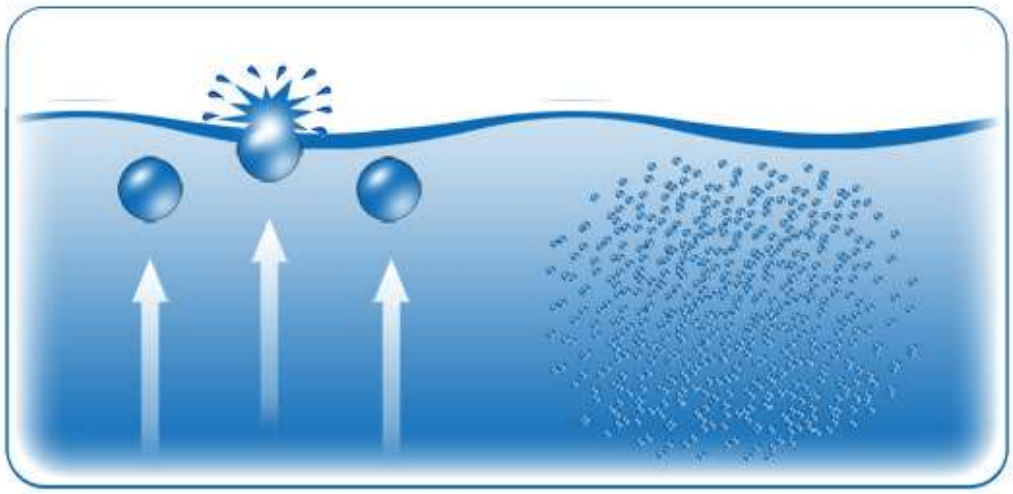
NINURTA

HYPOCHLOROUS ACID NANOTECHNOLOGY

What are Nanobubbles ?

Nanobubbles are nanoscopic gaseous (typically air) cavities - ten thousand times smaller than a human hair - in aqueous solutions that have the ability to change the normal characteristics of water. Ordinary bubbles have a diameter which range from 1 µm and larger. These quickly rise to the surface of a liquid and collapse. Nanobubbles which are <100 nm in diameter will randomly drift owing to what is termed, Brownian Motion and can remain in liquids for an extended period of time.



How is electrochemically generated Hypochlorous Acid different?

Water that is processed through the Ninurta generator creates a dispersion of paramagnetic chlorine-oxygen nanobubbles, the presence of which gives the water highly functional properties that are not found in "normal" water. It is these characteristics that give *electrochemically generated* Hypochlorous Acid its unique properties that make it extremely effective.

Bubble Stability & Longevity

Based on the Young–Laplace equation, bubbles grow or shrink by diffusion based on whether the surrounding solution is over or under-saturated with gas relative to the cavities pressure. Since the solubility of gas is proportional to the gas pressure and this pressure is exerted by the surface tension in inverse proportion to the diameter of the bubble, the normal tendency is for bubbles to shrink in size and dissolve in a few microseconds. However, nanobubbles are observed in water for days.

The stability of nanobubbles is not well understood but is thought to be a balance of the van der Waal's force of attraction and the electric double-layer force of repulsion between neighboring nanobubbles, with additional contributions from the virtual disappearance of buoyant force, bridging nanobubbles, entropic restriction, and fluid structuring.

The longevity factor of nanobubbles in water increases residence time of oxygen in the water and in doing so, directly impacts any type of aerobic or anaerobic interaction with viruses and bacteria.

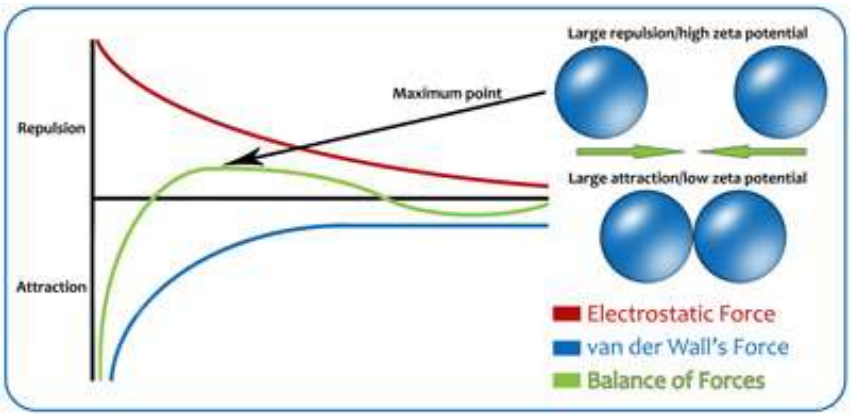


Diagram showing how the balance of energy forces affects the stability of Colloidal (nanoparticle) suspensions.

What is Zeta Potential?

Zeta Potential is a measure of the electrical force that exists between atoms, molecules, particles, and cells in a fluid. Zeta potential's strength determines the amount of material (nutrients, wastes) that fluids such as your blood and lymph can carry. In this way, more nutrients can be carried throughout your body and accumulated deposits of waste can be removed.

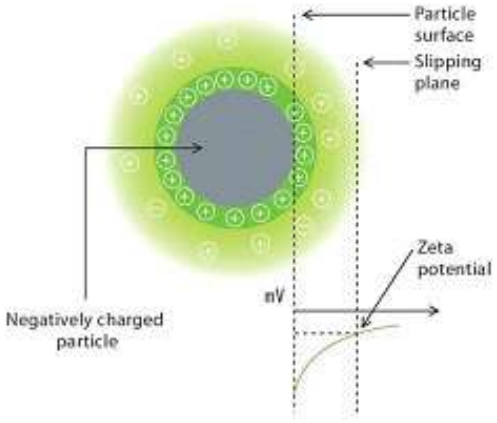


Diagram showing the ionic concentration and potential difference as a function of distance from the charged surface of a particle suspended in a dispersion medium.

