Glossary of Terms & Definitions related to Ultra Fine Bubbles (UFB)

Sl No	Terms	Definitions	Notes
1	Absorbance	Natural logarithm of the ratio of the light amount before and after transmission of the test water-soluble dye with the photometric amount defined in ISO 80000-7:2019, 7-32.1.	
2	Aeration / Oxygenation	Process of introducing of air/oxygen into a body of water to increase its oxygen saturation	
3	Ambient ozone concentration	Concentration of ozone existing in the air or surrounding the ozone treatment apparatus	
4	Analyte	Element or constituent to be determined	
5	Application fields	Applied areas and fields of industry where fine bubble technologies are effectively used, demonstrated and commercialized	
6	Aspect ratio	Ratio of length of a particle to its width	
7	Average hydrodynamic diameter x_{DLS}	Hydrodynamic diameter that reflects the central value of the underlying particle size distribution	The average particle diameter is either directly determined without calculation of the particle size distribution, or calculated from the computed intensity-, volume- or number-weighted particle size distribution or from its fitted (transformed) density function. The exact nature of the average particle diameter depends on the evaluation algorithm. The cumulants method yields a scattered light intensity-weighted harmonic mean particle diameter, which is sometimes also referred to as the “z-average diameter.”

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			Arithmetic, geometric and harmonic mean values can be calculated from the particle size distribution according to ISO 9276-2. Mean values calculated from density functions (linear abscissa) and transformed density functions (logarithmic abscissa) may significantly differ (ISO 9276-1). x_{DLS} also depends on the particle shape and the scattering vector (and thus on the angle of observation, laser wavelength and refractive index of the suspension medium).
8	Bioactive gases	Gases having an effect upon a living organism, tissue or cell	Example: Nitric oxide, oxygen, hydrogen, carbon dioxide, carbon monoxide.
9	Bioinert gases	Gases which do not initiate a response or interact when introduced to biological tissue	Example: Air, sulfur hexafluoride or perfluorocarbons.
10	Brownian motion	Random movement of particles suspended in a liquid caused by thermal movement of medium molecules	
11	Bubble	Gas in a medium enclosed by an interface	
12	Bubble and Particle Size Distribution	Range (minimum to maximum) of bubble and particle size in a measurement	
13	Bubble collapse	Action by which bubble is suddenly broken into smaller constituents	
14	Bubble generating system	System for creating bubbles in a liquid medium	
15	Bubble number	Number of bubbles per unit volume of	The medium can be solid medium or

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	concentration	medium	liquid medium.
16	Bubble number stability	Duration for the number of bubbles to increase twofold or reduce by half under a given temperature and pressure conditions	
17	Bubble shell	Object or a collection of objects that cover the bubble surface almost completely	
18	Bubble size stability	Duration for a volume equivalent diameter of a bubble to increase twofold or reduce by half under given temperature and pressure conditions	
19	Bubble stability	Duration for total volume of bubbles in dispersion to increase twofold or reduce by Half under a given temperature and pressure conditions	
20	Bubble temperature	Temperature at which an infinitesimal amount of vapor is in equilibrium with a bulk liquid for a specified pressure	
21	Bubble volume	Spherical (or otherwise) volume of a bubble	In case of a bubble covered by its bubble shell, the volume of the bubble shell should be included.
22	BVC (Bubble Volume Concentration)	Index of the volume of bubbles contained in the unit volume of water.	It is calculated by the ratio of the total bubble volume to the volume of generated bubble water during any given time, expressed in %.
23	Bubble-point pressure	Pressure under which gas bubbles form in a liquid at a particular operating temperature which gas bubbles form	
24	Cavitation	Formation and collapse of bubbles in a liquid when the pressure falls to or below the liquid vapor pressure, the collapse releases energy, sometimes with an audible sound and vibration	
25	Cell constant	Proportional constant between the applied electric field, either in a constant voltage or a constant current, and the electric field strength in the measurement zone of the sample cell, which is unique for each cell	

