Neutral Electrolyzed Water

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1.0 Preface

NEW (Neutral Electrolyzed Water) is an all-natural, organic, non-toxic, non-irritant, environmentally and ecologically safe sanitizing and disinfecting solution. It is produced from the electrochemical reaction of water, salt and electricity. The applications for this technology are infinite and include any process requiring a sterilizing, disinfecting, cleaning or water purification facility.

NEW is revolutionizing sanitization and disinfections in the food industry. Not only does this product provide a 'Green' solution to help protect the nation's food supply, it is in line with the American public's concern over escalating food product recalls and their growing demand for the industry to move quickly to implement more safe and natural products.

NEW offers many advantages over traditional chemical technologies, including:

- Safety
- Superior disinfections performance
- Removal of bio-film
- A more stable, longer-lasting chlorine residual
- Enhanced micro flocculation (reduction in turbidity)
- Improved taste and odor
- Oxidation of iron, manganese and hydrogen sulfide

The primary component of NEW is hypochlorous acid, the most effective element of chlorine. NEW is pH neutral, super-oxidized water generated by electrolysis of a diluted NaCl solution passing through an electrolytic membrane. This process creates large volumes of a gentle, but extremely potent antimicrobial solution capable of rapid reduction of bacteria, viruses, spores, cysts, scale and bio-film. NEW is stable, cost-effective to produce, greener than traditional chemical technologies, and can be used in multiple applications across a wide variety of industries.

NEW $_{is}$ an oxidizing agent; due to a mixture of free radicals it has an antimicrobial effect. Studies have shown that NEW is highly biocidal and can substantially reduce pathogens such as *Salmonella* and *E. coli* without the use of costly toxic chemicals. In addition, it offers the added benefits of being able to remove biofilm and scale from manufacturing equipment, thus, greatly minimizing a major contributor to contamination problems.

Because NEW effectively destroys microorganisms, they cannot build up resistance to NEW as they can to other sanitizers and disinfectants. Standard toxic chemicals can create strains of pathogens that become resistant over time, because the cell can expel or neutralize the chemical before it can kill it, thereby causing the overall efficacy of chemical cleaners and disinfectants to be significantly reduced.

Numerous applications have been identified in agricultural, food processing and retail grocery venues where the produce, poultry, meat, seafood and dairy industries are particularly impacted. NEW can be safely applied to food products, equipment and facilities using a variety of methods, including fogging, direct application or dosing.

The following document describes the benefits and applications of NEW, and describes the production of NEW using the ChlorKing machines.

2.0 Contact Information

ChlorKing is a supplier of Devices for onsite production of Electrolyzed Water and Chlorine generators manufactured by ChlorKing Inc. Atlanta, GA.

ChlorKing is located at:
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Additional information on NEW can be obtained by contacting:
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3.0 Electro Chemical Activation (ECA) Technology

3.1 Background

A breakthrough in chemical engineering can now generate consistently high quality, pure HOCl (Hypochlorous acid) from unassuming food grade precursors to produce the biocidal disinfectant NEW. The technology used to produce NEW is based on the electrochemical activation of water and salt brine (ECA technology, described below), and has been developed in line with the world trend to reduce the amount of chemicals, especially Chlorine, used to purify, disinfect or sterilize. This technology was originally designed in Russia as a disinfections process, and is currently being successfully used in Europe and Canada.

Until now, HOCl has simply been thought of as a transient byproduct in the ubiquitous chlorine chemical family. However, HOCl generated by ECA technology carries with it fewer negative hydroxides than the previous HOCl formed via disassociation from sodium Hypochlorite. Because of this, ECA-generated HOCl behaves uniquely and must be considered separately from chlorine. HOCl as a stand-alone chemical, separate from chlorine, has not been available in the market until now. This breakthrough results in a need for a paradigm shift in biocidal approaches. HOCl is an “old”, well appreciated chemical but is now “NEW” in availability as NEW with possibilities and applications that many consider revolutionary.

NEW is manufactured through validated processes and devices in accordance with EPA and ISO standards. Not only can NEW be produced in large volume (making onsite production of NEW commercially viable), it also has an extended shelf life as a result of using a rectified AC-voltage on the patented Electrolytic Cell.

The biocidal disinfectant produced by the ChlorKing machines consists of 85 - 100% NEW
The general product specification of NEW is:

- PH 6.8 –7.8, adjustable by the operator
- Oxidation-Reduction Potential (ORP) > 800mV+
- EC 5-15ppm (varies with the amount of free available chlorine)
- Free Available Chlorine (FAC) 50-500 ppm, adjustable by the operator

The active oxidizers present in NEW are HOCl and Hypochlorite ion, OCl^-. The quantity of HOCl and OCl^- is dependent upon the pH of NEW and is therefore adjustable to suit the needs of the operator.

Table 1: Composition of NEW

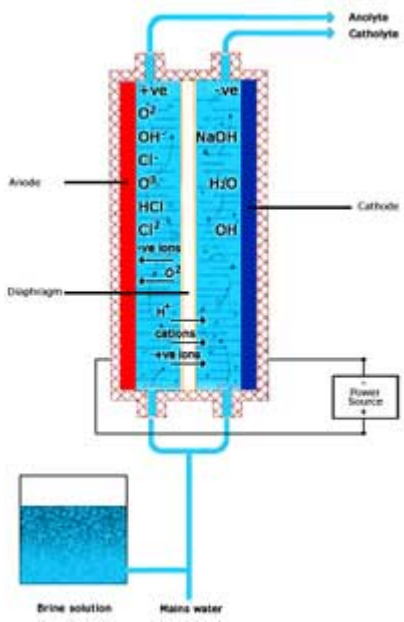
Ingredient		CAS-No	EINICS-No	Wt/Vol %	Symbols
Sodium Chloride		7647-14-5	231-598-3	<0.26%	NaCl
Free Available Chlorine (FAC)	Hypochlorous Acid (chlorine)	7790-92-3	323-323-5	<0.05% *Amount HOCl and OCl- depending on pH*	HOCl
	Hypochlorite ion (Sodium Hypochlorite)	7681-52-9	231-668-3		OCl^-
Water		7732-18-5	231-791-2	>99.69	H_2O

3.2 Electrochemical Activation (ECA) Technology

NEW is generated by electrolysis of a dilute NaCl solution passing through an electrolytic cell. This process is known as Electrical Chemical Activation, or ECA technology. ECA technology is based on Faraday's laws of electrolysis, and was further developed by Russian scientists to combat biological contamination.

