# Hypochlorous Acid (HOCl) - Research

This is the disinfectant produced by the
**Disinfection Systems of Pristine Water®**

This document contains a selection of a few references to published papers and technical literature that have studied the usefulness and efficacy of Hypochlorous solution in various applications.

## Common Names for Hypochlorous Acid Solutions are:

- Electrolytically Generated Hypochlorous Acid
- Neutral Electrolyzed Water (NEW)
- Electrolyzed Oxidizing Water (EOW)
- Electro-chemically Activated Water (ECA)
- Super-oxidized water (SOW)

## Guide to Minimize Microbial Food Safety Hazards

FDA Source: Click Here

The FDA has recognized the antimicrobial activity of hypochlorous acid in its *Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables* published in February of 2008.

## Control of Microbial Hazards on Fresh and Fresh-Cut Produce

FDA Source: Click Here

Hypochlorous acid (HOCl) is the form of free available chlorine that has the highest bactericidal activity against a broad range of microorganisms. In aqueous solutions, the equilibrium between hypochlorous acid (HOCl) and the hypochlorite ion (OCl-) is pH dependent with the concentration of HOCl increasing as pH decreases.

## Evaluation of Liquid- and Fog-Based Application of Sterilox Hypochlorous Acid Solution for Surface Inactivation of Human Norovirus

Source: Click Here

Noroviruses (NVs) are the most frequent cause of outbreaks of gastroenteritis in common settings, with surface-mediated transfer via contact with fecally contaminated surfaces implicated in exposure. NVs are environmentally stable and persistent and have a low infectious dose. Several disinfectants have been evaluated for efficacy to control viruses on surfaces, but the toxicity and potential damage to treated materials limits their applicability. Sterilox hypochlorous acid (HOCl) solution (HAS) has shown broad-spectrum antimicrobial activity while being suitable for general use. The objectives of this study were to evaluate the efficacy of HAS to reduce NV both in aqueous suspensions and on inanimate carriers. HOCl was further tested as a fog to decontaminate large spaces. HOCl effectiveness was evaluated using nonculturable human NV

Pristine Water®
B234, Okhla industrial Area, Phase 1, New Delhi 110020
www.pristinewater.in ; disinfection@pristinewater.in
Ph: +91 11 40550731 ; + 91 11 26811710 ; +91 7290004257

measured by reverse transcriptase PCR (RT-PCR) and two surrogate viruses, coliphage MS2 and murine NV, that were detected by both infectivity and RT-PCR. Exposing virus-contaminated carriers of ceramic tile (porous) and stainless steel (nonporous) to 20 to 200 ppm of HOCl solution resulted in>99.9% (>3 log10) reductions of both infectivity and RNA titers of tested viruses within 10 min of exposure time. HOCl fogged in a confined space reduced the infectivity and RNA titers of NV, murine NV, and MS2 on these carriers by at least 99.9% (3 log10),regardless of carrier location and orientation. We conclude that HOCl solution as a liquid or fog is likely to be effective in disinfecting common settings to reduce NV exposures and thereby control virus spread via fomites.

## Evaluation of Electrolytically-Generated Hypochlorous Acid ('Electrolyzed Water') for Sanitation of Meat and Meat-Contact Surfaces

Source: Click Here

'Electrolyzed water' generators are readily available in the food industry as a renewable source of hypochlorous acid that eliminates the need for workers to handle hazardous hypochlorite concentrates. We applied electrolyzed water (EW) directly to multi-strain cocktails of *Listeria monocytogenes, E. coli* O157:H7, and *Salmonella* sp. at 250 ppm free available chlorine (FAC) and achieved greater than 6-log reductions in 2 min. Lower EW values were examined as antimicrobial interventions for fresh meat (beef carcasses), processed meats (frankfurters), and food contact surfaces (slicing blades). Little or no reduction relative to controls was observed when generic *E. coli*-inoculated beef carcasses or *L. monocytogenes*-inoculated frankfurters were showered with EW. Spray application of EW (25 and 250-ppm FAC) onto *L. monocytogenes*-inoculated slicing blades showed that greater reductions were obtained with 'clean' (3.6 and 5.7-log reduction) *vs.* 'dirty' (0.6 and 3.3-log reduction) slicing blades, respectively. Trials with *L. monocytogenes*-inoculated protein-EW solutions demonstrated that protein content as low as 0.1% is capable of eliminating FAC, reducing antimicrobial activity against *L. monocytogenes*. EW appears better positioned as a surface sanitizer with minimal organic material that can otherwise act as an effective reducing agent to the oxidizing solution rendering it ineffective.