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		and can be obtained by measuring a medium with known conductivity	
26	CRM (Certified reference material)	Reference material characterized by a metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability	
27	Coalescence	Action by which bubbles unite to form larger bubbles	
28	Condensation method	Method by which hollow fine structures (capsules and particles) are often preformed and filled with gases to form shell fine bubbles.	
29	Contact zone	Zone where the floc particles are carried into and generate the particle-bubble aggregates by contacted with air bubbles	
30	Contaminant	Foreign matter, undesired substances of Organic and inorganic origin, undesired matter	
31	Control section	Area to grow plants using raw water as a reference for fine bubble section	For the purpose of this document, plants grown are lettuces.
32	Control section	Test beaker containing control water for use in germination tests of barley seeds in control water	
33	Control suspension	Suspension used to validate the growth condition of test bacteria and validate the test, i.e. bacterial test suspension produced without using fine bubble generation	
34	Control water	Water for use as a control sample for the effects of UFB	
35	Control water/ blank water	Water used as reference in comparative test on the ultrafine bubble water	
36	Count rate/	Number of photon pulses per unit time	It is also a photodetector current

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	photocurrent, I_s		which is proportional to the scattered intensity as measured by a detector.
37	Critical micelle	State of maximum concentration of dispersing agent before micelles form	
38	Cross-linked shell	Shell materials connected by covalent bonds.	
39	Culture solution	Solution containing liquid fertilizer supplied to hydroponic cultivation system	
40	Cycle frequency	Ratio of circulating water flow rate to tank volume.	Expressed in h^{-1}.
41	Diluent	Non-volatile homogeneous liquid which is used to decrease the concentration of particles in a suspension without any deleterious effects such as changing particle total number, state of aggregation, particle size or surface chemistry	
42	Disinfection Efficiency	Ratio of viable cell count to the initial number of the test bacteria	
43	Dispersion	Multi-phase system in which discontinuities of any state (solid, liquid or gas: discontinuous phase) are distributed in a continuous phase of a different composition or state	This term also refers to the act or process of producing a dispersion; in this context, the term “dispersion process” should be used. If solid particles are distributed in a liquid, the dispersion is referred to as a suspension If the dispersion consists of two or more immiscible liquid phases, it is termed an “emulsion”. A suspoemulsion consists of both solid and liquid phases distributed in a continuous liquid phase.
44	Dispersion method	Method by which fine bubbles with a shell of biocompatible materials are produced by sonication or high-speed agitation to disperse the shell materials with the gas	

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		interface.	
45	DAF (Dissolved air flotation) bubble bed compactness, DAF bubble bed compactness	Index indicating the degree to which the dissolved air flotation bubble bed is saturated with bubbles at state of equilibrium	It is calculated as the ratio of the total bubble volume to the volume of DAF bubble bed, expressed in % $C = \frac{V_b}{V_{bb}} \times 100 = \sum_i (ni \times i) \times 100$ Where *C* is DAF bubble bed compactness (%); V_b is the volume of bubbles in DAF bubble bed, calculated as the sum of each bubble volume (ml); V_{bb} is the total volume of DAF bubble bed, calculated by multiplying surface area and effective depth of DAF bubble bed (ml); *i* is the volume of a bubble (ml); n_i is the bubble number concentration whose volume is *i* (1/ml).
46	DAF (Dissolved air flotation) bubble bed	Layer generated by fine bubbles in the separation zone	
47	DAF (Dissolved air flotation) tank	Tank in which dissolved air flotation process is performed and that is roughly divided into two compartments containing contact and separation zone according to the step of flotation process formation of Particle-bubble aggregates and rising to the surface	
48	DAF (Dissolved	Flotation process by which low density	Pressurized solution system is

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	air flotation)	particles are removed from water and wastewater by using fine bubbles which are produced by the reduction in pressure of a water stream saturated with air	usually for generating fine bubbles used in DAF process. However, every fine bubbles generating system can be used if number concentration and size of microbubbles can be produced.
49	DH (Dissolved hydrogen)	Hydrogen molecules, dissolved in a liquid	
50	DO	Amount of dissolved oxygen in water or other liquids.	Expressed in mg/l
51	Doppler shift	Change in frequency and wavelength of a wave for an observer moving relative to the source of the wave	
52	Dormancy	Failure of an intact viable seed to complete germination under favorable conditions	The related term 'dormancy breaking' describes the breaking of dormancy.
53	Double layer shell	Shell made up of two continuous layers consisting of two monolayer shells	
54	Effective depth of dissolved air flotation bubble bed, effective depth of DAF bubble bed	Thickness of dissolved air flotation bubble bed after the dissolved air flotation process reaches state of equilibrium	
55	Effective function	Useful and characterized phenomena obtained successfully by the fine bubble technologies, which are used in the actual industrial applications	
56	Electric surface potential	Difference in electric potential between the surface and the bulk liquid	Electric surface potential is expressed in volts.
57	Electro kinetic potential or zeta-potential, ζ-potential, ζ	difference in electric potential between that at the slipping plane and that of the bulk liquid	Electrokinetic potential is expressed in volts.
58	Electrolysis	Process in which electric current is used to promote a chemical reaction	In the case of water, the separation reaction generating hydrogen and oxygen is a typical example.

