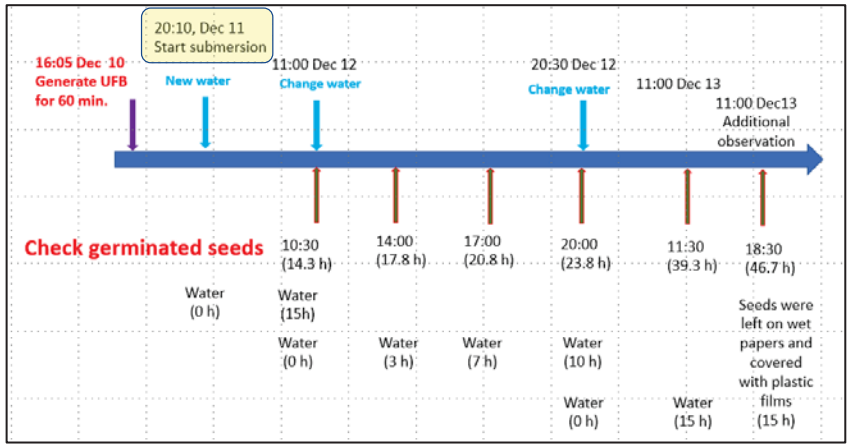
UFB was generated on December 10, 2018 at MetroGrow Hawaii and sampled on Dec. 11 in glass bottles with pipettes according to the regulation of ISO/TC281 with getting the cooperation of Dr. Kerry Kakazu.
After 1 day of sampling, air bubble was appeared.

Experimental procedure (at MetroGrow Hawaii)

getting the cooperation of Dr. kerry Kakazu

Air UFB generation
At New site: **Dec. 10, 2018, 16:05 to 17:05 (60 min.),** Room temp.=27.0oC, Water (26.5 oC→41.0 oC)

After moving to Current site, UFB water was sampled into 4 glass bottles (50 mL) according to ISO
Sampled UFB water: DO=10.83 mg/L & 25.5 oC at 18:07
Control (Distilled water): DO=8.99 mg/L, 24.0 oC at 18:30



Germination test in Chiang Mai (Thailand)

June 13 to 18, 2018

Research Laboratory of Ultra-Fine Bubble for Advanced Technology,
Rajamangala University of Technology Lanna

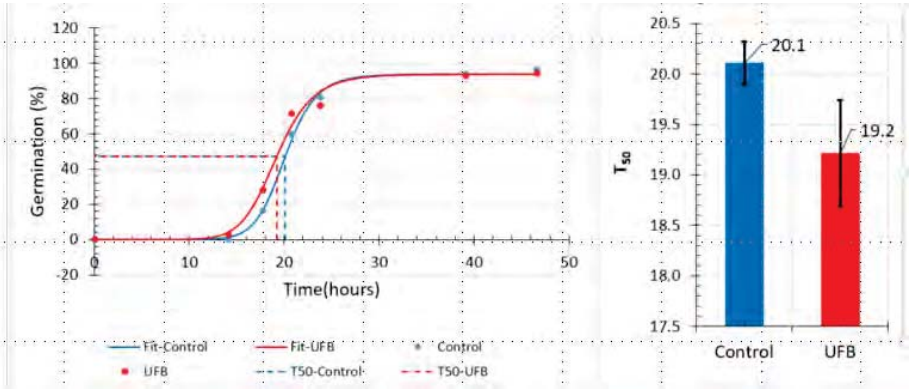
Counterpart
Asst. Prof. Vishnu Thonglek
Dr. Kiyoshi Yoshikawa
(Research Adviser to the President of Rajamangala University)

Visitor
S. Oshita (The Univ. of Tokyo)
S. Maeda (IDEC Corporation)

UFB water was generated on June 5th and transported to Chian Mai by air, then used for germination test on June 14th to 15th.

Promotion of germination – Hawaii

Seeds harvested in 2016 (high quality)

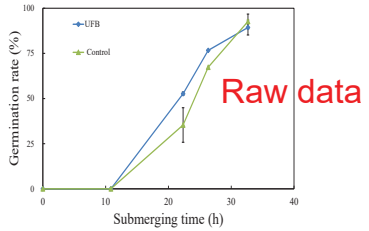


Conclusions

Promotion effect of UFB on barley seed germination was supported by Inter-laboratory collaborative test

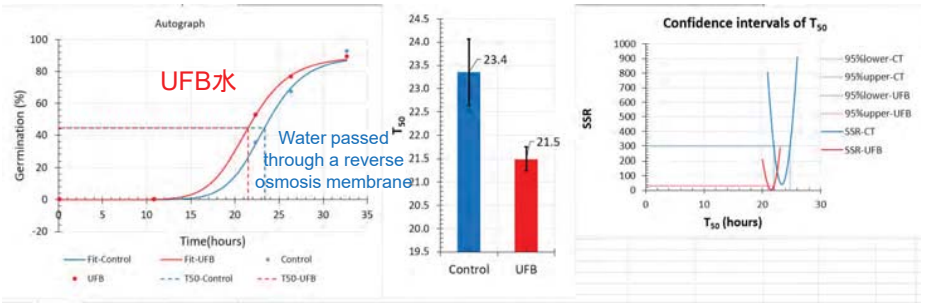
Inter-laboratory test has been shown to be useful to assure the repeatability of experimental results

