SIO Nanobubbles Q & A

Q. What are Nanobubbles?

A. Nanobubbles are nanoscopic gaseous cavities in aqueous solutions that have the ability to change and improve the normal characteristics of water.

SIO generates nanobubbles with a mean particle size between 50-120nm. Nanobubbles of this size are stable in liquid because they have reached equilibrium with bubble surface tension, internal pressure, external pressure and their surface charge. Their stability and size give them neutral buoyancy and they can remain suspended in liquids for an extended period of time without rising to the surface and off-gassing.

The longevity factor of nanobubbles in water increases residence time of oxygen in the water. When nanobubbles are stimulated, they destabilize and collapse, releasing the hydroxyl radical which is one of the strongest known oxidizers to kill contaminants in water.

Nanobubbles have a strong negative surface charge that keeps them stable in liquid and enables them to randomly drift owing to what is termed, Brownian Motion to continuously participate in and stimulate physical, biological, and chemical interactions. It also enables them to physically separate small particles and droplets like emulsified fats, oils, and grease from water.

Q. How does the SIO processor create Ultra-fine bubbles?

A. The SIO patented processor combines three types of generation methods to produce Ultra-fine bubbles.

Static Mixing	A method for combining fluid materials which are forced feed 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.

Q. Does the SIO processor require external gasses to create nanobubbles?

A. No. Our system's geometry produces vapor-filled cavities in liquids without the need for any external gasses.

Q. Can external gasses such as oxygen, nitrogen and ozone be injected into nanobubbles?

Yes. Our gas injection model efficiently mixes and dissolve gaseous products and generates gas rich nanobubbles.

Q. What are SIO Mean and Mode bubble size?

A. It depends on many conditions and parameters such as fluid type, flow, pressure, temperature, etc. so we cannot say a certain size each time. However, and average Nanosight[(1)] measurement on SIO nanobubbles in pure water are as follows:
Mean: 106 nm
Mode: 82 nm
Bubble concentration: 2.74e+09 bubbles/ml (2.74 billion bubbles/ml)

Q. Why is the Zeta Potential important for nanobubbles?

The electrical properties of gas bubbles are important in determining the interaction of nanobubbles and how they interact with other materials such as solid particles or oil droplets. Knowledge about this helps application development in fields such as , protein skimmers, froth flotation, food processing, washing surfaces and purification.

Q. What is Zeta Potential?

The Zeta Potential is a scale of measurement for determining the degree of repulsion between adjacent, similarly charged, particles in a solution and its measurement is particularly relevant to colloidal (nanoparticle) dispersions. It is a useful indicator for understanding the state of the nanoparticle surface charge and as such, in predicting the long-term stability of such dispersions. A high zeta potential will confer stability, i.e., the suspension or dispersion will resist agglomeration. When the potential is low the dispersion will coagulate (i.e. aggregate).

Examples of Zeta Potential in practice and applications

- **Horticulture and agriculture**
  A high zeta potential delivers stable solutions to plant roots which can easily absorb nutrients. A nutrient solution for plants with a low zeta potential shows clustered nutrients which are less accessible for plant roots.
- **Lake and pond remediation**
  Probiotic bacteria are an important component for wastewater cleaning, lake and pond remediation and septic tank cleaning. Probiotic bacteria is aerobic and they require oxygen as an energy source and the more oxygen the better. A probiotic bacteria is sized between 200 nm to 10,000 nm compared to an average SIO nano bubble between 50 to 120 nm. The probiotic bacteria accumulate nutrients from the environment by diffusion. A high oxygen concentration in the water with a high zeta potential helps these positive bacteria to thrive. With a high zeta potential, the nutrients for the probiotic bacteria are well dispersed through the solution and makes them easily accessible. When the water solution has a low zeta potential nutrients are clustered, less accessible and it will take more time for the probiotic bacteria to clean up a body of water.
- **Water treatment**
  In water treatment, system monitoring of the Zeta potential gives an indication for the amount of chemicals or nanobubbles that need to be dosed.

- **Biofilm and bio-fouling**
  The increase in zeta potential of tubes and pipes eliminates bio-film and bio-fouling of membranes and extends filter life.
- **Sludge**
  Stabilize clay and other particles in water, reducing the tendency for aggregation so they do not settle as soft-sludge.
- **Free Radicals**
  When nanobubbles are compressed at high concentrations, the zeta potential will increase during compression and the ion concentration around the bubbles increases. After several minutes of compression, so many access ions are formed that free radicals are created.

Q. What is Bubble Surface Area?

A. Surface area is a fundamental parameter that directly impacts the performance characteristics of any suspensions. The smaller the material, the greater the surface area and surface-to-volume ratio per given mass of material. It is one of the reasons why catalysts perform as they do.

Surface area is a very important concept in water treatment and water use. With air bubbles, it strongly influences the rate at which oxygen diffuses from air into water; the greater the surface area, the faster oxygen can move through the surface.

The SIO nanobubbles processor produces an exponentially increased surface area-to-volume ratio per mass as compared to water containing normal bubbles.

This substantial increase in the interface between air and water provides a much greater contact area for better water sterilization. It impacts the efficiency of chemical reaction with any dissolved or suspended components in the water and enhances aerobic bacterial activity.

Q. What is Brownian Motion?

Brownian motion is the random motion of particles suspended in a medium (a liquid or a gas). This pattern of motion typically consists of random fluctuations in a particle's position inside a fluid sub-domain, followed by a relocation to another sub-domain. Each relocation is followed by more fluctuations within the new closed volume.

Q. What is a Colloid/Colloidal Dispersion

A. A colloid is a mixture in which one substance of microscopically dispersed insoluble particles are suspended throughout another substance. The term colloidal suspension refers unambiguously to the overall mixture.

The SIO processor produces a high concentration of nano size bubbles. These “colloidal particles” exhibits all the characteristics of a colloidal dispersion and will influence the nature and extent of any interfacial behavior of that water.

Q. What is the Young–Laplace equation?

A. The Young–Laplace (Y–L) equation describes the difference between inside pressure and outside pressure of a spherical bubble due to surface tension.

Q. What are Hydroxyl Radicals?

A. The Hydroxyl Radical (HO) is a three-electron reduction product of molecular oxygen. It is the most reactive species of oxygen and one of the strongest known oxidizers commonly used to destroy hard to treat and hard to kill contaminants in water.

SIO nanobubbles produce hydroxyl radicals and provide a chemical-free means for improving water quality. It destroys or inactivates pathogens such as bacteria and viruses.

Q. What is DO (Dissolved Oxygen)?

Dissolved Oxygen is the amount of oxygen that is present in water.

Q. What happens to nanobubbles in hot water?

A. Conventional methods of generating fine bubbles normally involves dissolving the gas under pressure and later releasing the bubbles. At higher temperatures you cannot dissolve as much gas and therefore less numbers of bubbles. Also, higher temperatures mean higher kinetic energy, larger bubbles which break more quickly and shorter retention times.

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1. **NanoSight** is a UK company that designs and manufactures instruments for the scientific analysis of nanoparticles that are between approximately ten nanometers (nm) and one micron (µm) in diameter.