## Guideline for Disinfection and Sterilization in Healthcare Facilities

CDC Source: Click Here

The CDC recognizes electrolyzed water, also called "superoxidized water", and the microbiocidal activity of hypochlorous acid (HOCl) in its guidelines for disinfection and sterilization in healthcare facilities.
The microbicidal activity of chlorine is attributed largely to undissociated hypochlorous acid (HOCl).
The microbicidal activity of a new disinfectant, "superoxidized water," has been examined The concept of electrolyzing saline to create a disinfectant or antiseptics is appealing because the basic materials of saline and electricity are inexpensive and the end product (i.e., water) does not damage the environment. The main products of this water are hypochlorous acid (e.g., at a concentration of about 144 mg/L) and chlorine. As with any germicide, the antimicrobial activity of superoxidized water is strongly affected by the concentration of the active ingredient (available free chlorine) 536. One manufacturer generates the disinfectant at the point of use by passing a saline solution over coated titanium electrodes at 9 amps. The product generated has a pH of 5.0-6.5 and an oxidation-reduction potential (redox) of >950 mV. Although superoxidized water is intended to be generated fresh at the point of use, when tested under clean conditions the disinfectant was effective within 5 minutes when 48 hours old.

In October 2002, the FDA cleared superoxidized water as a high-level disinfectant.
"Superoxidized water" has been tested against bacteria, mycobacteria, viruses, fungi, and spores. Freshly generated superoxidized water is rapidly effective (<2 minutes) in achieving a 5-log10 reduction of pathogenic microorganisms (i.e., M. tuberculosis, M. chelonae, poliovirus, HIV, multidrugresistant S. aureus, E. coli,

Candida albicans, Enterococcus faecalis, P. aeruginosa) in the absence of organic loading. However, the biocidal activity of this disinfectant decreased substantially in the presence of organic material (e.g., 5% horse serum) 537, 549, 550. No bacteria or viruses were detected on artificially contaminated endoscopes after a 5-minute exposure to superoxidized water 551 and HBV-DNA was not detected from any endoscope experimentally contaminated with HBV-positive mixed sera after a disinfectant exposure time of 7 minutes.

## Hypochlorous Acid as a Topical Antimicrobial Wound Healing Agent

By Prof Benedetta Allegranzi, MD, DTM&H Coordinator, a.i. Infection Prevention and Control Global Unit, World health Organisation
Source: Click Here

Professor Bongiovanni concludes: "Perhaps the greatest advance in VLU[venous leg ulcer]care is the addition of HCA[hypochlorous acid]to the treatment armamentarium. These aqueous solutions of hypochlorous acid, even in trace amounts, will kill most pathogens within 30 s of exposure. Additional actions of HCA include reduction of mast cell degranulation and active capillary dilation. The latter effect is of great importance in the diabetic VLU patient since one of the paradoxes in diabetes is the reduction of capillary perfusion via arteriovenous shunting at the microcirculatory level. The capillary dilation in turn elevates the tcpO2 within the wound. We have observed that this improvement in periwound tissue oxygen concentration and perfusion can be persistent to 72h following exposure to the HCA."1The 2016 International Wound Infection Institute (IWII) Consensus Guidelines published in the Journal Wound were supported by an educational grant from IWII and sponsored by a number of commercial organisational which did not include a manufacturer of NEW. 2 These consensus guidelines note that NEW (super-oxidised solution with hypochlorous acid) is the only wound care solution and hydrogel that penetrates biofilm and kills microbes from within while not promoting antimicrobial resistance.