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59	Electroosmosis	Motion of liquid through or past a charged surface, e.g. an immobilized set of particles, a porous plug, a capillary or a membrane, in response to an applied Electric field, which is the result of the force exerted by the applied field on the countercharge ions in the liquid	
60	Electroosmotic velocity, u_{eo}	Uniform velocity of the liquid far from the charged interface	Electroosmotic velocity is expressed in meters per second.
61	Electrophoretic mobility, μ	Electrophoretic velocity per electric field strength	Electrophoretic mobility is positive if the particles move toward lower potential (negative electrode) and negative in the opposite case. Electrophoretic mobility is expressed in meters squared per volt second.
62	Electrophoretic velocity, u_e	Particle velocity during electrophoresis	Electrophoretic velocity is expressed in meters per second.
63	Elimination of fine bubbles	Process for decrease of the concentration index of fine bubbles	
64	Equivalent diameter	Diameter of a sphere that produces a response by a given particle size measurement method that is equivalent to the response produced by the particle being measured	The physical property to which the equivalent diameter refers is indicated using a suitable subscript (see ISO 9276-1:1998). For discrete-particle-counting, light-scattering instruments, an equivalent optical diameter is used. Other material constants like density of the particle are used for the calculation of the equivalent diameter like Stokes diameter or sedimentation equivalent diameter. The material constants, used for the calculation, should be reported additionally.

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			For inertial instruments, the aerodynamic diameter is used. Aerodynamic diameter is the diameter of a sphere of density 1 000 kg m−3 that has the same settling velocity as the irregular particle.
65	Exhaust residual ozone concentration	Ozone concentration (3.1.6) at the outlet of an off-gas ozone treatment unit	
66	Field of view	Area viewed by the imaging probing system	
67	FBD (Fine bubble dispersion)	Liquid which contains fine bubbles	
68	Fine bubble generating system	System which mechanically generates fine bubbles (bubbles less than 100 μm in diameter) using water and air	
69	Fine bubble section	Area to grow plants using fine bubble water	For the purpose of this document, plants grown are lettuces.
70	Fine Bubble Showerhead Device	Device driven by the outer water pressure and applied to discharge fine bubble dispersion in water into the air or water in the form of a spray or shower of water droplets	
71	Fine Bubble Water	Water containing air fine bubbles.	
72	Fine bubble water	Water including fine bubbles and used in plant factories (3.1)	
73	FB (Fine Bubble)	Bubble with a volume equivalent diameter of less than 100 μm	100 μm is also represented as 1×10^{-4} m.
74	Fine Bubble Jet Device	Device that accelerates and releases fluid with fine bubbles, including swirling flow system, ejector system and venture system	
75	Flotation process	Gravity separation process in which gas	Different methods of producing gas

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		bubbles attach to solid particles to cause the apparent density of the bubble-solid agglomerates to be less than that of the water, thereby allowing the agglomerate to float to the surface	bubbles give rise to different types of flotation processes: electrolytic flotation, dispersed air flotation, and dissolved air flotation.
76	Flow path	Passage that conveys fluid	
77	Flow Velocity, u_d	Fuid velocity of ultrafine bubble water in the long winding pipe	
78	Frame	Single static image obtained by a camera in a video recording process	For the purpose of this document, the term "frame" does not include the edge of the field of view.
79	Gas-filled structures/particles dispersed in liquids	Preformed structures/particles with removable cores (templates or water) filled with gases and redispersed in liquids to form the gas-filled fine colloidal dispersions	
	Generated ozone amount	Mass of ozone generated in a unit time	
80	Generated ozone concentration	Ozone concentration (3.1.6) in the gas phase at the outlet of an ozone generator	
81	Germination	Appearance of a sprout of at least 1 mm of length	
82	G (Germination ratio)	Ratio of the seeds observed during inspection to have germinated to the total number of seeds provided for the test	
83	Growth period	Period from sowing of seeds through the final germination observation	
84	Half-life of absorbance	Time required for the change in absorbance to reach 50 % of the initial concentration.	
85	Hard shell	Bubble shell materials that are less permeable to the entrapped gas and can re-stabilize at the gas-liquid interface when the volume diameter of a shelled bubble doubles or halves.	Example: Polymeric or nanoparticle shells.
86	High-pressure water jet	Equipment that forces water out of a small orifice at high speed	

