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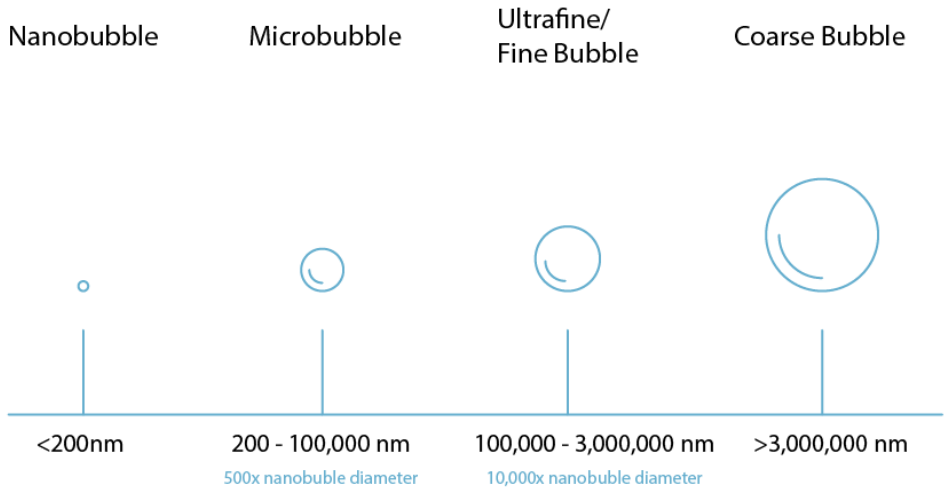
AQUAOX

What are Nanobubbles ?

Nanobubbles are long-lasting gas-containing cavities in aqueous solutions.

Due to their size, nanobubbles exhibit unique properties that improve numerous physio-chemical, physio-mechanical and biological processes



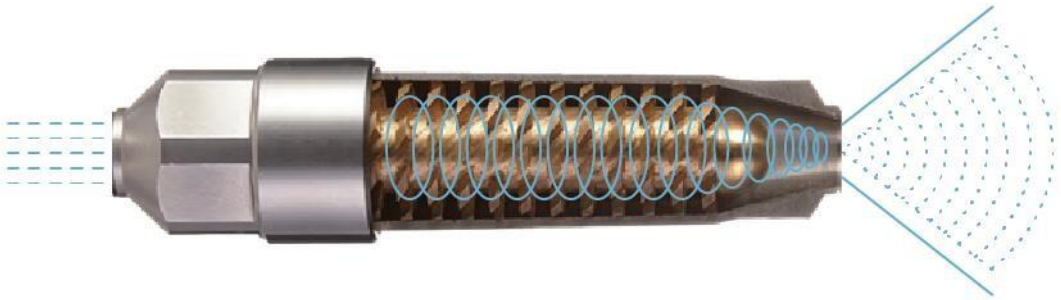
The Aquaox Nanobubble generation method consistently produces high density solutions of optimally sized nanobubbles, averaging 100 nm in diameter and ranging between 50 and 100 nm.

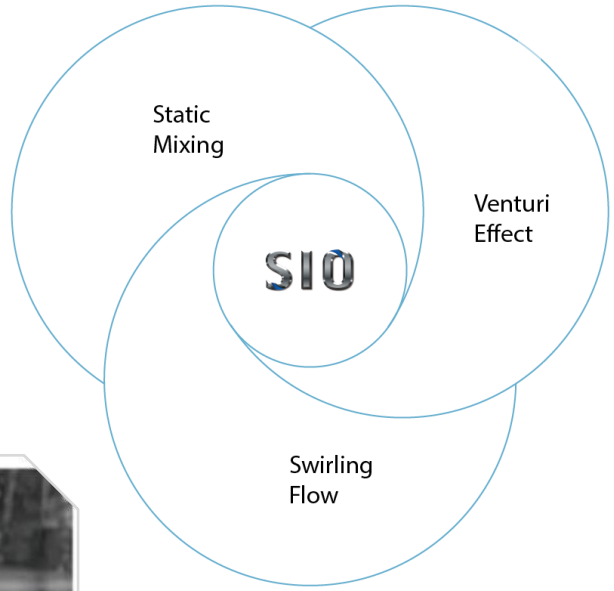
Nanobubbles of this size are stable in liquid because they have reached equilibrium with bubble surface tension, internal pressure, external pressure, surface charge, and their environment.

Their stability and size give them neutral buoyancy and remain suspended until they interact with surfaces or contaminants.