## Status Report on Topical Hypochlorous Acid

Source: Click Here

Hypochlorous acid (HOCl), a naturally occurring molecule that is a component of the human innate immune response, is recognized as a major active component of bleach and demonstrates antimicrobial properties supported by both *in-vitro* and *in-vivo* studies.1–9 One important function of HOCl in host immunity is its release by neutrophils to destroy pathogenic organisms (i.e., respiratory burst). Over time, a variety of anti-inflammatory and other biologic properties of HOCl have led to applications for wound healing, pruritus, and diabetic ulcers, as well as applications for the management of some inflammatory skin disorders, such as seborrheic dermatitis and atopic dermatitis (AD).8–18

## The science of chlorine-based disinfectant

Source: Click Here

Hypochlorous acid (HOCL) is the most effective disinfectant in the chlorine family available in dilute solution. It is suggested that HOCL is 80 to 120 times more efficacious than sodium hypochlorite.[5] Because HOCL has no charge and has a relatively low molecular weight it is better able than the other chlorine based disinfectants to penetrate the cell walls. It also reacts more rapidly than other chlorine-based disinfectants to oxidation reactions with organic matter, i.e. the critical components of microbial cells. Conversely the hypochlorite ion is a relatively poor disinfectant because of its inability to diffuse through the cell wall. Since it is negatively charged it is electrostatically repelled from the cell walls, which are also negatively charged. It is much larger in size than an HOCL molecule so it also diffuses more slowly due to its larger size.

## Hypochlorous Acid: Harnessing an Innate Response

Source: Click Here

- Stabilized hypochlorous acid (HOCl) is rapidly emerging as an exceptionally effective environmental disinfectant. This development seems especially fitting amidst growing concerns about eco-persistence of synthetic chemicals, and antimicrobial resistance trends amongst newly resurgent agents of disease (Choffnes, Relman, and Mack, 2010; Coates, 2012; Gualerzi, Brandi, Fabbretti and Pon, 2014; Ventola, 2015).
- HOCl is considered by the FDA to be "the form of free available chlorine that has the highest bactericidal activity against a broad range of microorganisms" (US FDA, 2015)
- HOCl has no toxic material disposal requirements, and is not considered by OSHA to be hazardous waste adding yet another advantageous element to HOCl use (OSHA Hazard Communication Standard).
- The fields of environmental hygiene, disinfection, food safety, and sanitation are now likely to benefit from HOCl as an untapped resource in infection control.
- Over the last two decades more than one hundred reports have appeared in the literature documenting HOCl performance in horticulture, dairy facilities, animal production housing, extended care institutions and hospitals, making a strong case for HOCl as an attractive option for reliable, safe, high-level disinfection within institutional settings (Al Haq *et al.* 2012, Thorn *et al.,* 2012). HOCl has shown potent efficacy as a chemical sterilant against resistant spore-forms of key indicator microbes (Loshon, Melly, Setlow and Setlow, 2001).

## Hypochlorous Acid – What is Hypochlorous Acid?

Source: Click Here

### Healthcare & medical uses of hypochlorous acid

Hypochlorous acid is so gentle that it has several uses in the healthcare and medical space. It's FDA approved for use in wound healing, wound care and eye care products and is also common in veterinary care products. It's even used to eradicate biofilm. There has been extensive research on the gentleness and efficacy of HOCl when it comes to killing bacteria. It is so trusted and effective, that hospitals use it as a disinfectant in both the US and Japan.

### Hypochlorous acid for disinfecting

Given how effective it is at killing microbes without leaving behind harmful residues, hypochlorous acid is also used for preserving fresh produce. It's even USDA approved for use in organic crop production. At Force of Nature, we've harnessed the power of hypochlorous acid by miniaturizing the industrial-grade electrolyzed water technology to fit on your countertop. Our small appliance with its patented electrolyzer transforms tap water, plus a capsule of salt, water and vinegar into a powerful multipurpose cleaner, disinfectant and deodorizer that replaces bleach, deodorizers, kitchen, bath, glass and even rug cleaners. Really! It's just as effective as the top conventional cleaners, but with zero toxic chemicals. It even earns the 100% top allergen-free rating by the Mayo Clinic's SkinSafe product safety rating system.