NEW Technology involves the electrolysis of molten salts. It utilizes electrolytic cells encompassing an anode chamber separated from the cathode chamber by a unidirectional ionic ceramic diaphragm (semi-porous membrane). The electrolytic cell allows migration and separation of ions through a high rejection membrane and substantially limits the production of gaseous chlorine (Cl_2). By passing an electrical current through the solution, an electrochemical or oxidation-reduction (Redox) process occurs, generating a number of oxidized species.

Figure 1: ECA Technology



An ECA electrolysis process is one in which positive and negative electrodes are submerged in a solute containing positive and negative ions.

During this process, two separate streams of activated water are produced: Anolyte and Catholyte. Positive ions (cations) are drawn towards the electron-rich negative cathode, where they receive electrons, forming Catholyte, a negatively charged antioxidant solution. At the positive anode, negative ions (anions) are attracted, which give up their additional electrons to the electron-depleted anode to form Anolyte, a positively charged oxidant solution.

The cathode area produces alkaline (high pH) reducing water. The anode area produces acidic (low pH) oxidizing water. In the generation of NEW, part of the negatively charged antioxidant solution formed at the cathode is channeled back into the anode chamber to produce more Anolyte, thus increasing the content of Hypochlorite ions, OCl, one of the active biocidal substances in NEW. By re-introducing the alkaline water back into the acidic water, any pH level up to neutral 7.0 can be created. This solution is called NEW. NEW is an oxidizing agent due to a mixture of free radicals present in the solution, and has an antimicrobial effect.

3.3 Mechanism of Action

NEW is composed of oxidizing biocides HOCl and OCl^-, which are general chemical oxidants. Since NEW consists of both HOCl and OCl^- it is believed that the bactericidal action exhibited is due to the combination of these substances. They are not selective for living organisms, but react with any oxidizable matter. They are a bactericidal because certain bacterial cell components can react readily with them, having a higher oxidation potential than most other chemicals present in water.

The bacterial cell membrane provides the osmotic barrier for the cell, and allows the active transport of substances into the cell. The bacterial membrane itself has an electrical charge. Alternations in transmembrane potential by the

anions present in NEW result in the rupture of the membrane and outflow of the bacterial cell content; instantaneously destroying the cell.

NEW can also disrupt other functions of the cell. Unlike “higher” organisms, single celled organisms such as bacteria obtain their energy sources from the environment immediately outside the cell. Small molecules are transported across the cell membrane via an electrochemical gradient. Thus, any significant change in the ORP of the immediate environment has drastic consequences for the cell. Even if instantaneous death of the cell does not occur, all enzymatic functions in the membrane are affected and this will also result in loss of cell livability.

The mechanism of action for the eradication of various microorganisms by NEW is well documented by third party resources. The mode of action is as follows:

- The free ions in NEW rapidly react and denature proteins. For this reason, NEW should not be used on protein-based products because it will react with and destroy the proteins.
- Once NEW comes in contact with a microorganism; it attacks the bacterial proteins located in the cell membranes.
- Because of the osmolarity difference (the concentration of ions in the solution versus in the cytoplasm), NEW induces the rupture of cell membranes, leading to cell lysis.

The high oxidation of NEW first damages bacteria cell walls, allowing infiltration by water. The microbe reaches capacity, causing an osmotic, or hydration, overload. The acidic fluid and water floods the cell faster than the cell can expel it, literally causing the cell to burst.

NEW produces a residual that continues to remain available based on bacterial demand. ORP levels can last for long periods of time depending and organic burden. Tests show that not only is NEW an effective sanitizer and disinfectant, but it is also sporicidal. Sporicidal tests have demonstrated that NEW treatment eliminates bacterial spores and biofilm.

There is a push by the American public to reduce or ban antibiotic use in food-supply animal feeding rations. Antibiotics are becoming ineffective in animals and humans, and are leading to the development of antibiotic-resistant “super bugs”. The use of NEW greatly reduces the need for antibiotics in animal feed rations due to the bactericidal nature of the solution. Because NEW effectively destroys microorganisms, they cannot build up resistance to NEW as they can to other sanitizers and disinfectants.

3.4 Chemistry

ECA technology generates NEW consisting of the following known chemical species:

- Hypochlorous Acid (HOCl)
- Sodium Hypochlorite (NaClO)
- Sodium Chloride (NaCl)

In aqueous solution, hypochlorous acid partially dissociates into the anion Hypochlorite ClO^-:

$$HOCl \rightleftarrows OCl^- + H^+$$

HOCl and OCl^- exist in a state of equilibrium:

$$OCl^- + H_2O \rightleftarrows HOCl + OH^-$$
$$Cl_2 + H_2O \rightleftarrows HOCl + Cl^- + H^+$$

The relation between HOCl and OCl^- is solely dependent on pH value. The pH level of NEW is preferably set to ~7 to produce the highest HOCl content. HOCl and OCl^- are measured as FAC (Free Available Chlorine). The FAC compound is adjustable in NEW from 50 to 500ppm, which is many times less than the level currently found in most biocides, but many more times potent due to the composition of NEW.

HOCl and OCl^- have been shown to be the sole active substances in the biocidal effect of NEW. The quantity of HOCl and OCl^- formed is dependent upon the pH of NEW. This is in contrast to traditional electrolysis processes, which would typically result in unstable oxidized water. Electrolysis of water may produce such products as H^+ and

OH ions, H and OH radicals, H_2, O_2, HO_2, and O_3 due to Redox reactions. As a result, hydrogen and ozone gas are released and a percentage of hydroxides remain in the solution in various forms including but not limited to hydrogen peroxide.