The SIO Advantage

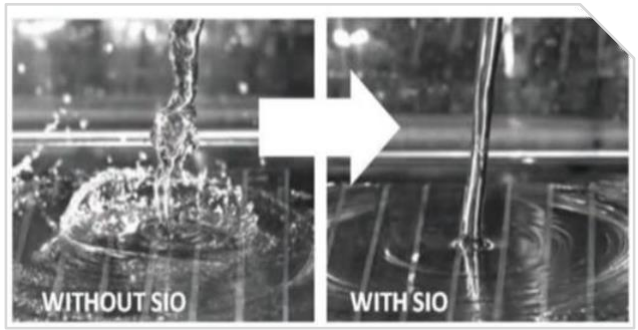
The SIOs unique, patented process of combining the following three fluid mechanic principals contribute to the hydrodynamic cavitation and shearing forces used to produce a high concentration of stable ultra-fine bubbles.





Static Mixing

A method for combining fluid materials which are forced fed over a pattern of mixing elements to generate a homogenous fluid stream.



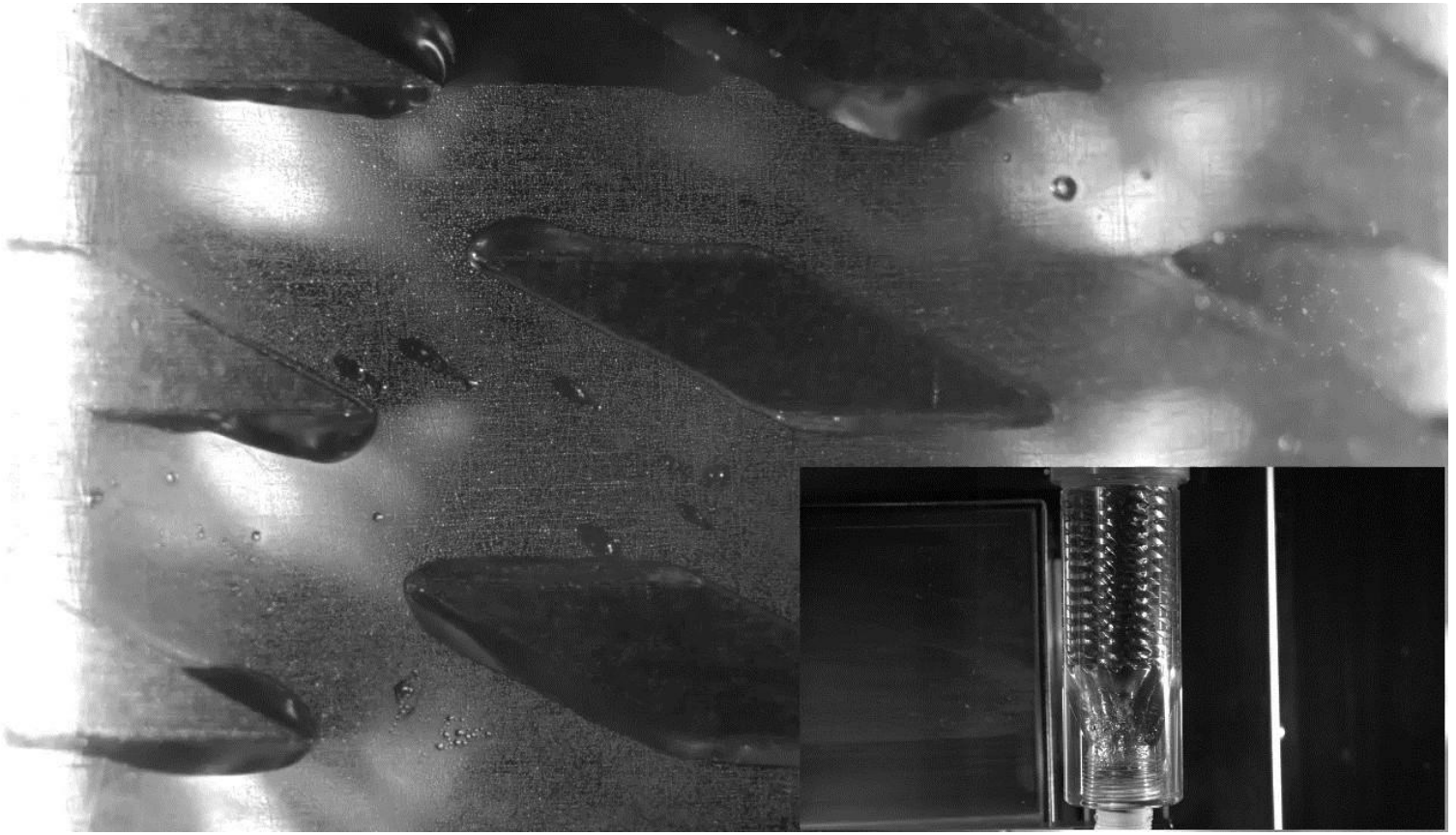
Venturi Effect

The Venturi Effect is the reduction in fluid pressure caused by fluids passing through multiple channels of different widths. At the same time, it induces cavitation which leads to the formation of bubbles.