## Evaluation of sprayed hypochlorous acid solutions for their virucidal activity against avian influenza virus through *in vitro* experiments

Source: Click Here

- Hypochlorous acid (HOCl) solutions were evaluated for their virucidal ability against a low pathogenic avian influenza virus (AIV), H7N1. HOCl solutions containing 50, 100 and 200 ppm chlorine (pH 6) or their sprayed solutions were mixed with the virus with or without organic materials.
- Under plain diluent conditions (without FBS), harvested solutions of HOCl after spraying could decrease the AIV titer by more than 1,000 times, to an undetectable level (< 2.5 log10$TCID_{50}$/ml) within 5 sec.
- When HOCl solutions were sprayed directly on the virus on rayon sheets for 10 sec, the solutions of 100 and 200 ppm could inactivate AIV immediately after spraying, while 50 ppm solution required at least 3 min of contact time.
- In the indirect spray form, after 10 sec of spraying, the lids of the dishes were opened to expose the virus on rayon sheets to HOCl. In this form, the 200 ppm solution inactivated AIV within 10 min of contact, while 50 and 100 ppm could not inactivate it. These data suggest that HOCl can be used in spray form to inactivate AIV at the farm level.

## FDA Food Contact Notification 1811 - Hypochlorous Acid at up to 60 ppm for Produce, Fish & Seafood, Meat and Poultry Sanitation

Source: Click Here

Hypochlorous acid may be used in processing facilities at up to 60 ppm for use in process water or ice which comes into contact with food as a spray, wash, rinse, dip, chiller water, and scalding water for whole or cut meat and poultry, including carcasses, parts, trim, and organs; in process water, ice, or brine used for washing, rinsing, or cooling of processed and pre-formed meat and poultry products as defined in 21 CFR 170.3(n)(29) and 21 CFR 170.3(n)(34), respectively; in process water or ice for washing, rinsing or cooling fruits, vegetables, whole or cut fish and seafood; and in process water for washing or rinsing shell eggs.

## EPA: Food-Contact Surface Sanitizing Solutions - Allowance of Hypochlorous Acid at up to 200 ppm

Source: Click Here

The following chemical substances when used as ingredients in an antimicrobial pesticide formulation may be applied to food-contact surfaces in public eating places, dairy-processing equipment, and food-processing equipment and utensils. When ready for use, the end-use concentration of all hypochlorous acid chemicals in the solution is not to exceed 200 ppm determined as total available chlorine.

## FDA Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables

Source: Click Here

The antimicrobial activity of a chlorine-based disinfectant depends on the amount of hypochlorous acid (also called "free chlorine") present in the water. The amount of hypochlorous acid in the water depends upon the pH of the water, the amount of organic

material in the water, and, to some extent, the temperature of the water. If the amount of hypochlorous acid is not maintained when the amount of organic material increases, the antimicrobial agent may lose effectiveness in maintaining water quality. If a fresh-cut processor uses a chlorine containing compound as a disinfectant, we recommend that the processor monitor the processing water for free chlorine or hypochlorous acid concentrations.

## Hypochlorous acid: harnessing nature's germ killer

Source: Click Here

Hypochlorous acid (HOCl) is the perfect weapon to fight germs. It hits hard against pathogens like Methicillin-Resistant Staphylococcus Aureus and Pseudomonas Aeroginosa. Yet this powerful weapon is 100 percent safe for humans, chemical free, non-toxic and all-natural. That's an impressive combination. It has been used in the medical field for over a century. Before antibiotics were available, HOCl was used to irrigate and disinfect wounds in World War I. It is now used in everyday settings including daycare centers, hospitals, and even produce sections in grocery stores.