Promotion of barley seed germination by UFB water



T_{50}=13.0 h (UFB water)

T_{50}=14.8 h (Control)

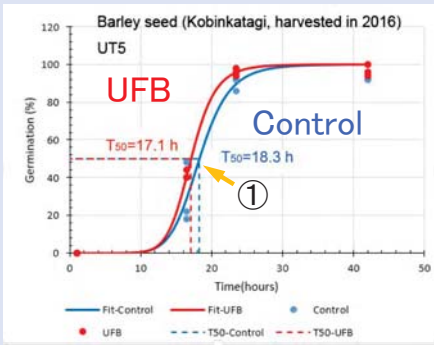


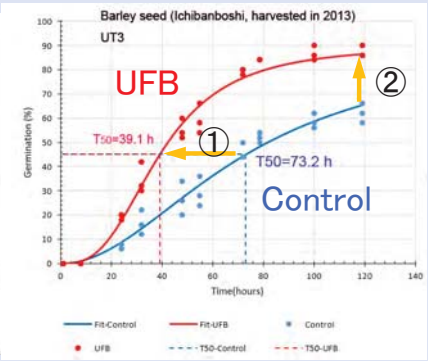
Thank you for your kind attention!

Acknowledgement to financial support by
METI International Standardization Program and FBIA, Japan.

Promotion effect in 2 patterns

UFB assists to
① put germination ahead
② increase in germination rate



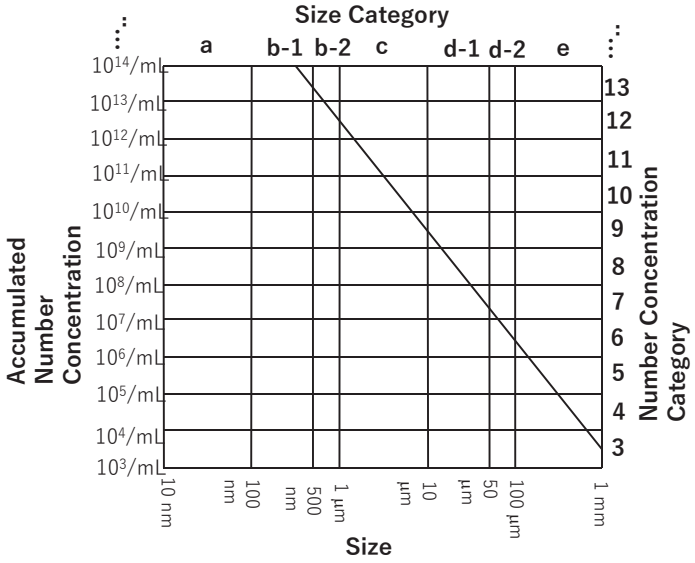


Pattern A
Seed of high quality

Pattern B
Seed of low quality

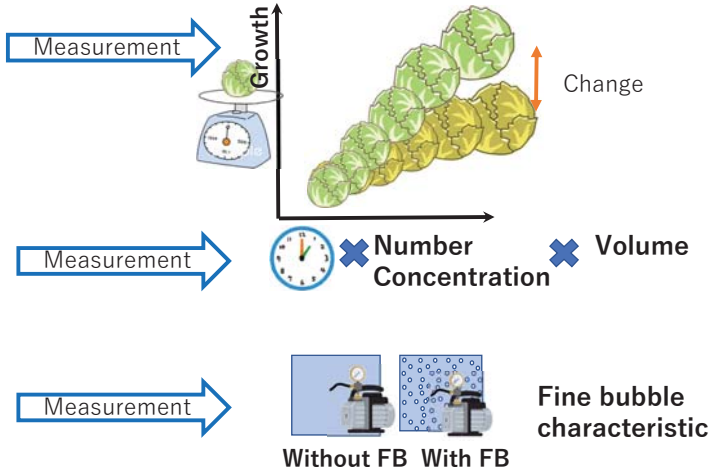
FBIA Category of Fine Bubble Characteristic

Assign a category to each FB Water



Role of Inter Laboratory Comparison

Performance Testing
Evaluation parameter
(Increase in) Mass of product
Number Concentration & Size of FB (Applied)



Testing the performance of FBT products

Measurement of FB characteristic

Measurement of FB-enhanced Performance

Size and Number Concentration

Change in parameter

Capability of Testing = Measuring Instrument, Procedure, Environment, Proficiency

Laboratories

Equivalence of InterLab Test Results

Mutual Confidence Established

Examples of Performance	Parameter
Growth Germination	No. Germinated Seed
Quality of Product Sweetness	Sugar Content
Washing Post Harvest	Removal of P.H.
Quality of Water	BOD, VOD, Mad
Decolorization	Decolorization
DAF performance	
Sterilization Parasitic germ	Biological analysis
Fresh Fish Transport	Desolv-ed Oxygen

DAF: Dissolved Air Floatation

Announcement to Possible Participants to APEC-WS1

"3. Measurement Comparison for fine bubble technology

High concentration UFB water in a bottle is sent to a laboratory of the participant and is applied to its measurement on average size and total number concentration. Identical water is measured too in Japan and these results will be compared and introduced in WS 2. In order to conduct the measurement, special measuring instrument, such as Nanosight of Malvern make, must be available. The sequence of the technical part of comparison will be finished preferably by end of March 2021. If you are eligible, please inform me of your potential."