4.0 Benefits of NEW

NEW is revolutionizing sanitization and disinfections in the food industry. Not only does this product provide an organic 'Green' solution to help protect the nation's food supply, it is in line with the American public's concern over escalating food product recalls and their growing demand for the industry to move quickly to implement more safe and natural products.
The following benefits are realized with the use of NEW:

NEW is Efficient:

- NEW is generated on demand and applied where required to eliminate the logistical concerns of purchasing, transporting, storing, preparing and using traditional chemical applications
- The elimination of hazardous chemicals translates into reductions in regulatory paperwork, safety training requirements, safety inspections, and liability exposure
- Eliminates the need to monitor for chlorine dioxide residuals, chlorite, or bromates
- Provides more effective cleaning ability than other toxic chemicals
- The higher biocidal capacity relative to traditional chemical solutions permits the use of lower dose rates, lessening the risk for environmental impact
- The solution is less corrosive than alternate products
- Reduces the frequency of cleaning within a facility
- Allows for the disinfections of areas where toxic chemicals are not permitted

NEW is Effective:

- NEW has been demonstrated to be up to 80 to 200 times more effective than sodium Hypochlorite, Extensive tests have shown that the solution has the power to kill bacteria, viruses, fungi, spores and microbial toxins
- Rapidly destroys microorganisms, scale, and biofilm
- More effective than alternate sanitation chemicals
- Can be used effectively to protect against bio-terrorism
- Reduces risk mitigation
- Allows for the marketability of a "clean" & "Green" facility
- Completely safe, non-harmful, green product using only natural ingredients
- More effective sanitization than Chlorine alone
- The systems are all "plug and play" and require little adjustment

NEW Saves Money:

- NEW is cost effective due to the fact that many more deliveries of bulk chemicals are required for the same chlorine equivalent generated by a single delivery of salt, a fact that becomes even more critical as fuel costs rise
- The capital cost of the on-site ChlorKing device can often be recovered in 1 to 3 years
- ChlorKing devices are depreciable assets
- A single unit produces a natural solution to supply an entire facility with numerous cost effective applications
- Eliminates the need for expensive and potentially toxic chemicals
- Reduces the costs of purchasing, transporting, storing, preparing and using traditional chemical applications
- Decreases labor requirements and costs

NEW Promotes Hygiene:

As part of a HACCP plan, NEW is aiding the food manufacturer in risk mitigation by helping to:

- Reduce microorganisms in foods including fish, fresh vegetables, poultry and meat
- Reduce disease risk in treated products
- Increase shelf life of treated products

- Break down bacterial biofilm in pipe systems
- Disinfect food processing areas
- Reduce the risk of consumer health concerns

NEW is Convenient:

- Onsite generation allows NEW to be produced on demand, 24/7
- NEW can be applied as it is being produced
- The systems are mobile
- Produced and applied directly from a validated system

NEW is Safe:

Safe for Products:

- Addresses public safety concerns
- All-natural, safe
- Non-toxic, non-hazardous
- No storage compatibility issues
- No residue to rinse
- No special disposal required
- Does not require a hazardous use permit

Safe for Users:

- No health and safety risks
- No protective gear required
- No eye or skin irritation
- Non-toxic (inhalation, ocular, cutaneous, ingestion)
- Non-hazardous
- No additional protective equipment required
- No exposure limits
- Lowers the risk of sickness and absence in the work place
- In its most *concentrated* form, NEW could be ingested without any physical harm (though not recommended)

Safe for the Environment:

- The only elements introduced into the system are water, salt and electricity, and are all safe and environmentally friendly
- No disposal precautions
- Provides opportunity to reduce water usage
- Reduces volume of wastewater
- No adaptive resistance chance for microorganisms
- No environmental impact
- Fully biodegradable
- Satisfies the demand for implementing safer and more natural food products

4.1 Comparison of NEW to Currently Used Technologies

In the early development of electrolyzed water, electrolytic cells were only capable of generating small volumes of acidic electrolyzed water with a limited shelf life. In recent years, neutral electrolyzed water (NEW) has been introduced as a stable, high-level disinfectant, which is non-corrosive and able to penetrate cell membranes more easily in comparison with other currently used technologies.

NEW is less toxic, less volatile, easier to handle, compatible with other water treatment chemicals, effective against biofilm and generates no by-products compared to currently used biocides. NEW is highly biocidal, but has a very low

chemical load (measured in FAC) as compared to sodium Hypochlorite, and is thus not harmful for the environment or human beings.

Because NEW effectively destroys microorganisms, they cannot build up resistance to NEW as they can to other sanitizers and disinfectants. Standard toxic chemicals can create strains of pathogens that become resistant over time, because the cell can expel or neutralize the chemical before it can kill it, thereby causing the overall efficacy of chemical cleaners and disinfectants to be significantly reduced.

NEW offers an environmentally sound alternative to chlorine and other oxidizing biocides. NEW is proven to be more effective in killing bacteria, noroviruses, molds and other microbiological organisms than Chlorine* alone and yet remains benign enough to ingest in concentrated form. (*Hydrochloride)

NEW is by chemical content nearly identical to the active components found in common chemical bactericidal agents. However, unlike the extremely toxic substances, such as chloramines, formaldehyde or iodine, the active components of NEW are non-toxic, non-irritant, biologically harmless and ecologically safe. Because of its neutral pH, NEW does not aggressively contribute to the corrosion of processing equipment or irritation of hands, and is more stable due to the fact that chlorine loss is significantly reduced at pH 6-9.

NEW has a high Oxidation-Reduction Potential (ORP, expressed in millivolts). ORP correlates to the level of sanitizing ability of treated water irrespective of the kind of disinfectant used. For example, any water which is treated to have an ORP of >500mV for more than approximately one hour would be assured of being free of *E. coli, Listeria, Salmonella* and other pathogens. The high ORP levels of >800 mV found in NEW are possible due to the elimination of caustic chemicals. This feature of NEW allows for a higher level of ORP than disinfectants such as Sodium Hypochlorite (NaOCl), for example. When caustic Sodium Hypochlorite is used, it also simultaneously raises the pH of water and thereby dramatically reduces its efficacy (ORP). When NEW is used, the pH of water is not raised, but is slightly lowered, and its ORP remains stable or is enhanced.

Electrochemically synthesized reagents, such as the neutral electrolyzed water of NEW©, are gaining rapid popularity in a number of applications. Not only does this technology offer a cost-effective alternative to existing technologies, but it is also contributing to the protection of the environment. Advantages of electrochemically-synthesized reagents include:

- These reagents are synthesized from diluted solutions of inorganic salts. This is in contrast to traditional chemical reagents, which are prepared by dissolving corrosive acids and alkalis
- Important parameters such as pH and oxidation-reduction potential (ORP) are manipulated by variation of the salt mixture. To achieve a similar level of manipulation for traditional chemical reagents, additional chemical compounds have to be added
- Since these reagents are manufactured on-site, transportation costs are eliminated. This is in contrast to the use of traditional chemicals, which may require timely planning, purchasing and proper storage infrastructure
- Because these reagents are produced by an environmentally safe technology, there is no need for neutralization or purification prior to use as with traditional chemical technologies

All water disinfections will result in the formation of disinfections by-products. NEW is no exception, but has the advantage that it does not contain the hydroxl ion and will oxidize organic material to form lower levels of chlorates, thus reducing halogenated by-products. The inorganic by-products, (trihalomethanes, THMs, chlorite, chlorate and chloride ions) formed when NEW is used are held in balance at much lower levels. Thus, lower disinfections by-products are produced in the process, at a level of about 30% - 50% when compared with sodium Hypochlorite and other oxidants.

