

TECHNOLOGY

HOCl Hypochlorous acid Generator Technology for On-Site Disinfection

ECA stands for electrochemical activation and is a technology that has been employed for more than 100 years, although it was not until the 1970's that the physicochemical properties of ECA were extensively researched at the All-Russian Institute for Medical Engineering.

The transformation of low mineral salt solutions into an activated metastable state, by electrochemical unipolar action, generates two separate and distinct compounds, generically termed anolyte and catholyte, which correspond to their derivative electrode chambers:

- the **anodic** (positive charge) solution contains a variety of **oxidants**, including **hypochlorous acid**, **singlet oxygen**, **peroxide anion**, **superoxide**, **ozone**, **monoatomic oxygen**, and **free radicals**, known to possess **antimicrobial properties**.
- the **cathodic** (negative charge) solution develops **detergent** properties and contains **sodium hydroxide** in a highly excited state.

The use of electrolysis for producing reductant-oxidant solutions is used in the processes of water purification and decontamination, as well as for transforming water or diluted electrolyte solutions into environmentally friendly anti-microbial, washing, extractive, and other functionally useful solutions.

This is largely due to **ECA** high activity, use of cheap raw materials, and ease of production. The system produces a liquid disinfectant, non-toxic and degradable, capable of destroying bacteria, spores, viruses, molds, yeasts, fungi, and biofilms (biological incrustations) on pipes and removing odors. Its operation requires only water, Sodium or Potassium Chloride (salt), and electricity.

How HOCl Hypochlorous Acid ECA Works

ECA works the same way as the human immune system. When the body is under attack from invading bacteria and viruses, the immune system immediately responds by sending neutrophils (white blood cells) to the invasion site.

In detail, the system consists of an electrolysis cell containing two electrodes, a cathode, and an anode, separated by a diaphragmatic membrane. In the cell is injected an aqueous solution consisting of filtered and softened water and depending on the application, sodium chloride (NaCl, salt) or potassium chloride (KCl). With the use of electricity with predefined and controlled amperage and voltage values, the cell produces an electrically activated liquid, Anolyte, with high disinfection power that can be used in various applications.

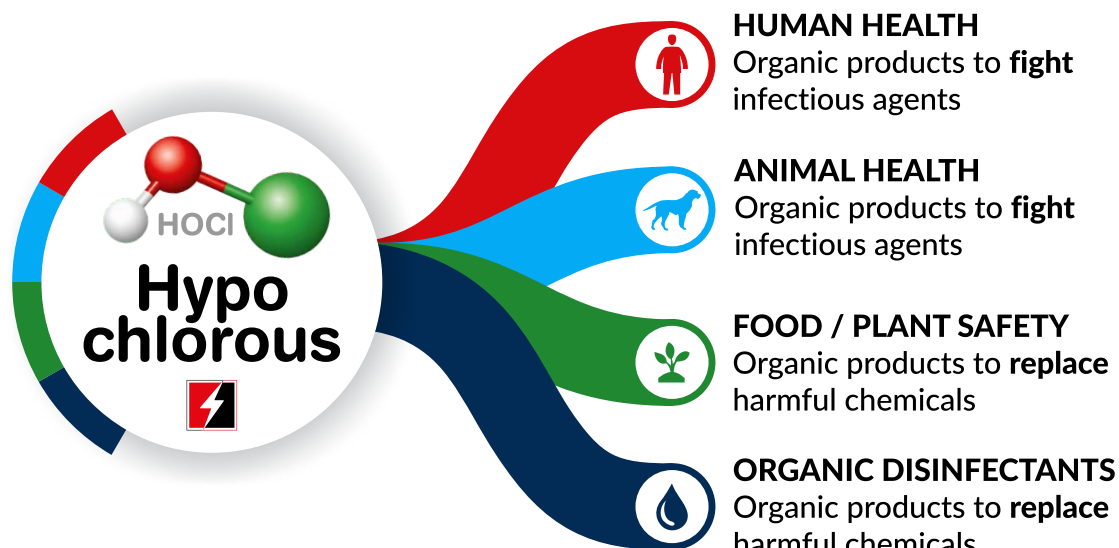
HOCl Hypochlorous Acid On-site Generator Typical Installation



- **Acid Anolyte** is a strong oxidizing and disinfecting agent and can be used wherever there are no constraints on the pH value (in the absence of corrosion hazards). Acid Anolyte acts extremely quickly and effectively against all bacteria, viruses, spores, moulds, fungi, and algae, even if diluted in water or nebulized.