Swirling Flow

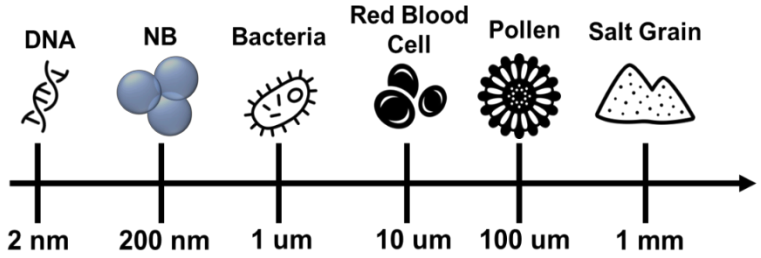
A method in which a swirling flow is generated in the device. The strong centrifugal force of the flow generates fine bubbles due to high smash and shear action of the fluids.

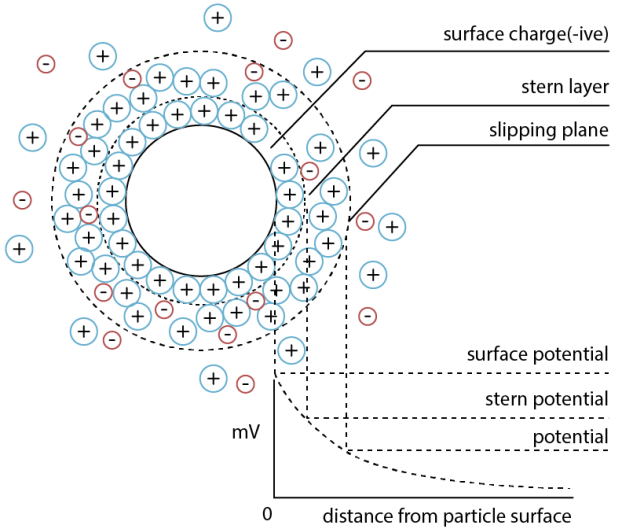
SIO Generation of nanobubbles with a mean particle size between 50-100 nm



The Unique Characteristics of Nanobubbles

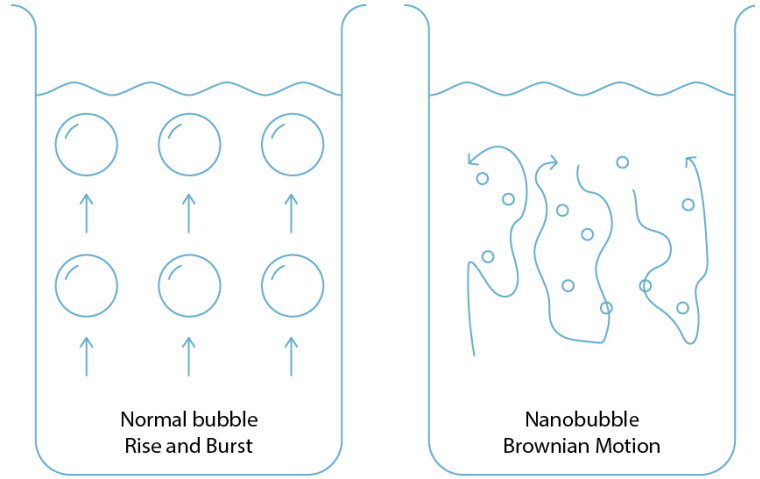
Nanobubbles are one of the smallest known bubble sizes, roughly 2500 times smaller than a single grain of salt, or less than 200 nanometers (nm) in diameter.