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87	Hybrid shell	Shell materials composed of the combination of organic and inorganic materials	
88	Hydraulic loading rate	Index representing the treatment capacity (3.4) at a limited area, calculated as the ratio of the flowrate to the dissolved air flotation process to the surface area of the dissolved air flotation tank	
89	Hydrodynamic Cavitation	Fine bubble generation method used by physical hydrodynamic structures and pressures	
90	Hydrodynamic diameter	Equivalent diameter of a particle in a liquid having the same diffusion coefficient as a spherical particle with no boundary layer in that liquid	In practice, nanoparticles in solution can be non-spherical, dynamic and solvated. A particle in a liquid will have a boundary layer. This is a thin layer of fluid or adsorbates close to the solid surface, within which shear stresses significantly influence the fluid velocity distribution. The fluid velocity varies from zero at the solid surface to the velocity of free stream flow at a certain distance away from the solid surface.
91	Hydrogen UFB	Hydrogen molecules, dissolved as ultrafine bubble (UFB)	
92	Immersion	Act of immersing unprocessed barley seeds in ultrafine bubble water or control water	
93	Impeller	Spinning disc in a centrifugal pump with protruding vanes, which is used to accelerate the fluid in the pump casing solubility maximum mass of a solute that can be dissolved in a unit volume of solution measured under equilibrium conditions	
94	Inorganic shell	Shell materials composed of colloidal	

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		particles or nanoparticles such as colloidosomes, colloidal crystals, iron oxide nanoparticles and silicon nanoparticles	
95	Insoluble gases in a shelled bubble	Gas that has generally non-affinity with water	Example: Oxygen, hydrogen, sulfur hexafluoride, carbon monoxide or perfluorocarbons.
96	Intermediate precision	Measurement precision under set of intermediate precision conditions of measurement	
97	Light scattering	Change in propagation of light at the interface of two media having different optical properties	
98	Limit of detection, LOD	Lowest amount of an analyte that is detectable with a given confidence level	The limit of detection can be calculated as three times the standard deviation of blank measurement results. This represents a probability of 50 % that the analyte will not be detected when it is present at the concentration of the LOD. The LOD can be used as a threshold value to assert the presence of a substance with a known confidence. The LOD only refers to concentration measurements and not to particle sizing.
99	LOQ (Limit of quantification) or quantification limit	Lowest amount of an analyte that is quantifiable with a given confidence level	The confidence level can be calculated as ten times the standard deviation of blank measurement results. This concept applies to concentration measurements only. The value LOQ can be used as a threshold value to assure quantitative measurement of an

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			analyte accurately.
100	Lipid shell	Shell components composed of the phospholipids	For example, the lipid molecules are phosphatidylcholine (PC), phosphatidylethanolamine (PE), phosphatidic acid (PA) and lysophosphatidic acid (LPA), phosphatidylglycerol (PG). The lipid components also consist of a glycerol molecule, two fatty acids and a phosphate group that is covalently linked with molecules (chloramine, amino acid, etc.) or polymers i.e. polyethylene glycol, etc.
101	Liquid fertilizer	Liquid used as nutrient to grow plants	
102	Liquid medium	Material in liquid phase in which the bubbles are dispersed	
103	Long Winding Pipe	Long plastic pipe with small inner diameter winding on the bobbin to simulate the behavior of the long-distance plastic pipe for practical use	
104	Loss factor, k	Coefficient relating the time derivative of the surviving rate to the surviving rate itself.	In the analysis of the report, the relationship is assumed to be linear and the loss factor, k, is its proportional coefficient.
105	Measurement time	Period for a sequence of measuring process, whereas the size index and/or the number concentration index of the microbubbles can be assumed stable all through the period and reproducible over the periods with similar measurement condition	Measurement time is described by the starting time and the ending time, or by either of them and the duration.
106	Median germination period, T_{50}	Time where the inferred germination ratio marks 50 % of the maximum germination ratio	
107	Method repeatability	Closeness of agreement between multiple measurement results of a given property in	The variability includes those uncertainties due to operator sub