Please Join the Comparison!

Requirement for participation

Measuring Instrument: NanoSight(Malvern), Zeta Views(ParticleMetrix)), SALD(Shimadzu)

Deionized Water: For Cleaning

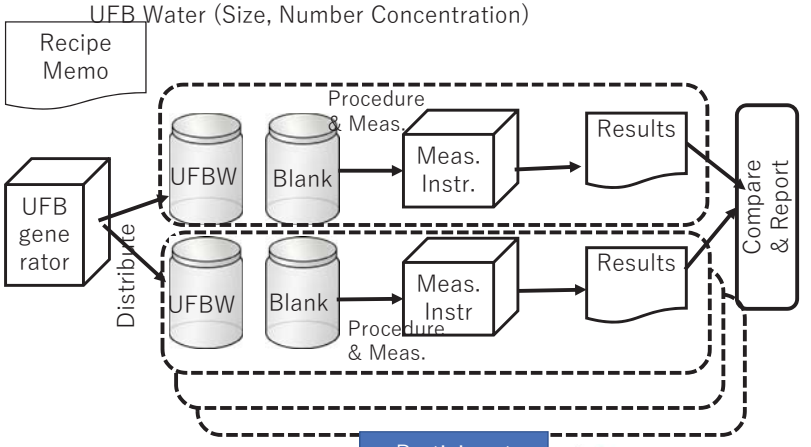
Glass Bottles: For tentative container, Homogenizing

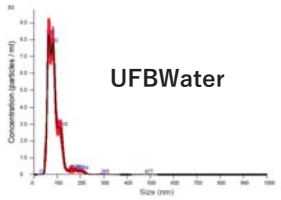
Glove: For cleaning and sampling without contamination

Period: One day 2021 Jan -2021 April: Fixed by coordination of available days.

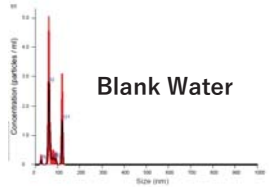
Please contact M.TANAKA /Project organizer at fbia-apec-ws@fbia.or.jp

APEC WS int'l comparison (trial) on measurement of UFB Water (Size, Number Concentration)



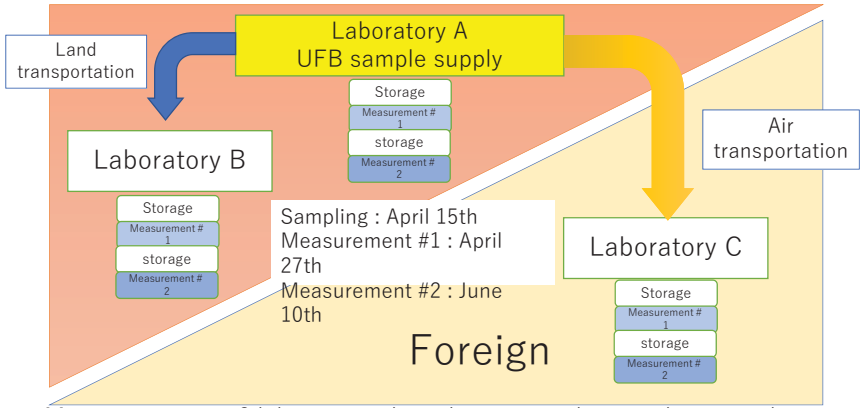


UFBWater



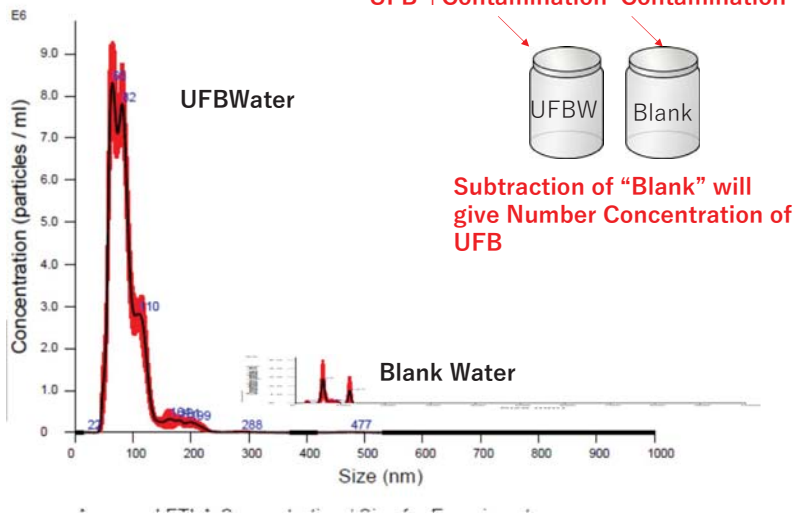
Blank Water

Procedure for Voluntary Trilateral Inter-Laboratory Comparison on Number Concentration Index Measurement of UFB