4.1.1 Comparison of NEW to Chlorine

Chlorine is currently the most widely used oxidizing biocide. It is a powerful oxidant and is used in bleaching and disinfectants.

The use of chlorine as a micro-biocide and water disinfectant is declining because of safety, environmental and community impact considerations. According to the MSDS for chlorine, this chemical is highly toxic, corrosive, and may be fatal if inhaled. It is considered to be a marine pollutant, and in the upper atmosphere, chlorine atoms have been implicated in destruction of the ozone layer. An environmentally sound alternative to chlorine and other oxidizing biocides is needed.

Various alternatives to chlorine use have been explored, including bleach, bleach with bromide, bromochlorodimethyl hydantoin (BBCDMH), non-oxidizing biocides, ozone, ultraviolet, chlorine dioxide, sodium chlorite, chloramines (chlorine & ammonia), copper-silver ionization, and thermal disinfections. Alternative devices include chlorinators, electrically generated ozonators, and copper/silver cathodes, which use electrical activity to cause the release of silver and copper ions into drinking water. Each chemical and device offers some unique advantages, but each has distinct disadvantages.

The HOCl of NEW is found to have the advantages of other biocidal alternates without their disadvantages. Categories of objective analysis include: efficacy, safety, taste and odors, impact on equipment and systems, effect on scale, biofilm, residual effects, ease of use, maintenance and cost.

NEW is a mixed-oxidant solution. Although it is measured and dosed as free available chlorine, it exhibits behavioral traits associated with more active chlor-oxygen chemistry than traditional chlorine. In contrast to other chlorine technologies, mixed oxidants such as NEW offer superior disinfections efficacy, elimination of biofilm, more durable chlorine residual levels, and reduced formation of disinfections by-products. Mixed oxidants readily oxidize ammonia; sulfides, iron and manganese, and can cause a micro flocculation effect (reduction in turbidity) in pretreatment. In addition, mixed oxidants offer improved taste and odor. NE©, even at residual levels over 12 ppm in treated water, leaves minimal to no odor or chlorine taste.

Production of NEW is similar to the process of fabricating standard sodium Hypochlorite (NaOCl), with one significant difference. Sodium Hypochlorite combines Cl_2 with caustic soda (lye) to stabilize chlorine. The manufacture of NEW eliminates the use of caustic soda by instead using high rejection membrane technology to produce pure HOCl. With the sodium removed, the benefits of HOCl become immediately evident when used as a biocide. Elimination of lye makes disinfection possible without the high pH elements associated with sodium Hypochlorite. NEW exists at a neutral pH (7-8), thereby delivering high efficacy in short contact times without the use of caustics. The human body pH level is approximately 7.3, therefore NEW falls within the range where it is safe to the human body.

Independent research has confirmed that the effectiveness of NEW on reducing total microbial counts is superior to that of sodium Hypochlorite. The biocidal activity of HOCl generated by the current ECA technology is 300 times more active than the sodium Hypochlorite generated by earlier systems. Sodium Hypochlorite or gaseous chlorine at the same concentration as that found in NEW leads to slower microbial kill and more corrosion when tested per ASTM guidelines.

Activated solutions such as NEW have been conclusively shown to exceed chemically derived equivalents both in low dosage effectiveness as well as physicochemical purity. This heightened biocidal capacity relative to traditional chemical solutions permits the use of NEW at lower dose rates, decreasing the risk of adverse environmental impact.

5.0 Efficacy of NEW

5.1 Bio-films

Biofilms are a complex aggregation of microorganisms, including bacteria, protozoa and algae. Biofilms are usually found on solid substrates submerged in or exposed to an aqueous solution, and given sufficient resources for growth, will quickly grow to be macroscopic. In industrial environments, biofilms can develop throughout plants and on food processing equipment, which can lead to clogging, corrosion and rampant contamination. Reductions of biofilm in industrial facilities can result in substantial thermal efficiency improvements.

Biofilms are comprised of organisms which are closely packed and firmly attached to each other and usually a solid surface. Formation of a biofilms begins with the attachment of free-floating microorganisms to a surface. If the first colonists are not immediately separated from the surface, they can anchor themselves more permanently using cell adhesion molecules such as pili. The first colonists facilitate the arrival of other cells by providing more adhesion sites and building the matrix that holds the biofilms together. Once colonization has begun, the biofilms grows through a combination of cell division and recruitment, and may continue to change in shape and size.

Bacteria living in a biofilms usually have significantly different properties from free-floating bacteria of the same species because the dense and protected environment of the film allows them to cooperate and interact in various ways. This environment allows the bacteria to develop increased resistance to detergents and antibiotics, as the dense extracellular matrix and the outer layer of cells protect the interior of the community.

Traditionally, there have been several strategies for preventing or removing biofilm, including:

- Using bactericidal compounds to chemically kill bacteria
- Using liquid or gas dispersants to break up the biofilm
- Using mechanical means to physically remove biofilm
- Using enzymes or chelants to weaken the biofilm structure

In the past, no traditional strategies have been proven to be completely effective against biofilm. Even high levels of disinfectant cannot eliminate pathogens within even small amounts of scale. Because biofilm is attached to the substrate by virtue of an electrical charge, dislodgement must be accomplished by disturbance of the charge – therefore very few chemicals are effective.

Now, researchers have been demonstrating the success of the use of electrochemically-activated water as an effective alternative for removing biofilm. Results of the studies described below demonstrate the efficacy of NEW on the complete removal of biofilm from surfaces and tubing.

5.1.1 Study: Biofilm Removal from Surfaces

A study was performed to research the removal of mature biofilm by application of electrochemically-activated water. Figure 2a shows the mature biofilm control. Results show that exposure of the biofilm to a 1:00 dilution of electrochemically activated water did not yield any noticeable removal of the biofilm (Fig 2b); however, a 1:10 dilution and an undiluted solution resulted in the dispersion and removal of the biofilm after a 20 min exposure (Figures 2c and 2d).