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		different aliquots of a sample, executed by the same operator in the same instrument under identical conditions within a short period of time	sampling technique, any changes in the sampled material together instrument variations.
108	MBD (Microbubble Dispersion)	Liquid which contains microbubbles	
109	Microbubble generating system	System for creating microbubbles in a liquid medium	
110	MB (Microbubble)	Fine bubble with a volume equivalent diameter in the ranges from equal or greater than 1 μm to less than 100 μm	
111	Microfluidic system method	Method by which fine bubbles with a shell of biocompatible materials are produced by an injection device that consists of three components: micro syringe, micropipette, and pipette.	
112	Migration	Directed particle movement (sedimentation or creaming and flotation) due to acting gravitational or centrifugal fields	Sedimentation occurs when the density of droplets or particles is larger than that of the liquid. Creaming and flotation occur when the density of droplets or particles is smaller than that of the liquid. In these two processes, particles move in opposite directions.
113	Migration velocity	Absolute value of sedimentation or creaming and flotation terminal velocity	Velocity of creaming and flotation is indicated by a negative sign.
114	Monolayer shell	Shell consisting of a single continuous layer one molecule or particle thick	
115	Multilayer shell	Shell made up of three or more continuous layers consisting of three or more monolayer shells	
116	Nanomaterial	Material with any external dimension in the nanoscale or having internal structure or surface structure in the nanoscale	See “engineered nanomaterial”, “manufactured nanomaterial” and “incidental nanomaterial” in ISO

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			80004-1 for definitions of certain types of nanomaterial. The nanoform of a material is a nanomaterial.
117	Nanoparticle	Discrete piece of material with all external dimensions in the nanoscale.	If the dimensions differ significantly (typically by more than three times), terms such as "nanofiber" or "nanoplate" are preferred to the term nanoparticle.
118	Non-condensable gas	Air and/or other gases which is not liquefied under the conditions of a Saturated steam	
119	Noncross-linked shell	Shell materials not connected by covalent bonds.	
120	Nozzle	Device driven by water pressure applied from outside that discharges fine bubble water into the air or water through a single columnar pass.	Various types of fine bubble generating technologies such as venturi tube type and ejector type are used as fine bubble nozzles.
121	Nozzle	Structure that accelerates and releases fluid	
122	Number concentration distribution density	Distribution density (frequency) of the particle number concentration represented as a function of the particle size	
123	Number concentration index	Quantity representing the concentration of objects in a fine bubble dispersion measured by an industrially available and agreed method	Fine bubble dispersion in reality often contains not only fine bubbles but also other components with application-specific functions.
124	Number of Circulation, n_p	Number of ultrafine bubble water circulation passing through the transport system. The number is defined by the ratio of the product of flow rate in the long winding pipe with elapsed time of an experiment to volume of long winding pipe.	
125	Off-gas ozone concentration	Ozone concentration at the outlet of an ozone contactor	

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126	Oil cleaning index	Number representing the residual oil removed from the test surface after cleaning	
127	Organic shell	Shell materials composed of organic materials	For example: phospholipids, polymers, proteins, surfactant, etc.
128	Oxygen mass transfer coefficient, $K_{L,a}$	Parameter used to assess rates of oxygen transfer from air to water	Expressed in h^{-1} or min^{-1}.
129	Ozone concentration	Volume, mass or mole of ozone in a unit volume or mass of gas or liquid	
130	Ozone concentration monitor	Instrument capable of measuring ozone concentration in samples continuously	
131	Ozone demand	Amount of ozone consumed to oxidize material in water	
132	Ozone dose	Mass of ozone injected into a unit volume of water	Ozone dose is expressed in units of mass-per-volume concentration (g/m3 or mg/l).
133	Ozone Fine Bubble Water	Water containing ozone fine bubbles.	
134	Particle	Minute piece of matter with defined physical boundaries	A physical boundary can also be described as an interface. This general particle definition applies to nano-objects A particle can move as a unit.
135	Particle counting and sizing method	Particle counting method which allows both the determination of the number of particles and also the classification of the particles according to size	
136	PCM (Particle Counting Method)	Indirect method to count the number of bubbles and its size distribution in a measurement.	Particle Counting Method (PCM) can trace the variation tendency of the BVC index. Effective range of particle counter to measure bubble size is from 1 μm to 100 μm.