- **Neutral Anolyte** is used wherever a neutral pH (corrosion risk) is needed. Neutral Anolyte is extremely effective against a wide range of pathogens such as viruses, bacteria, spores, moulds, and fungi;
- **Catholyte** is a powerful reducing agent. It is alkaline and is an excellent detergent liquid that can also be used in the flocculation and precipitation of heavy metals. It can also be used in applications where pH correction is required.

Solution	Active element	pH	ORP/REDOX
Active Cl			
Acid Anolyte	500 / 700 ppm	2,5 / 5,0	1200 / 1000 mV
Neutral Anolyte	500 / 700 ppm	5,5 / 8,0	950 / 850 mV
Sodium hydroxide			
Catholyte	1000 ppm	10,0 / 12,0	-800 / -900 mV



As presented in several scientific publications, **multicellular organisms**, including humans and hot blood mammals, to defend themselves against **pathogens** and **foreign microorganisms**, can synthesize, through metabolism, complex mixtures of **metastable oxidizing compounds**.

These compounds possess a wide spectrum of action and can damage **all major systemic groups of pathogenic microorganisms** (bacteria, mycobacteria, viruses, moulds, spores, etc.) **without damaging multicellular organisms and human tissues**.

The **oxidizing** liquids and their chemical production mechanisms are **similar to those generated in our ECA** system and are precisely these common characteristics that give Anolyte high biocompatibility with human tissues and multicellular organisms besides not being toxic to the environment.

Anolyte has the following advantages:

- It has a high ORP (oxidation-reduction potential) value of between 850 and 1200 mV, obtained thanks to the numerous oxidizing **compounds present in large quantities, but each with low concentration**; this peculiarity allows Anolyte to have much greater efficacy than chloramines, sodium hypochlorite, and most other disinfectant and sterilizing agents.

- It is a **powerful biocidal** product that kills pathogenic, viral, and fungal microorganisms (*Staphylococcus aureus*, *Legionella Pneumophila*, *Pseudomonas Aeruginosa*, *Bacillus Cereus*, *Escherichia coli*, *Listeria*, *Salmonella*, *Hepatitis B virus*, *virus Poliovirus*, *HIV*, *Adenovirus*, *Norovirus*, *pathogenic Tuberculosis*, *Dermatomycoses* and others).
- Thanks to the mixture of various metastable active ingredients of which it is composed, Anolyte **eliminates the ability to adapt the microorganisms to their bactericidal effect**, thus not allowing the developing resistance.
- Has a low concentration of active oxygen and chlorine compounds, which guarantees absolute safety and non-toxicity to humans and animals, even after prolonged use of the Anolyte.
- Can be applied in the liquid form, ice or aerosol (mist), in pure or diluted form.
- Contrary to other disinfectants, it can be used as a multifunctional solution at all levels of disinfection, both as a detergent and as a sterilizer at the same time.
- Degrading various organic compounds into harmless residues.
- After its use, **it degrades spontaneously** without leading to the formation of toxic xenobiont (the synthesis products in biology).
- **Does not require any neutralization** before disposal.

Anolyte and Catholyte also have the following characteristics:

- Do not require special attention to handling
- Can be used in all stages of disinfection (Anolyte) and cleaning (Catholyte)
- At recommended concentrations, do not bleach materials and surfaces
- Are hypoallergenic
- Have a quick action
- Their production only develops water, hydrogen, and oxygen
- Generated by-products are not toxic, are environmentally friendly, and do not leave chemical residues
- It can be generated in situ by eliminating the handling and storage of chemicals
- It can be safely disposed of in sewage systems

HOCl Reactrina® Technology

Our ECA technology incorporates components with unique architecture that makes it revolutionary. Unlike other cylindrical coaxial cells, which today are the most common and widely distributed on the market, our cell has been optimized, conceived, and developed with a **special anode geometry** that has allowed us to integrate a **double electrodes (anode-cathode) cooling system**.

The development and design of new components have helped solve the typical issues of this class of devices, increase performance and increase reliability through the following technical solutions:

- Special anode geometry
- Double electrodes (anode-cathode) cooling system
- Anode-cathode coupled without threads
- Adjustable heads
- Self-adjusting mounting system
- Manual clamping with a pressure ring

Which eliminates the typical problems of cylindrical coaxial cells, such as:

- Breaks, crevices, and cracks at junction points with the heads
- Initiation and diffusion of etching phenomenon on the anode, with relative damage to the coating
- Not optimal clamping of components
- Excessive overheating in operation
- Production of limited electro-activated solutions due to excessive heat development

It should be noted that the increase in production of electro-activated solutions requires an increase of current, the cell power current intensity, with a consequent increase of heat produced. Thanks to the integrated double electrodes cooling system (the world's first and only for this cell class) and the geometry of the components, efficient and optimal heat recovery is guaranteed, with increased performance in terms of flow per single cell in absolute safety and reliability; The ECA production takes place with lower amounts of salt in the saturated aqueous solution and, therefore with less electrolyte, resulting in lower energy consumption and Chlorides residual; The residual Chlorides concentrations in ECA produced are negligible, with a reduction in environmental hazards due to the lack of xenobiont formation.