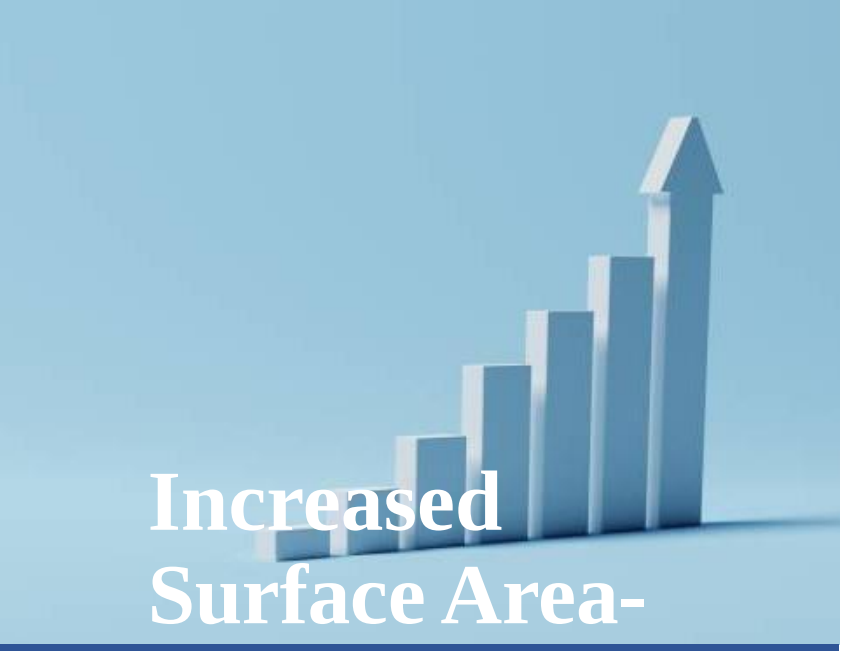




Nanobubbles have a strong negative surface charge that keeps them stable in liquid and enables them to continuously participate in and stimulate physical, biological, and chemical interactions.

Nanobubbles are neutrally buoyant and can remain suspended in liquid for weeks without rising to the surface and off-gassing.



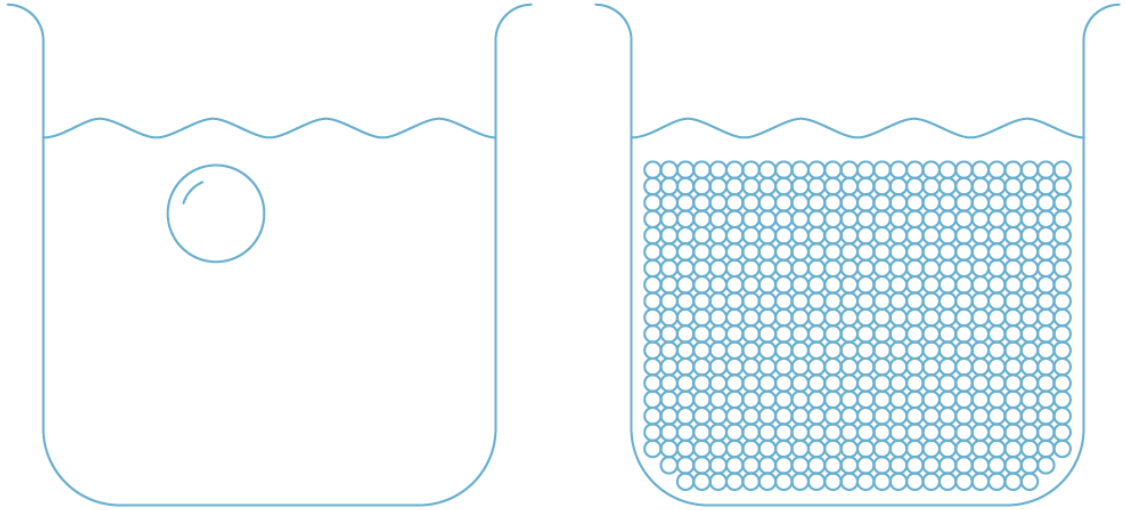


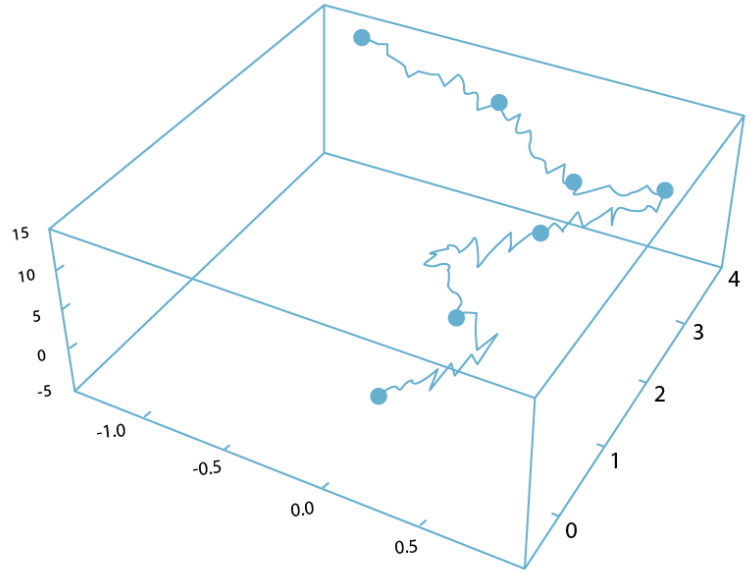
Increased Surface Area-to-Volume Mass

- Creates a stabilized fluid platform for process optimization
- Shortens reaction times
- Improves Heat Exchange efficiency
- Improves chemical conversion efficiency
- Penetrates into organic materials including biofilms
- Drastically reduces pipeline & equipment corrosion

When one square mm of water is filled with nanobubbles, the surface area-to-volume mass increases exponentially as compared to water filled with normal bubbles.