HOCl is a weak acid that occurs naturally in our body. Neutrophils are white blood cells that are the first to arrive on site when an invading pathogen is detected. Neutrophils will chase down and engulf the pathogen through phagocytosis. Upon contact, neutrophils release a burst of bactericidal chemicals including its most powerful oxidizing agent, HOCl. This kills the pathogen by tearing down the cell membranes and proteins.

## Disinfection efficacy and mechanism of slightly acidic electrolyzed water on Staphylococcus aureus in pure culture

Source: Click Here

Slightly acidic electrolyzed water (SAEW), considered as a broad-spectrum and high-performance bactericide are increasingly applied in the food industry.

## Guideline for Disinfection and Sterilization in Healthcare Facilities (2008)

Source: Click Here

The microbicidal activity of a new disinfectant, "superoxidized water," has been examined The concept of electrolyzing saline to create a disinfectant or antiseptics is appealing because the basic materials of saline and electricity are inexpensive and the end product (i.e., water) does not damage the environment. The main products of this water are hypochlorous acid (e.g., at a concentration of about 144 mg/L) and chlorine. As with any germicide, the antimicrobial activity of superoxidized water is strongly affected by the concentration of the active ingredient (available free chlorine) [536]. One manufacturer generates the disinfectant at the point of

use by passing a saline solution over coated titanium electrodes at 9 amps. The product generated has a pH of 5.0–6.5 and an oxidation-reduction potential (redox) of >950 mV. Although superoxidized water is intended to be generated fresh at the point of use, when tested under clean conditions the disinfectant was effective within 5 minutes when 48 hours old [537]. Unfortunately, the equipment required to produce the product can be expensive because parameters such as pH, current, and redox potential must be closely monitored. The solution is nontoxic to biologic tissues.

## The Bactericidal Effects of Electrolyzed Oxidizing Water on Bacterial Strains Involved in Hospital Infections

Source: Click Here

The study is designed to investigate bactericidal actions of electrolyzed oxidizing water on hospital infections. Ten of the most common opportunistic pathogens are used for this study. Cultures are inoculated in 4.5 mL of electrolyzed oxidizing (EO) water or 4.5 mL of sterile deionized water (control), and incubated for 0, 0.5, and5 min at room temperature. At the exposure time of 30 s the EO water completely inactivates all of the bacterial strains, with the exception of vegetative cells and spores of bacilli which need 5 min to be killed. The results indicate that electrolyzed oxidizing water may be a useful disinfectant for hospital infections, but its clinical application has still to be evaluated.

## Novel Electrolyzed Sodium Chloride Solution for the Disinfection of Dried HIV-1

Source: Click Here

Electrolyzed products of a sodium chloride solution contain free residual chlorine and have been proved to be effective for disinfection. Electrolyzed strong acid water containing a low sodium chloride concentration (ESW-L) is prepared by the electrolysis of a solution containing a low sodium chloride concentration (0.1% or less). Although ESW-L has been confirmed to be an effective disinfectant, disinfective efficacy against dried HIV-1 and a target of ESW-L against HIV-1 have not been clarified.

## Evaluating use of neutral electrolysed water for cleaning near-patient surfaces

Source: Click Here

This study aimed to monitor the microbiological effect of cleaning near-patient sites over a 48 hour period with a novel disinfectant, electrolysed water. Cleaning with electrolysed water reduced ACC and staphylococci on surfaces beside patients. ACC remained below pre-clean levels at 48 hours but MSSA/MRSA counts exceeded original levels at 24 hours after cleaning. While disinfectant cleaning quickly reduces bioburden, further investigation is required to clarify the reasons for rebound contamination of pathogens at near-patient sites.

## Efficacy of acidic and basic electrolyzed water in eradicating Staphylococcus aureus biofilm

Source: Click here

*Staphylococcus aureus* is a major pathogen. It can form biofilm on the surfaces of medical devices and food equipment, which makes it more difficult to eradicate. To develop a novel method to eradicate *S. aureus*

biofilm, the effects of electrolyzed water on removing and killing *S. aureus* biofilm were investigated in this study.