Comparing Methods of Water Disinfection [17]

	Mixed Oxidant	Bleach Produced Locally	UV	Ozone	Chlorine Dioxide	Chloramine	Calcium Hypochlorite	Bleach	Chlorine Gas
Effective Disinfection	yes	yes	yes	yes	yes	yes	yes	yes	yes
Safety	yes	yes	yes	no	no	no	no	no	no
Residual Chlorine	yes	yes	no	no	no	yes	yes	yes	yes
Less trihalomethanes production	yes	no	yes	yes	yes	yes	no	no	no
Less chlorite and bromate production	yes	yes	yes	yes	no	yes	yes	yes	yes
Biofilm Removal	yes	no	no	no	yes	no	no	no	no
Algae Removal	yes	no	no	yes	yes	no	no	no	no
Virus Removal	yes	no	no	yes	no	no	no	no	no
Remove Parasite Eggs	yes	no	no	no	no	no	no	no	no
Usage in the Pretreatment	yes	no	no	yes	yes	yes	no	no	no
Removing Taste and Odor	yes	no	no	yes	no	no	no	no	yes
Easy Maintenance	yes	yes	no	no	no	yes	no	no	yes

Comparison of Mixed Oxidant and Bleach in Terms of Deactivating Bacteria and Viruses [18]

Microorganisms	Mixed Oxidant Injection Rate (mg/L)	Bleach Injection Rate (mg/L)	Contact Time Mixed Oxidant (min)	Contact Time Bleach (min)	Inactivation (log)	Differentiating Parameter
Bacteria						
Vibrio Cholerae	2	2	1.8	4.0	4log	Time
Escherichia Coli	2	2	3.8	5.0	4log	Time
Pseudomonas Aeruginosa	2	2	10	10	>4.8 Mixed Oxidant 2.2 Bleach	Efficacy
Legionella Pneumophila	2	2	10	10	5 Mixed Oxidant 4.7 Bleach	Efficacy
Staphylococcus Aureus	2	2	60	60	1.6 Mixed Oxidant 0.8 Bleach	Efficacy
	4	4	60	60	3.7 Mixed Oxidant 2.3 Bleach	Efficacy
Listeria Monocytogenes	2	2	60	60	2 Mixed Oxidant 0.8 Bleach	Efficacy
	4	4	60	60	3.7 Mixed Oxidant 1.2 Bleach	Efficacy

Microorganisms	Mixed Oxidant Injection Rate (mg/L)	Bleach Injection Rate (mg/L)	Contact Time Mixed Oxidant (min)	Contact Time Bleach (min)	Inactivation (log)	Differentiating Parameter
Bacteria Spores						
Bacillus Stearothermophilus	2	2	30	30	>5 Mixed Oxidant 2.5 Bleach	Efficacy
Clostridium Perfringens Spore	2	2	13	18	2log	Time
Bacillus Globigii Spores Bacillus Anthracis (Sterne) Spores	2.5	2.5	15	15	3.6 Mixed Oxidant 2.4 Bleach	Efficacy
Viruses						
MS2 Coliphage	2	2	70	168	4log	Time
Vaccine (Smallpox Surrogate)	5	~70	20	10	4log Mixed Oxidant 3log Bleach	Time, Concentration, Efficacy
Poliovirus Vaccine Strain 1	>4	N/A	30	N/A	>log 5.5 Mixed Oxidant	N/A
Rotavirus SA-11	>4	N/A	30	N/A	>5.5 log Mixed Oxidant	N/A
Protozoa Oocysts						
Giardia lamblia	>4	N/A	30	N/A	4log Mixed Oxidant	N/A
Cryptosporidium Parvum	5	5	240	1440	3 Mixed Oxidant None, Bleach	Time and Efficacy
Cryptosporidium Parvum Oocysts	25	25	240	240	>1 Mixed Oxidant 0.25 Bleach	Efficacy, qRT-PCR and Tissue Culture of Infectivity