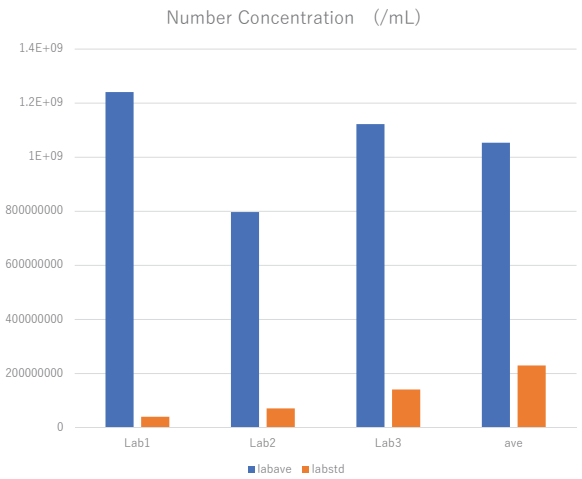


Measurements at 3 laboratories have been carried out at the same day.

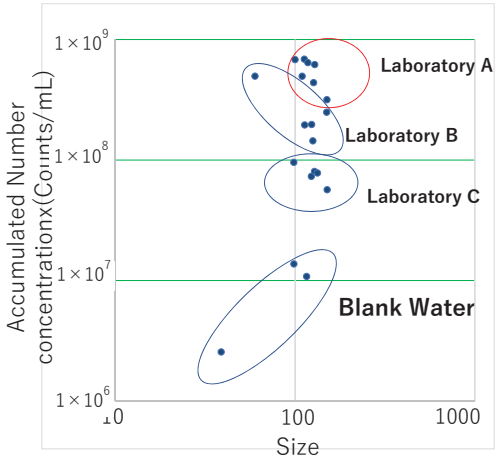
Set of sample for measurement #1 Set of sample for measurement #2



２０１９FY



Report of measurement



Results

UFB in the sample after 12days from generation could be confirmed by 3 laboratories of Foreign and Japan. Measured size index of 3 laboratories are almost similar.

It can be considered that storage and transportation of UFB are possible.

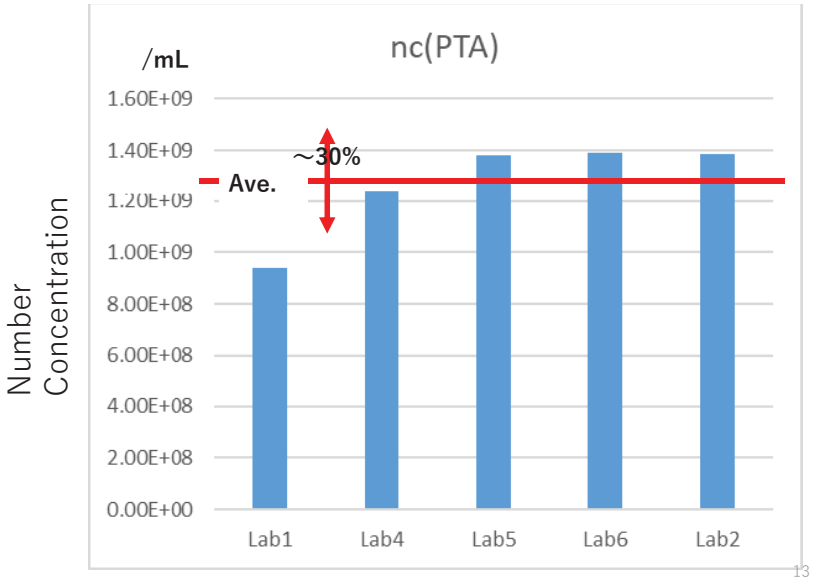
Issues to be considered

Cause of difference of number concentration index depending on 3 laboratories should be investigated. water leakage and mili bubbles have been found after the transportation. Optimum container should be surveyed and selected.