Figure 2a: Mature Biofilm control

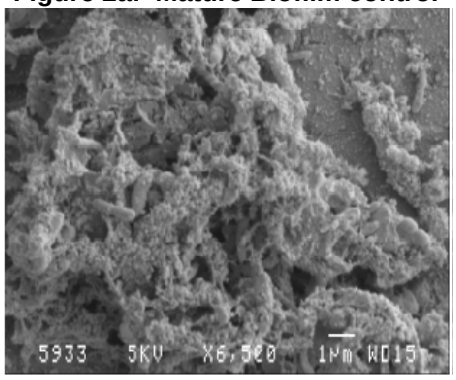


Figure 2b: 1:100 Dilution

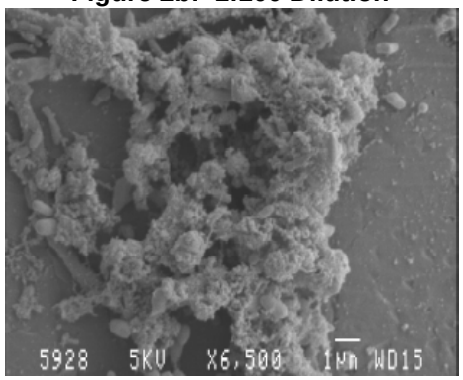


Figure 2c: 1:10 Dilution

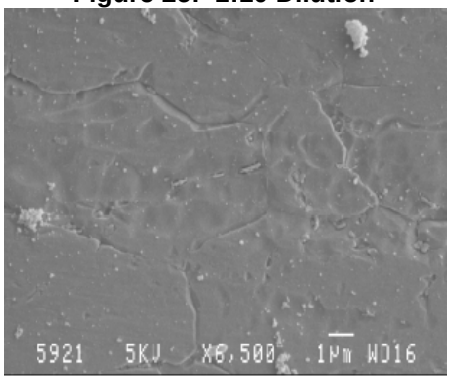
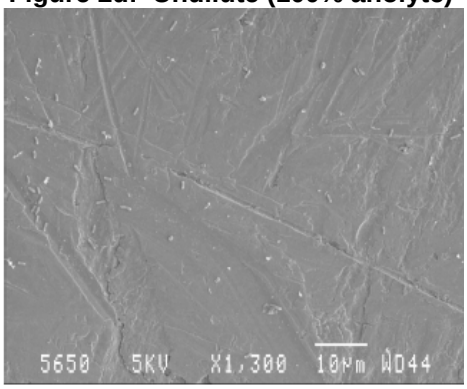


Figure 2d: Undilute (100% anolyte)



5.1.2 Study: Biofilms Removal from Tubing

A study was performed to demonstrate the removal of biofilm from 12-year-old tubing from the return line of a boat. The original piece of tubing was cut in half, and each half was placed in either H_2O or freshly generated NEW (HOCl). The pieces of tubing were allowed to incubate at room temperature for one hour. Results show complete removal of biofilm for the portion of tubing soaked in NEW. This proves that NEW can safely and effectively be used to remove biofilm from lines in any industrial application, instead of using dangerous chemicals, which may leave behind toxic residuals.

Figure 3a: Untreated Tubing

Figure 3b: Severed Untreated Tubing

Figure 3c: Incubation in H_2O or NEW (HOCl)

Figure 3d: Removal of Biofilm by NEW

5.2 Microorganisms

NEW has a strong bactericidal effect on most known pathogenic bacteria due to its high oxidation-reduction potential (ORP > 800 mV). This non-toxic oxidized antimicrobial solution capable of killing many pathogens in less than a minute. Since NEW consists of both HOCl and OCl^-, it is believed that the bactericidal action exhibited is due to the combination of these substances. Based on various bactericidal, fungicidal and Sporicidal testing performed to date; NEW has proven to be a high-level disinfectant, substantially reducing pathogens without the use of costly toxic chemicals.

Destruction of most vegetative cells of bacteria, molds, and parasites is usually not difficult because they are sensitive to heat and chemicals. However, many organisms excrete extra cellular polysaccharides and form biofilm that protect individual cells, and can be quite difficult to remove from surfaces and manufacturing equipment using traditional methods and chemicals. Studies have shown that NEW can remove biofilm and scale from manufacturing equipment, thus greatly minimizing a major contributor to contamination problems.

Molds, *Clostridium* spp., and *Bacillus* spp. form spores that are resistant to heat, acids, and other compounds. Parasites also produce resistant cells called cysts, and virus particles are notoriously resistant to heat, chemicals, and drying. NEW has been proven to be an effective Sporicidal, and provides rapid reduction of spores and cysts.

Over time, microbes evolve to become resistant to some sanitizers and disinfectants. Because NEW effectively destroys microorganisms, they cannot build up resistance to NEW as they can to other sanitizers and disinfectants.

NEW gives a much quicker inactivation rate of a wider range of microorganisms than traditional chlorination technologies, and therefore decreases the risk of waterborne diseases, outbreaks, and illnesses. NEW has been successfully tested against the variety of microorganisms listed below, including several different biological weapons agents:

- *Bacillus anthracis (anthrax)*
- *Bacillus cereus*
- *Bacillus stearothermophilus*
- *Bacillus subtilis spores*
- *Bacteriophage (F2)*
- *Clostridium perfringens spores*
- *Coliphage MS2*
- *Cryptosporidium parvum oocyst*
- *Escherichia coli*
- *Francisella tularensis*
- *Giardia lamblia cyst*
- *Giardia muris cyst*
- *Hepatitis A virus*
- *Hepatitis virus analog (F2)*
- *Klebsiella terrigena*
- *Legionella pneumophila*
- *Listeria monocytogenes*
- *Pseudomonas aeruginosa*
- *Salmonella typhimurium*
- *Staphylococcus aureus*
- *Vaccinia virus (smallpox)*
- *Vibrio cholerae*
- *Yersinia pestis (plague)*

5.2.1 Bacterial Kill Study

A study was performed to determine the percentage of kill of different bacterial strains using different concentrations of the active component of NEW produced using 3% NaCl. Bacteria were exposed to NEW concentrations of Undiluted, 1:10, and 1:20. Results appear in Table 2, and showed that the NEW gave 100% kill of all of the test strains at concentrations of Undiluted and 1:10. At a 1:20 dilution, variable kill percentages were observed, indicating variable susceptibility of different bacteria at dilute concentrations. In general, at the most dilute concentration (1:20), NEW was more effective against gram-positive organisms.