Area of Application: Private, Public, and Industrial Places

Bactericidal, fungicidal, and yeasticidal activity based on the results of HOCL made with Kirkmayer technology, product tests in accredited laboratories:

- Kills bacteria and yeast on the surface: Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Enterococcus hirae, Listeria monocytogenes, Salmonella enterica; Candida albicans: **(reduction: 6.0 log = 99.9999%) in 15 minutes**, with an active substance concentration: 0.02% (200 ppm), i.e. a 40% solution: tests performed according to the standard: **PN-EN 13697 + A1: 2019-08**
- Kills bacteria on the surface **(reduction: 6.0 log = 99.9999%)**, Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Enterococcus hirae, and yeast: Candida albicans **(reduction: 3.98 log = 99.99%)** within 5 minutes, at a concentration of the active substance: 0.025% (250 ppm), i.e. a 50% solution: tests carried out according to the standard: **PN-EN 13697 + A1: 2019-08**
- Kills bacteria: Legionella pneumophila: **(reduction: 6.0 log = 99.9999%) within 60 minutes**, with an active substance concentration: 0.01% (100 ppm), i.e. a 20% solution: quantitative suspension method according to the standard: **PN-EN 13623: 2010**
- Kills bacteria: Staphylococcus aureus **(reduction: 6.0 log = 99.9999%)** within 60 minutes, with an active substance concentration: 0.02% (200 ppm), i.e. a 40% solution: tests performed according to the standard: **EN 17272: 2019** (disinfection by fogging – distribution test)
- Kills bacteria: Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Enterococcus hirae **(reduction: 5.0 log = 99.999%)** within 15 minutes, with an active substance concentration of 0.02% (200 ppm), i.e. a 40% solution: within 1 minute with at concentration: 0.03% (300 ppm); quantitative suspension method according to the standard: **PN-EN 13727 + A2: 2015-12**

Virucidal activity based on the results of research on the effectiveness of HOCl against virus strains: Poliovirus type 1, LSc 2ab, Murine norovirus, Adenovirus type 5, Vaccinia virus strain Elstree (SARS CoV-2 test virus): tests performed according to the **PN-EN standard 14476 + A2: 2019-08**

- Kills viruses on the surface: (**reduction: 7.0 log = 99.99999%**) **within 15 minutes**, with active substance concentration: 0.02% (**200 ppm**), i.e. a 40% solution
- Kills viruses on the surface: (**reduction: 6.0 log = 99.9999**) **within 5 minutes**, at an active substance concentration: 0.025% (**250 ppm**), i.e. 50% solution
- Kills viruses on the surface: (**reduction: 7.0 log = 99.99999%**) **within 1 minute**, at an active substance concentration: 0.03% (**300 ppm**), i.e. 60% solution

Partial virucidal activity against Coronavirus (PEDV) by fogging with HOCl of the disinfection cabin in which there was a surgical mask bearing the coronavirus (PEDV). The whole process took 60 seconds: 10 seconds, fogging + 50 seconds, leaving the mask in the cabin (reduction: 1.0-1.2 log = 90-92%), with the active substance concentration: 0.02% (200 ppm), i.e. 40% solution. Tests were carried out at the State Veterinary Institute.

Under such fogging conditions, the maximum level of chlorine in the disinfection cabin does not exceed 0.7 mg / 1m³ / This concentration of chlorine is harmless to people – by the Regulation of the Minister of Family, Labor and Social Policy of the Minister of Labor of June 12, 2018.

Safety for people and the environment:

- HOCl has the Health Quality Certificate (P-BŻ-6071-06 / 20 / G) issued by the National Institute of Public Health in Poland, certifying that the product with the composition, intended use, and method of use declared by the manufacturer does not pose a threat to human health
- HOCl has the Hygienic Certificate (B-BK-60210-0825 / 20) issued by the National Institute of Public Health in Poland, certifying that the product is suitable for disinfecting drinking water for humans and animals.
- A dermatological study conducted on 25 volunteers, who were not allergic to any of the ingredients of the tested product, confirms that the tested product is well tolerated by the skin, as it did not show any irritating or allergenic properties. The product can be classified as NON-IRRITANT. The tests were carried out on a 60% solution, which contained 0.03% (300 ppm) of the active substance. Tests were conducted in a specialized laboratory using the h-RIPT method.



Your Leader in On-Site HOCl Hypochlorous Acid Generators

KIRKMAYER is a leading global provider of electrochemically activated solution (ECA) generators, delivering first-rate HOCl systems. Our mission is to design and build electrolytic cells that are more reliable, efficient, and durable than conventional ECA and HOCl generators available on the market today.



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