２０１８FY

Inter-Labo Comparison using PTA

average	1.27E+09
stdv	1.94E+08



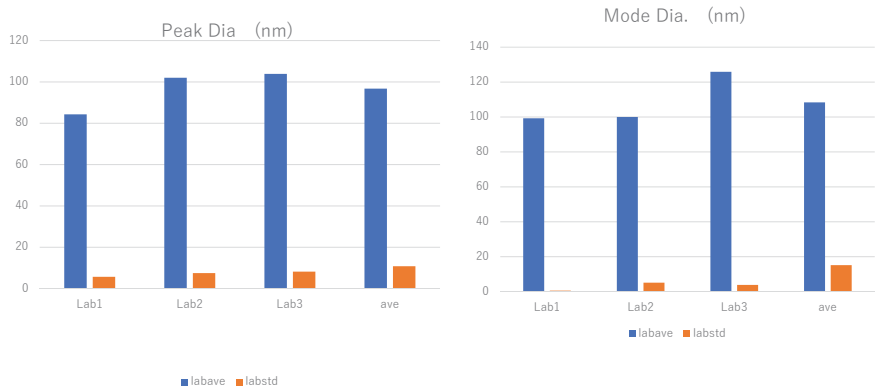
13

２０１９FY

Result of Inter-Labo Comparison for Designation

Dec 19, 2019, Blu:Meas.Result, Orange:Its Std

Ave: Average



01 CHILE

LAND OF CONTRASTS


Source: Pixabay


Source: Unsplash


Source: NASA

APEC Workshop I

kran

f) 18:00-18:15
"Activities in Chile"

Mr. Manuel VIAL, Head of Research & Development
KRAN

Chile

January 21, 2021

01 CHILE

AGRICULTURE


Source: Unsplash

- **+5.500 km² crops cultivated**
  Source: INE, 2020
- **+6 million tons in production**
  Source: INE, 2020
- **+9.000 million USD in exports**
  Source: ODEPA, 2020

INDEX

02 KRAN

WHO WE ARE

Interdisciplinary Team

Our Vision:

Give back to the environment what we have taken from it

Our Strategy:

Through a strong R&D department we deliver tailor-made solutions for each client

01 CHILE

AQUACULTURE

- **+6.000 km of coastline**
  Source: Gobierno de Chile
- **+1,5 million ton anual production**
  Source: Sernapesca, 2020
- **+700 processing plants**
  Source: Sernapesca, 2020

03 SUCCESSFUL CASES

AGRICULTURE

- Promotes plant growth
- Improves plant health
- Efficient use of water

AQUACULTURE

- Seabed purification
- Efficient oxygen transfer
- Improvement animal health

WATER TREATMENT

- Reduction in chemical use
- Better performance
- Better efficiency in aeration

01 CHILE

WATER TREATMENT

- **+750 million m^3/year industrial use**
  Source: Ministerio del Medio Ambiente, 2020
- **+3.000 liquid waste treatment plants**
  Source: INE, 2019
- **+50% audited plants didn't comply with regulations**
  Source: INE, 2019

03 SUCCESSFUL CASES

AGRICULTURE

- **Project:** Oranges post-harvest disinfection
- **Goals:** Increase the shelf-life of the product
- **UFB Properties involved:**

Zeta Potential – Radicals Formation – Surface Tension

- **Results:** 8 weeks increase in shelf-life
  Chlorine use was no longer necessary

03 SUCCESSFUL CASES

AGRICULTURE

- **Project:** Lettuce Growth Monitoring
- **Goals:** Reduce cycle times, increase yield
- **UFB Properties involved:**

Oxygen Transfer Efficiency - Zeta Potential - Radicals Formation

- **Results:** 10 days cycle time reduced
  166% increased yield
  Pythium sp fungae erradicated

03 SUCCESSFUL CASES

AQUACULTURE

- **Project:** FONSA (Healthy Seabeds)
- **Goals:** Restore de seabed to aerobic condition
- **UFB Properties involved:**

Neutral Buoyancy – Oxygen Transfer Efficiency

- **Results:** *Beggiatoa* bacteria was eradicated
  Sludge decomposition accelerated
  DO levels increased
  Biodiversity reactivated

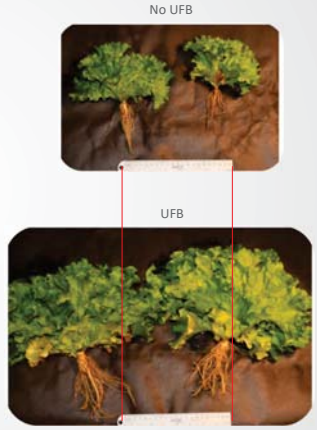
03 SUCCESSFUL CASES

AGRICULTURE

- **Project:** Lettuce Growth Monitoring
- **Goals:** Reduce cycle times, increase yield
- **UFB Properties involved:**

Oxygen Transfer Efficiency - Zeta Potential - Radicals Formation

- **Results:** 10 days cycle time reduced
  166% increased yield
  Pythium sp fungae erradicated



04 FINAL WORDS

03 SUCCESSFUL CASES

AQUACULTURE

- **Project:** Flow Ice
- **Goals:** Replace peracetic acid to sanitize fresh salmon with an ecofriendly solution
- **UFB Properties involved:**

Zeta Potential – Radicals Formation – Surface Tension

- **Results:** +735 mV ORP v/s +576 mV ORP
  Increased shelf-life and improved certification

kran

"ACTIVITIES IN CHILE"

Manuel Vial – Head of Research & Development
manuel.vial@kran-nanobubble.com

03 SUCCESSFUL CASES

WATER TREATMENT

- **Project:** DAF
- **Goals:** Reduce chemicals consumption
- **UFB Properties involved:**

Size Distribution – Zeta Potential

- **Results:** 50% decrease in coagulant maintaining efficiency

OVERVIEW

- Fine bubble technology in China
  start from the 1970' in metal extraction
- First standard
  in the 1990' about fine bubble aerator
- Micro/nano Bubble Committee of Chinese Society of Particuology
  established in 2018
- National Technical Committee on Standardization of Fine Bubble Technology
  established in 2019 (mirror TC of ISO/TC281)
- FBT has been widely used in many areas including agriculture, aquaculture, water treatment, cleaning, flotation column, chemical industry, ultrasound contrast agent, and etc. now.