Table 2: Percentage Kill of Bacterial Strains at Different NEW Concentrations

		NEW Concentration		
Bacterial Strain	**Gram Stain**	**Undiluted**	**1:10**	**1:20**
Bacillus subtilis	+	100	100	78
Pseudomonas aeruginosa	-	100	100	87
Acinetobacter calcoaceticus	-	100	100	100
Lactobacillus brevis	+	100	100	100
Micrococcus luteus	+	100	100	100
Streptococcus faecalis	+	100	100	31
Pseudomonas fluorescens	-	100	100	66
Staphylococcus aureus	+	100	100	100
Pseudomonas alcaligenes	-	100	100	52
Pseudomonas medocina	-	100	100	88
Pseudomonas putida	-	100	100	90
Bacillus cereus	+	100	100	92
Micrococcus roseus	+	100	100	100
Pseudomonas stutzeri	-	100	100	57
Pseudomonas syringae	-	100	100	87

5.2.2 *Daphnia magna* Study

A study was performed to research the toxicity of the active component of NEW on *Daphnia magna*, a water flea commonly used in toxicity studies on aquatic organisms. The study involved 21-day full life cycle testing measuring two endpoints, mortality and reproduction. The *Daphnia* clone used was of Finnish origin from the North Savo Regional Environmental Center in Kuopio, Finland. Results of the study showed that no significant differences were found in the reproduction of Daphnia magna in all tested media. The mortality of *Daphnias* during testing was <10%, with only one Daphnia dying during the study. There were no differences observed in the size and weight at the endpoint of experiments between *Daphnia magna* grown in the test samples and in the control. It was concluded that no chronic toxicity effects were observed for *Daphnia magna* grown in the presence of the active component of NEW.

6.0 Stability of NEW

NEW has an extended shelf life and is stable for longer than one month, although it is still highly recommended using freshly generated NEW. In contrast, many other super-oxidized waters are only stable for a few hours and are produced with electrolytic cells that are very limited in production capacity as well as limited in lifetime. In these products, free available chlorine is unstable and easily evaporates from the water, causing an immediate strong chlorine smell and complicating storage, transport and usage.

The parameters that are measured in order to establish shelf life include pH, ORP and FAC. In addition, a commonly used method to determine stability revolves around the ability of NEW to kill spores of *Bacillus subtilis*, a bacterium known to be among the most resilient to chlorine. This is a useful measurement used in determining the shelf life of NEW, since it is ultimately this anti-microbial nature that is key to News's action as a high-level disinfectant.

A study was performed to compare the shelf life of NEW (446 mg/L of active chlorine) to a NaClO solution (334 mg/L of active chlorine) during a 54-day period under the following storage conditions: at 4ºC under artificial light, and at room temperature (23 ± 2ºC) in the presence of natural light in both open and closed containers. The pH, ORP and active chlorine concentrations were periodically measured during storage. Results showed that NEW exhibited better shelf life than NaClO in all of the evaluated conditions in terms of active chlorine degradation and bactericidal activity. The half-life of NEW was determined to be 21 days at room temperature, and more than 54 days at 4ºC.

7.0 Toxicity of NEW

In data obtained from independent testing executed outside the USA by third parties, no evidence of toxicity in any form has been observed in any testing. Moreover, this claim is supported by the review of relevant literature, which has revealed that HOCl and OCl^-, at the low doses occurring in NEW**,** do not produce toxic effects. Based on this information, it can reasonably be concluded that NEW is non-toxic and safe to use in the industries and applications considered by ChlorKing.

8.0 Regulatory

8.1 EPA

The EPA has approved the use of NEW in the raw food industry without the need for an additional processing, and has granted an "establishment number" (82060-FL-001) allowing the use of electrolyzed water that is produced on-site for the food industry.

Because speciation studies from a variety of institutions have identified only chlorine in the mixed oxidant NEW solution, the U.S. Environmental Protection Agency (EPA) has determined that mixed oxidant customers need only to follow chlorine regulatory requirements, including use of chlorine CT values, limits on maximum chlorine allowed, and limits on total trihalomethanes (TTHM) and halo acetic acid (HAA5) formation.

NEW is approved under 21 CFR 173.315 for direct contact with processed foods, and is approved for several indirect food contract applications under 21 CFR 172.892, 21 CFR 175.105, 21 CFR 176.170 and 21 CFR 177.2800. It is an approved sanitizer that meets 21 CFR 178.1010.

The EPA has also given approval (40 CFR 180.1054) for washing raw foods that are to be consumed without processing.

NEW in its most concentrated form cannot be classified as hazardous in accordance with Directive 99/45/EC. Normal COSHH regulations apply. The ChlorKing device does not require a hazardous use permit.

Under Section 3 of the Pesticide Regulations under the Federal Insecticide Fungicide and Rodenticide Act as amended (FIFRA), the EPA regulates pesticides, which are registered and sold in interstate commerce. Under these regulations, Pesticide Devices are not required to be registered, but must have an approved label which meet the Section 3 Regulations, Part 162.10, and have a registered establishment in which they are produced. Under Section 7 of the FIFRA, each owner of a pesticide device must produce to the EPA enforcement program a report of products produced each year and to whom they are sold in a standard report form. The ChlorKing device has an EPA establishment number of 82060-FL-001and reports information pursuant to Section 7 of the Act.

Devices are subject to labeling and misbranding requirements under FIFRA section 2(p) and 2(q); registration and reporting requirements under FIFRA section 7; recording keeping requirements under FIFRA section 8; inspection requirements under FIFRA section 9; import and export restrictions under FIFRA section 17; and child resistant packaging requirements imposed pursuant to FIFRA section 25(c)(3).

The device uses electric current to produce hypochlorous ions on demand on site, which kill bacteria, mold, mildew, viruses and surface-filling algae. The device uses sodium chloride in a liquid format in water and an electric charge to generate the chlorine on demand. When the electricity has been turned off, the device produces no chlorine and contains no residual. No product is produced from the device for storage or later use per regulations.