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			The sampling flowrate is normally adjusted, and the numbers of bubble are counted in the applied volume of sample.
137	Particle number concentration	Number of particles per unit of volume of suspension	
138	Particle size	Linear dimension of a particle determined by a specified measurement method and under specified measurement conditions	Different methods of analysis are based on the measurement of different physical properties. Independent of the particle property actually measured, the particle size can be reported as a linear dimension, e.g. as an equivalent spherical diameter.
139	Particle size distribution	Distribution of the quantity of particles as a function of particle size	Particle size distribution may be expressed as cumulative distribution or a distribution density (distribution of the fraction of material in a size class, divided by the width of that class). The quantity can be, for example, number, mass or volume based.
140	PTA (Particle tracking analysis)	Method where particles undergoing Brownian and/or gravitational motion in a liquid suspension are illuminated by a laser and the change in position of individual Particles is used to determine their equivalent diameters	Analysis of the time-dependent particle position yields the translational diffusion coefficient and hence the hydrodynamic diameter using the Einstein relationship. Nanoparticle tracking analysis (NTA) is often used to describe PTA. NTA is a subset of PTA, since PTA covers a length range that exceeds the nanoscale.
141	Photosynthetic photon flux density, PPFD	Number of photons per unit of time and area, which are contained in 400 nm – 700 nm of wave length needed for photosynthesis	

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142	Plant factory	Facilities which allow systematic growth and production of plants where the internal environment conditions, e.g. temperature, carbon dioxide, and liquid fertilizer are controlled	
143	PI (Polydispersity index)	Dimensionless measure of the broadness of the size distribution	The PI typically has values less than 0,07 for a monodisperse test sample of spherical particles.
144	Polymer shell	Shell components composed of synthetic polymers or functionalized natural polymers	For example: synthetic polymers are polystyrene (PS), polypropylene (PP), polyvinyl chloride (PVC), polyvinyl alcohol (PVA), polyethylene (PE), polyurethane (PU), polycarbonate (PC), polyethylene terephthalate (PET), polyetheretherketone (PEEK), poly-(lactic-co-glycolic acid) (PLGA), polylactic-co-glycolic acid, poly(ε-caprolactone) (PCL), polylactic Acid (PLA), polyacrylic acid, poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV), poly(butyl cyanoacrylate) (PBCA), poly(n-butyl cyanoacrylate), Pluronic F-68, etc. For example, the natural polymers are dextran, hyaluronic acid, chitosan and cellulose, etc.
145	Porous membrane	Membrane containing pores (voids)	
146	Protein shell	Shell components composed of proteins (albumin, lysozyme, hydrophobin, etc.) or functionalized proteins	
147	Pure Oxygen	Gas containing more than 90 % oxygen	
148	Qualification	Proof with reference material that an instrument is operating in agreement with its specifications	
149	Raw water	Tap water or water with equivalent quality	

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		level provided to produce fine bubble water and used as the control water for the reference	
150	Raw water	Distilled water supplied as a raw material for both UFB water and control water	
151	Recycle ratio	Ratio of the flowrate of recycle water (3.6) to the flowrate of inflow to the dissolved air flotation process	In case of full stream saturation, no recycle water is required
152	Recycle water	Water used to generate fine bubbles required for the dissolved air flotation process among the treated water by the DAF process	
153	RM (Reference material)	Material, sufficiently homogeneous and stable with respect to one or more specified properties, which has been established to be fit for its intended use in a measurement process	
154	RLU (Relative Light Unit)	Unit used for adenosine triphosphate (ATP) luminescence measurement	
155	Reservoir	Vessel for ultrafine bubble water staying almost at rest during the water circulation filled with the water returning back from pipe at its inlet and fed to the gear pump at its outlet, intended to sample ultrafine bubble water for measurement	
156	Residual ozone concentration	Dissolved ozone concentration measured after a given contact time	It is expressed in mg/l.
157	Retention time	Period from the point generating or dispersing microbubbles in the retention container to the detecting point of the measuring instruments	
158	Rise velocity	Velocity of a fine bubble upwards in liquid	
159	Sampling	Sampling of ultrafine bubble water from the reservoir using a pipette and sampling bottle for the measurement of a size index and a number concentration index	