APEC Workshop I

g)18:15-18:30

Fine Bubble Technology in China -Application and Standardization

Mr. Zhaojun LI
Institute of Process Engineering,
Chinese Academy of Sciences
the People's Republic of China

January 21, 2021

OVERVIEW

CONTENTS

- Overview
- FBT applications
- Standardization of FBT
- Initiatives

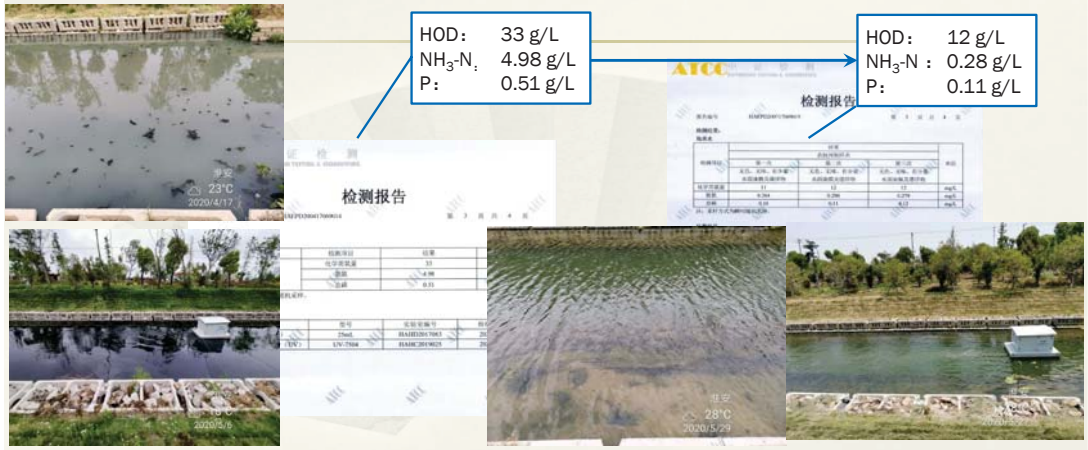
FBT APPLICATION – water

Main Reasons for Water Pollution

- Lack of oxygen
- High concentration of pollutants
- Reproduction of anaerobic bacterium
- Heavily polluted bottom mud

OVERVIEW

FBT APPLICATION – water - urban sewage



FBT APPLICATION - water

With the fast economic growth, more and more attention has been paid to the water pollution problem.

But nowadays the situation is changing rapidly.

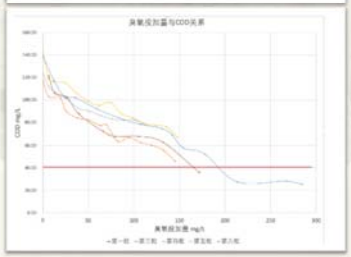
Surface water：

2012 grade I-III：69%, bad (below V)：10%

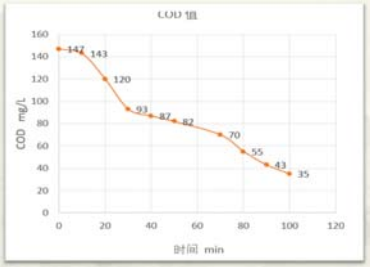
2020 grade I-III：80%, bad (below V)： 1%

FBT APPLICATION – water - industry sewage

Papermaking wastewater



Only 150-200 mg/L ozone needed



COD: 147 mg/L to 35 mg/L

Faster and cheaper than traditional technique

FBT APPLICATION – water - urban sewage

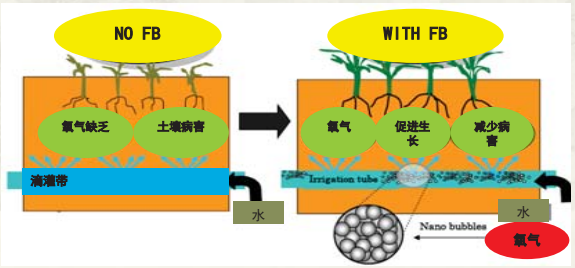
1 year

2 years

It's easy for fine bubbles to improve the quality of the river sediment just because of their size.

FBT APPLICATION - agriculture

- **Principle:** Transfer oxygen directly to the root of plants by FBs to improve the environment of growth.
- **Advantage:** Significantly increase the output and improve the nutritional quality of the plants.