In case of doubt or for clarification, ChlorKing should be consulted. ChlorKing is unable to anticipate all conditions under which the product may be used, and users are advised to carry out an assessment of workplace risk and carry out their own tests to determine safety and suitability for the process and conditions of use.

8.2 USDA

According to FSIS Directive 7120.1 of the United States Department of Agriculture Food Safety and Inspection Service, “Safe and Suitable Ingredients Used in the Production of Meat and Poultry Products”, Electrolytically Generated Hypochlorous Acid has been approved in 21 CFR as a food additive for use in meat and poultry products, approved in GRAS notices and pre-market notifications, and approved in letters conveying acceptability determinations.

Table 3: Table of Safe and Suitable Ingredients
Substance: Electrolytically Generated Hypochlorous Acid

Product	Amount	Reference	Labeling Requirements
Antimicrobials			
Red meat carcasses down to a quarter of a carcass	Applied as a spray at a level not to exceed 50 ppm calculated as free available chlorine	Acceptability determination	None under the accepted conditions of use (1)
On whole or eviscerated poultry carcasses	Applied as a spray at a level not to exceed 50 ppm calculated as free available chlorine	Acceptability determination	None under the accepted conditions of use (1)
In water used in meat and poultry processing	Not to exceed 5 ppm calculated as free available chlorine	Acceptability determination	None under the accepted conditions of use (1)
Poultry chiller water	Not to exceed 50 ppm calculated as free available chlorine (measured in the incoming potable water)	Acceptability determination	None under the accepted conditions of use (1)

Poultry chiller red water (i.e., poultry chiller water re-circulated, usually through heat exchangers, and reused back in the chiller)	Not to exceed 5 ppm calculated as free available chlorine (measured at influent to chiller)	Acceptability determination	None under the accepted conditions of use [(1)]
Reprocessing contaminated poultry carcasses	20 ppm calculated as free available chlorine Note: Agency guidance has allowed the use of up to 50 ppm calculated as free available chlorine	9 CFR 381.91	None under the accepted conditions of use [(1)]
On giblets (e.g., livers, hearts, gizzards, and necks) and salvage parts	Not to exceed 35 ppm calculated as free available chlorine in the influent to a container for chilling	Acceptability determination	None under the accepted conditions of use [(1)]
Beef primal	20 ppm calculated as free available chlorine	Acceptability determination	None under the accepted conditions of use [(1)]

[(1)] The use of the substance(s) is consistent with FDA's labeling definition of a processing aid.

8.3 FDA

The FDA has expressed no concerns and holds no opposition for the use of NEW.
The use of Electrolytically Generated Hypochlorous Acid is consistent with FDA's labeling definition of a processing aid

9.0 Applications of NEW

The ChlorKing device uses only salt, water, and electricity to generate NEW, which is used onsite in its appropriate application. Physical introduction methods are described further in Section 10.0, and include the use of a dosing pump, or application directly to products, equipment or facilities via fogging, misting, spraying, soaking, immersing or rinsing. The applications for this technology are infinite and include any process requiring a sterilizing, disinfecting, cleaning or water purification facility. Potential applications are identified in the following sections.

9.1 Food Industry

Pathogenic and spoilage organisms may be present in and on foods, but only a few of these are a serious health concern because of their ability to cause human illness. The most frequent or serious causes of food borne bacterial infections include viruses, notably noroviruses and hepatitis A, parasites such as *Cryptosporidium* and *Cyclospora*, molds such as *Aspergillus spp.* and *Penicillium spp.*, and bacteria such as *Salmonella spp.*, *E. coli* O157:H7, *Clostridium botulinum*, and *Listeria monocytogenes*. Other bacteria of concern include *Bacillus cereus*, *Campylobacter jejuni*, *Clostridium perfringens*, *Shigella* spp., *Staphylococcus aureus*, *Vibrio* spp., and *Yersinia enterocolitica*.

Food safety is ensured largely, but not exclusively, by controlling the presence and growth of pathogenic organisms in and on foods. Numerous cleaning compounds and processes have been developed to remove and destroy bacteria, viruses, and parasites from equipment and surfaces in food processing plants and from fresh produce and animal carcasses. It is a significant challenge to maintain a clean environment in food processing plants. Antimicrobial compounds are used to eliminate or limit the growth of pathogens in foods, but these are typically costly toxic chemicals.

NEW is revolutionizing sanitization and disinfections in the food industry. Not only does this product provide a 'Green' solution to help protect the nation's food supply, it is in line with the American public's concern over escalating food product recalls and their growing demand for the industry to move quickly to implement more safe and natural products.

Independent studies have discovered the following benefits of mixed oxidants such as NEW when used in food processing:

- Very effective control of target bacteria, even at elevated pH values
- Equally effective in direct contact or clean in place (CIP) applications

NEW is non-toxic, inexpensive to produce, and can be used in multiple applications due to its various inherent sanitizing characteristics. Food retailers can use it to wash incoming products, sanitize equipment, prevent cross-contamination, and clean their facilities. It can be used in food storage facilities in fogging systems to kill airborne pathogens, or in sanitized ice. Food processors can use it for cleansing processing equipment, eliminating biofilm from piping systems, and disinfecting surfaces and facilities. Food preparation facilities can use NEW to sanitize equipment and food prep areas to reduce the possibility of causing or spreading food borne illness.

9.2 Poultry Industry

9.2.1 Care of Chickens

Many applications have been identified for NEW in poultry house sanitization. The use of NEW can result in:

- Enhanced fodder assimilation
- Improved weight gain
- Increased vitality
- Decreased mortality rates
- Decreased incidence of avian influenza
- Improved pest control on feathers (lice)
- Reduced need for antibiotics
- Suppressed disease transfer by spraying or soaking fecal piles

This proven technology is already being successfully used in Europe and Canada, and is helping to protect the health of chickens by dosing their drinking water to remove biofilm and kill bacteria, misting or fogging the airspace in their living quarters, cleaning tools and equipment, and sanitizing the surfaces of living spaces (floors, walls).

There is a push by the American public to reduce or ban antibiotic use in feed rations. Antibiotics are becoming ineffective in animals and humans, and are leading to the development of antibiotic-resistant “super bugs”. The use of NEW greatly reduces the need for antibiotics in animal feed rations due to the bactericidal nature of the solution. Because NEW effectively destroys microorganisms, they cannot build up resistance to NEW as they can to other sanitizers and disinfectants.