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160	Saturation pressure	Inner pressure of saturator which is used for generating bubble	
161	Scattered intensity	Intensity of the light scattered by the Particles in the scattering volume	
162	Scattering volume	Volume defined by the intersection of the incident laser beam and the scattered light intercepted by the detector	
163	Self-priming	Suction of fluid into flow path without using a mechanism for feeding pressure	
164	Separation zone	Zone where aggregates are separated from the water and become concentrated in a float layer at the top of the tank	
165	Shell interface	Boundary of shell material molecules existing on the outermost surface of the liquid phase in contact with the gas phase	
166	Shell shape	Stable geometric contours of the shell such as spherical or irregular	Shell shape is usually observed by dark field microscopy, transmission electronic microscopy (TEM) and scanning electronic microscopy (SEM).
167	Shell thickness	Length of the shell boundary from gas interface to liquid interface	Shell thickness is usually measured by transmission electronic microscopy (TEM) and/or scanning electronic microscopy (SEM).
168	Shelled bubble	Gas in a liquid/solid medium (hollow particles), completely covered by an appropriate process with a shell made of biocompatible materials (proteins, polysaccharides, or lipids) or inorganic/organic particles at an interface	
169	Shelled bubble number half-life stability	Duration for the number of shelled bubbles to shrink to half under a given temperature and pressure conditions	Shelled bubble number half-life stability is usually determined by particle tracking analysis.
170	Shelled bubble size half-life stability	Duration time for a volume of a shelled bubble to shrink to half under a given temperature and pressure conditions	Shelled bubble size half-life stability is usually characterized by dynamic light scattering (DLS).

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171	Shelled fine bubble	Shelled bubble with a volume equivalent diameter of less than 100 μm	100 μm is also represented as 1×10^{-4} m.
172	Shelled microbubble	Shelled bubble with a volume equivalent diameter of from 1 to 100 μm	
173	Shelled ultrafine bubble	Shelled bubble with a volume equivalent diameter of less than 1 μm	
174	SMD (Simultaneous multispectral detection)	Method where optically scattering objects [such as particles or bubbles] are detected, counted and tracked by means of particle tracking analysis, using light sources of different wavelengths and different powers.	Detection, counting and tracking of objects is performed independently in each spectral regime.
175	Size index	Quantity representing an object size in a fine bubble dispersion measured by an industrially available and agreed method	Fine bubble dispersion in reality often contains not only fine bubbles but also other components with application-specific functions.
176	Soft shell	Bubble shell materials that are more permeable to the entrapped gas and can re-stabilize at the gas-liquid interface when the volume diameter of a shelled bubble doubles or halves.	Example: Lipid, surfactant, and protein shells.
177	Solid Medium	Material in solid phase in which bubbles are dispersed.	A solid medium can be a congealed or chemically immobilized (solidified) liquid which contains bubbles. As a result, bubbles are immobilized or have a restricted degree of mobility.
178	Soluble gases in a shelled bubble	Gas that has affinity with water	Example: Nitric oxide, carbon dioxide, sulfur dioxide, hydrogen sulfide and ozone.
179	Sonication-microfluidics method	Method which consists of two components: a microfluidic device to generate gas-in-liquid slug flow and a sonication device to realize cavitation and the coating of the bubbles.	
180	Stakeholder	Individual or group that has an interest in any decision or activity of an organization	
181	SAE (Standard	mass of oxygen transferred per unit energy	The standard conditions are T:

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	aeration efficiency)	at standard conditions.	293,15 K (20 °C), P: 101,325 KPa (kg-O_2/kW-h).
182	SOTE (Standard Oxygen Transfer Efficiency)	Quantity of the introduced oxygen that dissolves in water under standard conditions.	The standard conditions are T: 293,15 K (20 °C), P: 101,325 KPa (mass %).
183	SOTR (Standard Oxygen Transfer Rate)	Oxygen mass transfer rate at standard conditions.	The standard conditions are T: 293,15 K (20 °C), P: 101,325 KPa (kg-O_2/h).
184	Stokes diameter	Equivalent diameter of a sphere that has the same buoyant density and terminal sedimentation velocity as the real particle in the same liquid under creeping flow conditions	
185	Storage period	Time length when barley seeds are stored under 20 °C	
186	Surfactant	Surface active substance that reduces the surface tension of the solution	
187	Surfactant shell	Shell components composed of span-type surfactants (sorbitan fatty acid esters), and tween-type surfactants (sorbitan polyoxyethylene fatty acid esters)	
187	Surviving Rate, Φ	Ratio of number concentration index of ultrafine bubbles at the entrance of a pipe to that at the end of the pipe. The number concentration index of ultrafine bubbles in the water decreases during the flow through the pump and the winding pipe. The rate is evaluated for a sample taken from a reservoir. The vessel is open to room air and the water level is kept over the inlet and the outlet.	
188	Suspension	Heterogeneous mixture of materials comprising a liquid and a finely dispersed solid material	
189	Sustainability	State of the global goal system, including environmental, social and economic	The environmental, social and economic aspects interact, are