The increase in surface area dramatically enhances aerobic bacteria activities in the liquid and the efficiency of chemical reaction between the supplied gas and liquid ingredients.





Brownian_Motion. Diagram demonstrates a three-dimensional Brownian motion path of a single nanobubble

The Proven Benefits of Nanobubbles

- Higher dissolution efficiency and longer retention time.
- Reduction in surface tension and finer fluid particles.
- Rapid, ultrafine and thorough mixing.
- Higher zeta-potential and colloidal dispersion.
- Reduce chemical applications

Physical Separation of Suspended Particles

Nanobubbles have a strong negative surface charge that prevents them from coalescing and enables them to physically separate small particles and droplets such as emulsified fats, oils, and grease from water

Remove & Prevent Buildup

Nanobubbles effectively prevent and remove unwanted buildup in wet environments. They scrub surfaces in food washing, drip lines, swimming pools, and irrigation pipes, reducing the need for harsh chemicals that can damage pipes and filtration system

Chemical-free Means for Improving Water Quality

When nanobubbles are stimulated, they destabilize and collapse, releasing the hydroxyl radical. The hydroxyl radical (HO) is one of the strongest known oxidizers commonly used to destroy hard to treat and hard to kill contaminants in water.

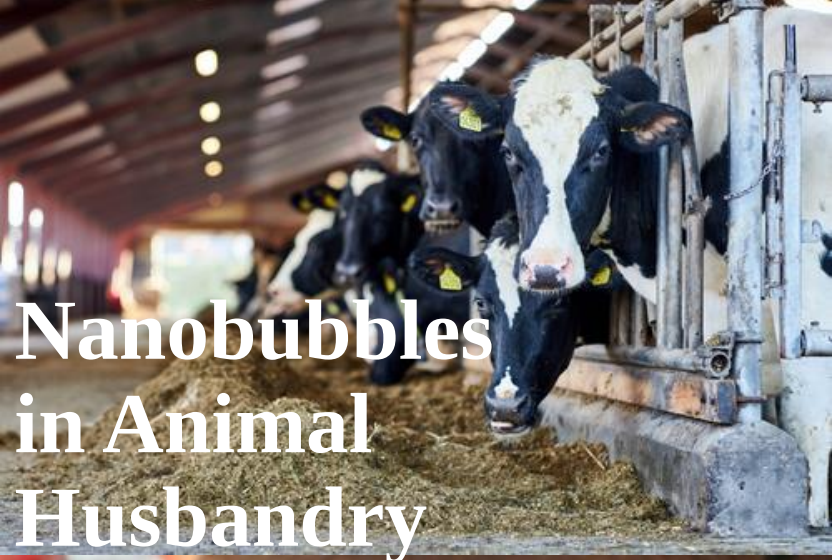
Aeration, Oxygenation & Gas Transfer

Nanobubbles remain suspended & disperse to deliver gas throughout the liquid volume.

TOKYO METROPOLITAN UNIVERSITY

VIRGINIA TECH

FUTURE FOODS LAB
CELLULAR Agriculture Initiative



Nanobubbles in Animal Husbandry

Biofilm Elimination

Nanobubbles have proven highly effective in significantly eliminating microbial biofilms on surfaces. In the context of animal farming, where biofilms can harbor harmful pathogens, this is a crucial advantage.

Increased Sanitizer Delivery

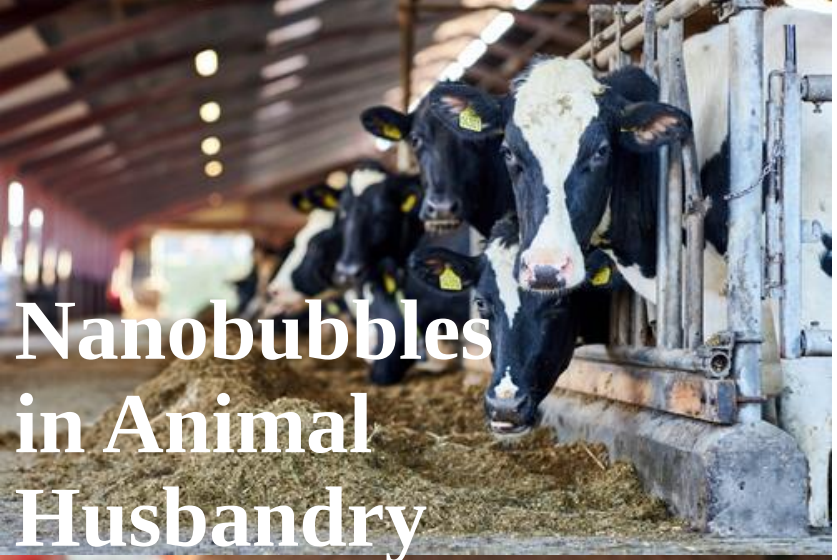
Nanobubbles enhance the delivery of sanitizers to bacteria, ensuring a targeted and efficient approach to microbial elimination