9.3 Egg Production

In the egg processing facility, NEW can effectively be used to sanitize surfaces, egg grading and packing equipment, as well as the eggs themselves. Eggs can be sprayed with NEW to disinfect their surfaces, effectively decreasing the risk of a potential food borne outbreaks without adding costly toxic chemicals to the semi-permeable surface of the egg.

In the University of Georgia’s poultry department, the use of NEW has been shown to have an impact on populations of pathogenic bacteria including *Salmonella typhimurium*, *Staphylococcus aureus*, and *Listeria monocytogenes*, all of which are common fresh egg contaminants. NEW was determined to be effective when used in conjunction with electrostatic spraying for the elimination of pathogenic populations of bacteria from egg surfaces, in many cases completely eliminating the pathogens.

During commercial processing, eggs are washed in an alkaline detergent and then rinsed with chlorine to reduce dirt, debris, and microorganism levels. A study was performed to determine the efficacy of NEW to decontaminate *Salmonella enteritidis* and *Escherichia coli K12* on artificially inoculated eggshells during this commercial egg washing process. Eggs were soaked in NEW at various temperatures and times. Treated eggs showed a reduction in population between $\geq$ 0.6 to $\geq$ 2.6 $\log_{10}$ cfu/g of shell for *S. enteritidis*, and $\geq$ 0.9 and $\geq$ 2.6 $\log_{10}$ for *E. coli K12*. Log_{10} reductions of 1.7 and 2.0 for *S. enteritidis* and *E. coli K12*, respectively, were observed for typical commercial detergent-sanitizer treatments, whereas $\log_{10}$ reductions of $\geq$ 2.1 and $\geq$ 2.3 for *S. enteritidis* and *E. coli K12*, respectively, were achieved using the NEW treatment. For the pilot-scale study, NEW was compared with the detergent-sanitizer treatment using *E. coli K12*. Log_{10} reductions of $\geq$ 2.98 and $\geq$ 2.91 were found using the NEW water treatment and the detergent-sanitizer treatment, respectively. The effects of 2 treatments on egg quality were

investigated. NEW and the detergent-sanitizer treatments did not significantly affect albumen height or eggshell strength. These results indicate that NEW has the potential to be used as a sanitizing agent for the egg washing process.

Research was conducted to compare the effectiveness of NEW applied using an electrostatic spraying system for killing populations of bacteria that are of concern to the poultry industry. Populations of pathogenic bacteria (*Salmonella typhimurium*, *Staphylococcus aureus*, and *Listeria monocytogenes*), and the indicator bacterium *Escherichia coli* were applied to eggs and allowed to attach for 1 hour.

Results showed that:

- NEW completely eliminated all *Salmonella typhimurium* on 3, 7, 1, and 8 out of 15 eggs in Repetitions (Rep) 1, 2, 3, and 4, respectively, even when very high inoculations were used
- NEW completely eliminated all *Staphylococcus aureus* on 12, 11, 12, and 11 out of 15 eggs in Rep 1, 2, 3, and 4, respectively
- NEW completely eliminated all *Listeria monocytogenes* on 8, 13, 12, and 14 out of 15 eggs in Reps 1, 2, 3, and 4, respectively
- NEW completely eliminated all *Escherichia coli* on 9, 11, 15, and 11 out of 15 eggs in Reps 1, 2, 3, and 4, respectively

Even when very high concentrations of bacteria were inoculated onto eggs (many times higher than would be encountered in industrial situations), NEW was found to be effective when used in conjunction with electrostatic spraying for eliminating pathogenic and indicator populations of bacteria from hatching eggs.

Already being successfully used in Europe and Canada, this proven technology is helping to protect the health of livestock by dosing their drinking water to remove biofilm and kill bacteria, fogging the airspace of the barn, cleaning tools and equipment, and sanitizing the surfaces of living spaces (floors, walls) of the animals.

The push by the American public to reduce or ban antibiotic use in feed rations also extends to the livestock industry. The development of antibiotic-resistant “super bugs” is causing antibiotics to become ineffective in animals and humans. The use of NEW greatly reduces the need for antibiotics in animal feed rations due to the bactericidal nature of the solution. Because NEW effectively destroys microorganisms, they cannot build up resistance to NEW as they can to other sanitizers and disinfectants.

10.0 Introduction Methods

NEW can be safely applied to food products, air, water, equipment and facilities. A variety of methods can be used to apply NEW in concentrated or diluted form. Upon production, NEW is collected into a storage container, from which it can be applied using methods such as dosing by means of a dosing pump, or applied to products, equipment or facilities via fogging, misting, spraying, soaking, immersing or rinsing. Items may be soaked or immersed in NEW for disinfection.

Fogging
Fog is a cloud in contact with the ground. Artificial fog is generated by means of aerosols or is created by vaporizing water. Fogging kills airborne bacteria, viruses and microbiological organisms. Fogging of NEW generally will not cause the floor to get wet.

Electrostatic Fogging
Electrostatic fogging occurs when a negatively charged solution is introduced into the air, which seeks out positively charged surfaces, causing larger areas to be treated more effectively.

Freezing
NEW can be dosed into ice machines creating sanitized ice, which has many applications in the food industry, including the storage and display of fish and shellfish.

Dosing

Dosing involves the introduction of NEW into a process fluid, atmosphere or to another media in intervals to give it sufficient time to react or show results.

Misting
A mist is a phenomenon of a liquid in small droplets floating through air. Misting is executed with the help of aerosols. Generally, misting NEW causes the floor to get wet.

Spraying
Spraying involves disinfecting a surface by applying NEW using a spray gun or high pressure cleaner. Spraying allows NEW sufficient contact time with the surface for disinfection.

Soaking
Soaking involves placing a subject in a bath and allowing the subject to become saturated or permeated with NEW.

Rinsing
Rinsing is accomplished by washing lightly, as by pouring NEW into or over a subject.

Immersing
Immersing in a bath involves plunging a subject into or placing it under a liquid, also known as dipping or sinking.

11.0 List of Abbreviations

COSHH	Control of Substances Hazardous to Health Regulations
ECA	Electro-Chemical Activation Technology
EPA	Environmental Protection Agency
FAC	Free Available Chlorine
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
HOCl	Hypochlorous Acid
NaCl	Sodium Chloride
NEW	Neutral Electrolyzed Water
OCl^-	Hypochlorite Ion
ORP	Oxidation-Reduction Potential