FBT APPLICATION – water - industry sewage

pharmaceutical industry

Lincomycin two stages

水质 聚铁混凝后	COD
原水	284
处理后	87

水质 生化出水	COD
原水	620
处理后	80

臭氧尾气为零

More effective and much cheaper

fosfomycin

生化后水质	organophosphor mg/L	total phosphorus mg/L
原水	40	45
处理后	0	0.5

Much cheaper than other techniques

FBT APPLICATION - agriculture

salinity: 0.5%
pH: 8.5

5 months

salinity: 0.2%
pH: 8.3

试验田编号	温度	盐度（%）	水分（%）	pH
1号田	20.5	0.53	54.5	8.7
2号田	19.4	0.49	51.3	8.5
5号田	20.4	0.51	53.3	8.4
6号田	19.3	0.52	56.8	8.6
对照	20.1	0.51	52.4	8.6

试验田编号	温度	盐度（%）	水分（%）	pH
1号田	18.3	0.18	37.1	8.3
2号田	19.3	0.16	36.8	8.2
5号田	19.1	0.18	36.2	8.3
6号田	18.6	0.18	37.7	8.3
对照	18.5	0.25	35.5	8.5

Unhusked rice: 6120kg/Ha

FBT APPLICATION - agriculture

Highly diffused system design

Output increase: 49.7% (unhusked rice)
71.3% (rice)
Plan: 10000Ha in 2021

FBT APPLICATION - agriculture

Tomato
Output 30.3%, Vc 68.1%, Lycopene 52.0%

Cucumber
Output 34.3% , Vc 64.6%, Soluble sugar 57.1%

Watermelon
Output 69.8% , Vc 48.8%, Soluble sugar 66.0%

FBT APPLICATION - agriculture

Saline-alkaline Land

FBT APPLICATION - aquaculture

4-5 days ' fish hatching	
Length	7mm ~8mm
quantity	30 % ~35% increase
Deformity	10%-15% → nearly 0%
Belly emptying time	8hrs → 3hrs
	more healthy
Gain 1 kg	14 months→12 months(cost 15% ↓)
Rate of water exchange	100%~150%/month →nearly 0%
Feeding stuff needed /kg	1.7kg → 1.2kg （cost 30%↓）

NO antibiotic
NO hormone
More delicious

FBT APPLICATION - agriculture

FB generator for soil sterilizing

FB generator for hydroponics

FB generator for bean germination

Standardization of FBT

- FBT is an excellent technique in many fields, whether it is used in water treatment or in agro-/aqua-culture, It is all the result of fine bubble effects in water. It seems that FBT can be used anywhere with water.
- But, in practical, the performances of FB generators varies widely although they are all called FB generators. To achieve better market order and reach conformity, standardization is the best solution.
- According to the development of FBT, besides some issued standards relating to generators, we are now investigating other standards:

Generator(issued)	dispersed aerator, rotary disc aerator
	high speed aeration centrifugal blower, jet aerator
	blast submerged aerator, rotary brush aerator
Measurement	Microbubble size analysis- Submerged image analysis methods
Characterization of generator	Measurement of oxygen mass transfer in clean water
Application	Engineering design and construction for FB application in saline-alkali soil

FBT APPLICATION - aquaculture

Jelawat (mad barb)
皇帝鱼，苏丹鱼

IPB University

APEC Workshop I

BSN BADAN STANDARDISASI NASIONAL

h)18:30-18:45
"Activities in Indonesia"
Application Finebubble Technology to Agri-aqua Farming

Prof. Dr. Aris Purwanto
IPB University
Indonesia

January 21, 2021

Initiatives

- **International Conference on FBT each year or every two years to make FBT more popular.**
  China will be willing to undertake the first conference in 2022
- **International comparison tests (Under way)**
- **Versailles Project on Advanced Materials and Standards (VAMAS)**
  The main objective of VAMAS is to promote world trade by innovation and adoption of advanced materials through international collaborations that provide the technical basis for harmonisation of measurement methods, leading to best practices and standards.
- **Focus on the evaluation of FB generator performances to achieve harmonious results to improve the conformity**

IPB University

APEC Workshop I

BSN BADAN STANDARDISASI NASIONAL

- We have to take food management and agricultural development seriously," the President said during the Opening of the 2021 National Working Meeting of Agricultural Development with the theme "Strengthening the Role of Agricultural Sector in Supporting Economic Growth amid the COVID-19 Pandemic" (Monday, 11/01/2021)
- President stressed that agricultural development for agricultural commodities such as **soybeans**, corn, sugar, and **garlic**, all of which are currently still being imported, is of great importance. "We have not imported rice for almost two years. I want to see what conditions are on the ground, whether we'll consistently do it for the coming years," he said, while calling for an agricultural development scheme to address the matter (importing commodities).

Thank you for your attention!