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What is a Colloidal Dispersion?

A colloid is any particle, droplet or bubble having a diameter between 1 and 1000 nanometers. A colloidal dispersion is a system in which colloidal species are dispersed in a continuous phase of different composition or state.

Ninurta Hypochlorous Acid solution contains a high concentration – 50,000,000> per 1 ml (1 cubic centimeter) - of nano size bubbles of chlorine-oxygen in the treated water. These "colloidal particles" exhibits all the characteristic of a colloidal dispersion and will influence the nature and extent of any interfacial behavior of that bulk water.

The Surface Chemistry of Suspensions

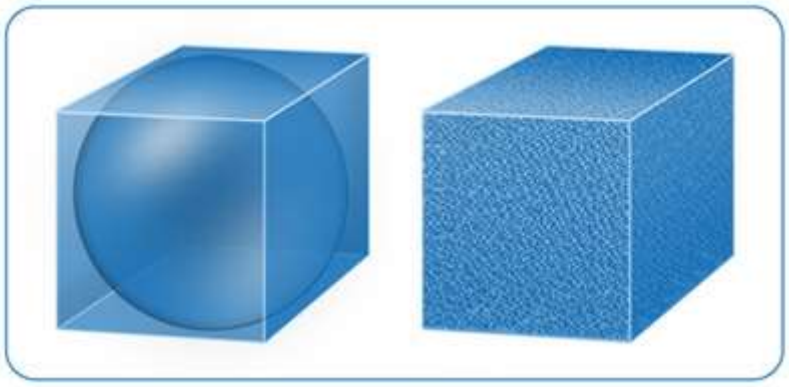
All particles have a "surface charge" in water. Just like "surface area", it is a fundamental parameter that directly impacts the performance characteristics of any suspension such as surface chemical activity. Surface charge effects are normally negligible for massive solids but they become dominant in the description of colloidal (nanoparticle) behavior.

Air bubbles in water are negatively charged. The high concentration of negatively charged paramagnetic chlorine-oxygen nanobubbles has two effects on particles suspended in water. First, it alters the ionic equilibria of any dissolved ionic species in a solution and second, it changes the net charge on a particle surface, both of which directly impact the stability (and ultimate processability) of the particle suspension.

What is Bubble Surface Area?

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 chlorine-oxygen diffuses from air into water; the greater the surface area, the faster chlorine-oxygen can move through the surface.



Ninurta Hypochlorous Acid solution contains an exponentially increased surface area-to-volume ratio per mass as compared to containing normal bubbles – more than 50,000,000 nanobubbles per 1 ml (1 cubic centimeter) of water.

As the particle size is reduced, the surface area-to-volume ratio per given mass increases – an essential characteristic to all colloidal (nanoparticulate) dispersions.

This substantial increase in the interface provides a much greater contact area and more effective transport system of vitamins and minerals throughout the intestinal tract. It impacts the efficiency of chemical reaction with any dissolved or suspended components in the water and enhances aerobic bacterial activity.

The combination of nanobubble technology with HOCl has a number of benefits, including:

Increased disinfection power: Nanobubbles can carry HOCl molecules deeper into surfaces and objects, which can help to kill more pathogens.
Improved contact time: Nanobubbles can increase the contact time between HOCl and pathogens, which can also help to kill more pathogens.
Reduced toxicity: Nanobubbles can help to reduce the toxicity of HOCl, which makes it safer to use in food processing and other applications.
Enhanced penetration: Nanobubbles can enhance the penetration of HOCl into porous materials, which can help to kill pathogens that are difficult to reach.

Studies with same or similar conclusions

Multiple studies confirm the efficacy of nanobubble-based HOCl in killing a wide range of pathogens. They also suggest that nanobubble-based HOCl has potential applications in a variety of settings, including food processing, healthcare, and air purification.

One study that investigated the benefits of combining nanobubble technology with HOCl was published in the journal Food Control in 2016. The study found that nanobubble-based HOCl was able to kill 99.99% of Salmonella on chicken skin in just 1 minute. This is a significant improvement over the disinfection time of HOCl alone, which is typically around 3 minutes.

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The study published in Applied Microbiology and Biotechnology in 2018 concluded that nanobubble-based HOCl was effective in killing 99.99% of Listeria on lettuce in just 30 seconds. This is again a significant improvement over the disinfection time of HOCl alone, which is typically around 1 minute.

The study published in Water Research in 2019 concluded that nanobubble-based HOCl was effective in killing a wide range of waterborne pathogens, including Salmonella, Shigella, and Giardia. The study also found that nanobubble-based HOCl was more effective than traditional disinfection methods, such as chlorine and UV radiation.

The study published in Journal of Oral Microbiology in 2020 concluded that nanobubble-based HOCl was effective in killing oral bacteria that can cause infections. The study also

found that nanobubble-based HOCl was safe to use in the mouth and did not cause any adverse side effects.

These are just a few of the many studies that have been conducted on the benefits of combining nanobubble technology with HOCl. The results of these studies suggest that nanobubble-based HOCl is a promising new technology that could be used to disinfect surfaces and objects in a variety of settings, including food processing, water treatment, and healthcare.

Sources*:

"A Comparative Study on the Efficacy of Hypochlorous Acid and Nanobubble-Mediated Hypochlorous Acid for the Disinfection of Food Contact Surfaces" (Food Science and Technology, 2018)

"Nanobubble-Mediated Hypochlorous Acid as a Potential Treatment for Wounds" (Journal of Wound Care, 2020)

"Nanobubble-Based Hypochlorous Acid for the Disinfection of Air" (Aerosol Science and Technology, 2021)

**not a complete source-list*