Cost effective and Sustainable

The use of nanobubbles allows for a reduction in the quantity of traditional chemical disinfectants required. This not only contributes to cost savings but also aligns with sustainable and eco-friendly practices.

Water Quality Improvement

Nanobubbles contribute to improved water quality. Ensuring that animals have access to clean and pathogen-free water, further supporting their overall health and well-being.



Nanobubbles in Animal Husbandry

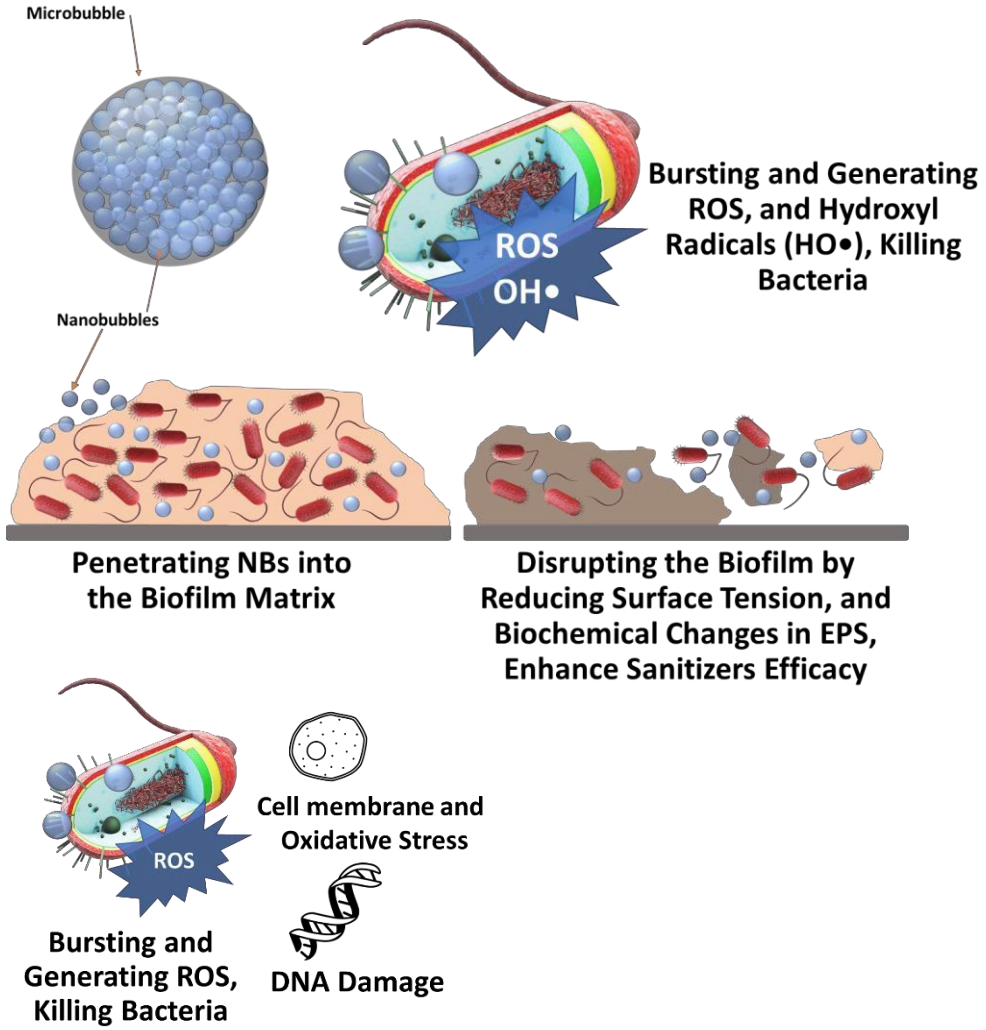
Advantages Nanobubbles in Animal Husbandry