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		aspects, in which the needs of the present are met without compromising the ability of future generations to meet their own needs	interdependent and are often referred to as the three dimensions of sustainability. Sustainability is the goal of sustainable development
190	Sustainable development	Development that meets the present needs of environmental, social and economic aspects without compromising the ability of future generations to meet their own needs	Derived from the Brundtland Report.
191	Systematic classification	Tables and figures where fine bubble technologies are identified and explained from various kinds of viewpoints, such as application fields, effective functions	
192	Terminal rise velocity	Balancing velocity between the buoyancy of fine bubbles and the viscous drag	It is the velocity in the opposite direction to the terminal settling velocity. If a rise velocity were to be defined as the terminal settling velocity, the rise velocity would be negative. Therefore, in the classification of fine bubbles, terminal rise velocity is preferred over terminal settling velocity to avoid confusion.
193	Test gas	Gas mixed in the middle of operating the cavitation unit	
194	Test piece	Hard flooring surface standardized for testing purposes	
195	Test soil	Hard flooring contaminant standardized for testing purposes	
196	Test solution	Solution samples obtained for the analysis of antibacterial activity after operating the test facility	
197	Test water	Either UFB water or control water	
198	Titration	Method or process of determining the concentration of a dissolved substance in	

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		terms of the smallest amount of a reagent of known concentration required to bring about a given effect in reaction with a known volume of the test solution	
199	Total bubble volume	Total volume of air which is used for bubble generation	
200	Total particle count method	Particle counting method in which the total number of particles in a certain sample volume is determined without classification according to size	
201	Track	Path of an object through space	
202	Tracking	Process of obtaining a track in x and y coordinates	
203	Transferred ozone dose	Mass of ozone applied into a unit volume of water	Transferred ozone dose is expressed in units of mass-per-volume concentration (g/m3 or mg/l).
204	Transparent medium	Medium which has a high transmittance of light in a given spectral range	
205	Treatment capacity	Capacity that a certain process can handle for a unit time	
206	UFBD (UFB dispersion)	Liquid which contains ultrafine bubbles	
207	UFB enabled efficiency (P)	Quantity measuring the efficiency of UFB for its enhancement in the germinating period	
208	UFB section	Test beaker containing UFB water for use in germination tests of barley seeds in UFB water	
209	UFBD (Ultrafine bubble dispersion)	Liquid which contains ultrafine bubbles	
210	Ultrafine bubble generating system	System for creating ultrafine bubbles in a liquid medium	

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211	UFB (Ultrafine bubble) generating system)	Equipment that uses water and air to generate ultrafine bubbles by mechanical action	Ultrafine bubbles (UFB) are bubbles with a diameter of less than 1 μm.
212	UFB (Ultrafine bubble) water	Water that includes UFB	
213	UFB (Ultrafine Bubble)	Fine bubble with a volume equivalent diameter of less than 1 μm	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.
214	Ultrasound	High frequency (over 20 kHz) sound waves which propagate through fluids and solids	
215	Validation	Proof with reference material that a measurement procedure is acceptable for all elements of its scope	Evaluation of trueness requires a certified reference material.
216	Venturi tube	Device which consists of a convergent inlet which is conically connected to the cylindrical part called the “throat” and an expanding section called “divergent” with a conical shape	
217	Viscosity, η	Ratio between the applied shear stress and rate of shear of a liquid	It is a measure of the resistance to flow or deformation of a liquid. The term "dynamic viscosity" is also used in a different context to denote a frequency-dependent quantity in which shear stress and shear rate have a sinusoidal time dependence.
218	Volume concentration index	Quantity representing the volume-based concentration of objects in a fine bubble dispersion measured by an industrially available and agreed method	

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219	Volume equivalent diameter, d_{eq}	Diameter of the spherical bubble of equivalent volume $d_{eq}=\sqrt[3]{\frac{6}{\Pi}V_{bubble}}$ where V_{bubble} is the volume of the considered bubble	
220	Water diluent	Homogeneous water which is used for dilution without causing any deleterious effects and whose number concentration of ultrafine bubbles is known	Water diluent is used to decrease the number concentration of ultrafine bubbles in a dispersion without changing their total number, state of aggregation with particles, size or surface chemistry. Water diluent is called blank water when its number concentration of ultrafine bubbles is known to be zero and when it is used for the evaluation of ultrafine bubbles.
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222	Zeta potential of shell	Outer surface of the gas shelled bubble in the core when dispersed in a liquid/solid medium	Zeta potential is often determined by dynamic light scattering (DLS).