Zhaojun LI
Institute of Process Engineering, Chinese Academy of Sciences
zjli@ipe.ac.cn
86-10-62521688
86-13520079628

o Promote germination of garlic seed

Garlic bulbs need to be stored for 5-6 months before replanting due to dormancy

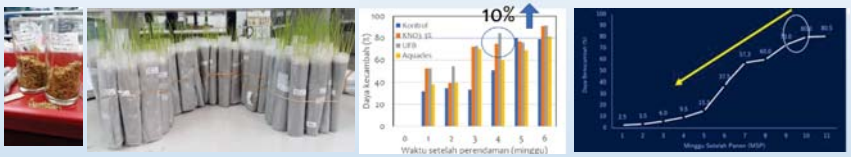
UFBs water and H_2O_2 solution both stimulated **seed germination speed** and had a similar pattern on the effect of gene expression profiles on barley seed sprouts

Liu, S, Oshita S, Thuyet DQ, Saito M, Yoshimoto T. 2018. Langmuir 34, 39: 11878–11885

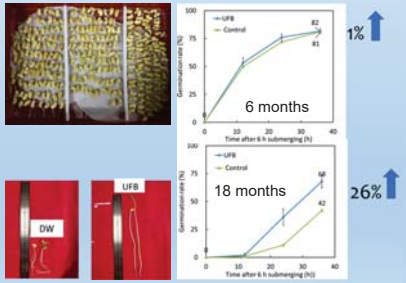
Apply finebubble technology for breaking dormancy and promoting germination of garlic seed

o Promote germination of seed

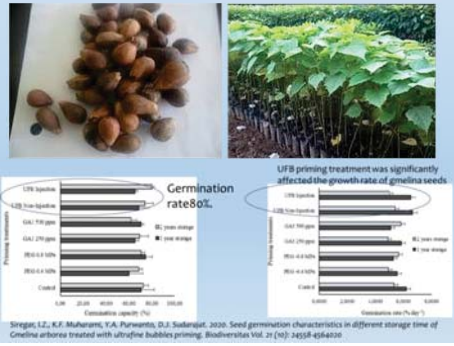
Rice seed



Soybean seed



Gmelina arborea Roxb. Seed



Siregar, I.Z., K.F. Muharami, Y.A. Purwanto, D.J. Sudarsjat. 2020. Seed germination characteristics in different storage time of *Gmelina arborea* treated with ultrafine bubbles priming. Biodiversitas Vol. 21 (10): 24558-4564020

o Promote germination of garlic seed

Application of ultrafine bubble (UFB) water for breaking dormancy of garlic seed (local variety)

- o Dissolved oxygen (DO) UFB water 8ppm
- o Immersion time 24 jam
- o Storage temperature 18 ± 2ºC.

Finebubble generator (FZ1N-10, IDEC Corporation)

Garlic bulb 1 month after harvesting

breaking dormancy plumula is the part of a young plant that becomes the shoot system > 60%

o Increase the density of fish/shrimp in fresh water fish/shrimp pond)

Dr.Anto Tri Sugiarto M.Eng, Indonesian Institute of Sciences

o Increase the quality of pond water

Ministry of Environment and Forestry

First time in Indonesia, garlic was harvested from garlic seed treated using ultrafine bubble

Restore the glory of garlic production using ultrafine bubble technology

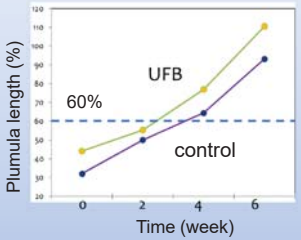
https://finance.detik.com/foto-bisnis/d-5335872/pertama-di-ri-benih-bawang-putih-hasil-ultra-fine-bubble/4

o Promote germination of garlic seed

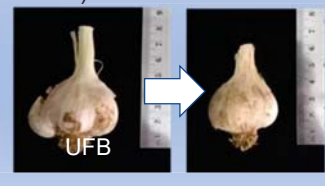
4 weeks after treatment

Control (water) UFB water 8ppm

Garlic seeds are ready to grow from 5-6 to 2-3 months



Grow at Experimental Field (>900 m above sea level)



Size and weight is not significant different as original seed

The fine bubble

breakthrough

Thank you

Grow at Farmer field (>900 m above sea level)

Planting (October 8, 2020)

Growing

Harvesting (January 14, 2021)

Ⅰ. Introduction on KS and KFBIA

INHA UNIVERSITY

APEC Workshop I

i) 18:45-19:00

Activities in Korea

-Introduction of fine bubble applications for the agriculture and the aquaculture

Chang Gyun Kim, Inha University

Korea

January 21, 2021

INHA UNIVERSITY

Current status of KS(Korea industrial Standard) on Fine bubble Technology

- 1st ㉾ published ('15.12.29)
  - "Terminology of finebubble techonology(KSL 1628)"
- Establishment of KFBIA (Korea Fine Bubble Industry Association)
  - KS and official certificate related business (2016. 9. 16~)
- Establishment of National Mirror Committee on Fine bubble Technology
  - Discussion and decision making on KS and IS issues (2019.4.25 ~)

CONTENTS