- ✓ Increased Sanitizer Delivery
- ✓ Cost effective and Sustainable
- ✓ Water Quality Improvement
- ✓ Biofilm Elimination
- ✓ Improved animal health
- ✓ Reduced stress levels
- ✓ Faster growth rates

Efficacy of Nanobubbles in Removing Biofilms

Virginia Tech, Department of Food Science and Technology

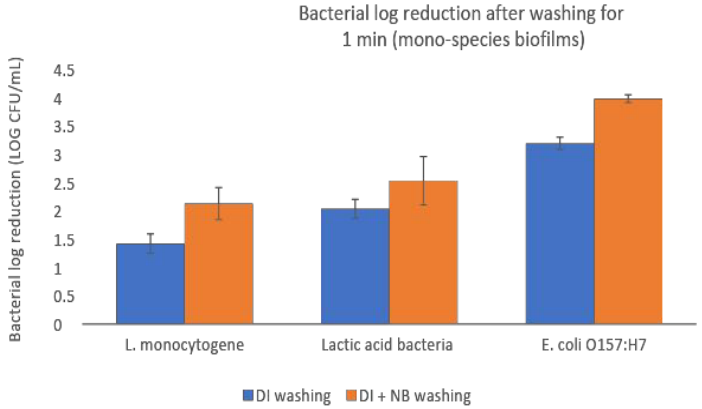
- Nanobubbles can significantly eliminate microbial biofilms on surfaces
- Nanobubbles will burst with Ultrasound and kill the bacteria
- Nanobubbles efficacy will be enhanced in combination with chlorine-based sanitizers
- Nanobubbles bacterial removal efficacy will be improved with shear force
- Nanobubbles can induce microbial injury
- Reduce chemical applications
- Increase sanitizers delivery to bacteria
- Penetrate into biofilms
- Proper for water treatment
- Proper for agricultural water treatment
- Could be used for removing biofilms from pipes
- Membrane sanitation in food industry



Biofilm Remediation

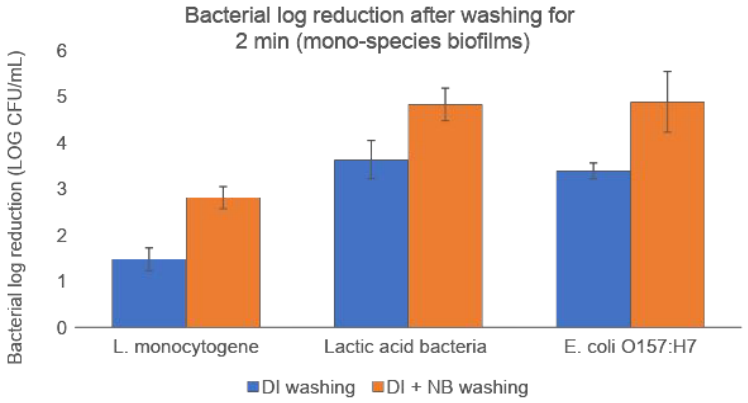
SIO nanobubbles penetrate and physically remove microbial biofilm on surfaces while preventing re-formation.

Study: Reduce Surface Bacterial Contamination with Nanobubbles to Enhance Sanitation in Dairy Processing Facilities



DI water spray (1 min)
- 2.0 log of Lactic acid bacteria
- 1.4 log of L. monocytogenes
- 3.2 log of E. coli 0157:H7

DI + MNBs spray (1 min)
- 2.5 log of Lactic acid bacteria
- 2.1 log of L.monocytogenes
- 4.0 log of E. coli 0157:H7

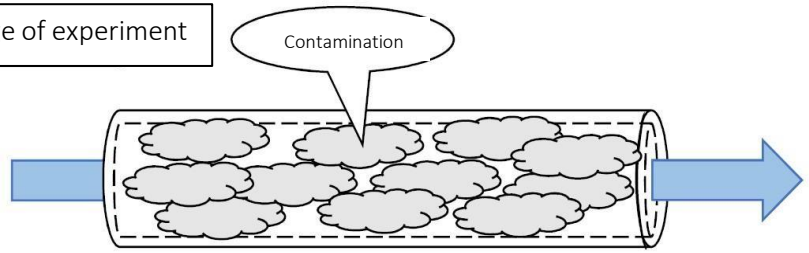


DI water spray (2 min)
- 1.5 log of L. monocytogenes
- 3.6 log of Lactic acid bacteria
- 3.4 log of E. coli 0157:H7

DI + MNBs spray (2 min)
- 2.8 log of L. monocytogenes
- 4.8 log of Lactic acid bacteria
- 4.9 log of E. coli 0157:H7

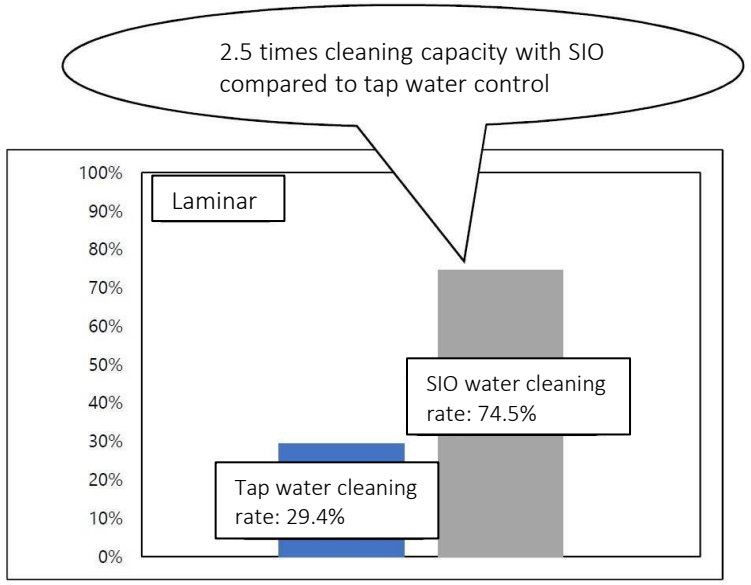
SIO Cleaning Process Trial
Tokyo Metropolitan University

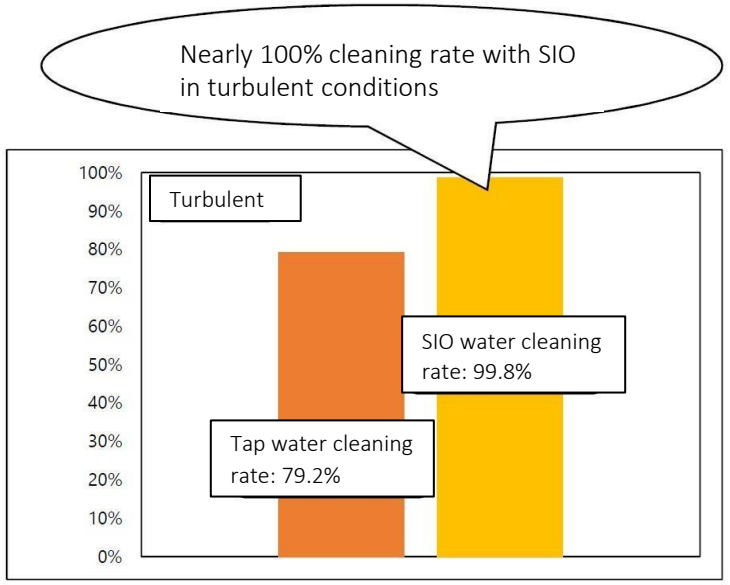
Image of experiment



Contamination was applied to the inside of the pipe and tap water and SIO Nanobubbles water were passed through it. The cleaning rate was calculated by measuring the mass before and after the water flow.

The SIO Nanobubbles water demonstrated higher cleaning ability in both laminar flow and turbulent flow conditions.





- SIO nanobubble water was created in a batch tank by running water through an SIO MS 25 unit at a flow rate of 23 LPM and pressure of 2 bar prior to applying to dirty piping.
- Reynold's number of laminar flow and turbulent flow were 1500 and 7000 respectfully during cleaning process.

Sustainable Applications

AGRICULTURE & HORTICULTURE

Heathier, higher yield crops using less chemicals.

AQUACULTURE

Reduced operational costs. Improved fish & ecosystem health.

BIOSCIENCE

Increased efficiency in drug delivery and treatment.

CEMENT

Increase compression and tensile strength. Shorter setting times.

CLEANING

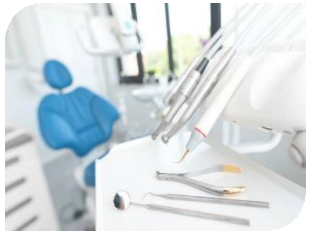
Reduces amount of water and cleaning detergent needed. Reduces labor.

CLEAN IN PLACE

Reduction in chemical use. Energy savings. Reduction in time

COOLING TOWERS

Increase heat transfer & energy efficiency. Mitigate biofilm and eliminate odors



DENTAL

Prevent biofilm and other microbial contamination of dental unit water.

LAKES & PONDS

Algae mitigation, Healthier fish, less odor.

LIVESTOCK

Improved animal health, reduced stress levels, faster growth rates.

PRECISION MACHINING

Machines run faster ,increased tool life and heat transfer

WASTEWATER

Improved biological and chemical oxidation processes. Enhances physical separation

Thank You For Your Interest !

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