TECHNICAL REVIEW • ADVANCED OXIDATION PROCESS

Mineral Oxychloride Advanced Oxidation Reagent

A second-generation advanced oxidation formula built on modified Fenton–Haber–Weiss chemistry — commercialized ready-to-use as a potent, ecofriendly oxidizer and disinfectant that needs no external energy source and carries no risk of flammability or explosion.

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2.8–2.9 V
OXIDATION POTENTIAL — 2ND ONLY TO FLUORINE (3.1 V)

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US EPA ANTIMICROBIAL DIVISION APPROVAL

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EPA GREEN-CHEMISTRY PRINCIPLES MET

Chemistry Basis

Mineral oxychlorides — represented by the formula $M_xO_yCl_z$ — are a family of compounds that bind both oxygen and chlorine to transition mineral elements. A tight in-plane mineral–oxygen (M–O) bond coexists with weak out-of-plane Van der Waals interactions between adjacent chloride (Cl–Cl) layers.

In aqueous media, $[(M_xO_yCl_z)_{(aq)}]$, these structures drive high-efficiency photocatalytic water splitting and the generation of highly reactive oxygen species (ROS). The molecules are deliberately weakly bound: on contact with inorganics, microorganisms, and organic matter, they readily release oxygen atoms that aggressively oxidize contaminants.

The solution is a modified Fenton reagent that predominantly produces hydroxyl radicals. The Haber–Weiss reaction simplifies the principal conversion pathway.

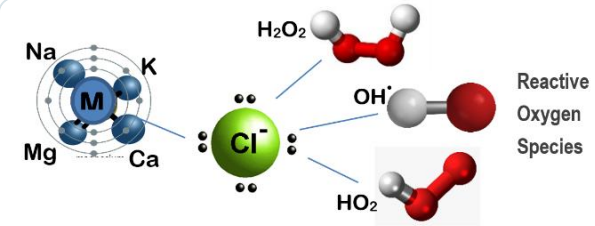


Figure 1 — Proposed structures for mineral oxychlorides and the reactive oxygen species they release in water.

HABER–WEISS PRINCIPAL PATHWAY

$$O_2^{\bullet -} + H_2O_2 \rightarrow \textit{(metal catalyst)} \rightarrow O_2 + OH^{\bullet} + OH^-$$

OXIDATION LEADERSHIP

Hydroxyl radicals give the mineral oxychloride reagent the highest electrochemical potential in the water-treatment industry — an estimated 2.80–2.90 V, second only to fluorine (3.1 V), which is not used in water treatment. The minerals act as catalysts, so all generated power is created and used at the atomic level.

Mechanism of Action

Advanced oxidation processes generate hydroxyl radicals in sufficient quantity to drive significant molecular-level changes in water contaminants, degrading most compounds to their elemental, harmless form. The mineral oxychloride reagent is a chemically based, homogeneous technology — powerful, fast-acting, and reliably effective against all known microorganisms, which cannot survive the level of oxidative stress driven by its ROS. It is NSF-certified and, in 2018, was approved by the US EPA Antimicrobial Division for water-treatment, agricultural, and post-harvest applications.

Alongside the hydroxyl radical, the reagent contributes large quantities of hydroxyl and singlet-oxygen ions, superoxide, hydroperoxide anions, and perhydroxyl radicals. The combined ROS assembly achieves a higher oxidation potential than any single species through a synergistic effect — catalyzed by the transition minerals' internal vibrational energy, with all power created and used at the atomic level. Hydroxyl radicals form in the largest amounts and follow more than one pathway: the dissociation, excitation, and ionization of water molecules.

Equations (1)–(5) trace the generation of hydroxyl radicals as water molecules dissociate, become excited, and ionize under the catalytic effect of the transition minerals.

DISSOCIATION

$$H_2O + e^- \rightarrow OH\bullet + H\bullet + e^- \quad (1)$$

EXCITATION

$$H_2O + e^- \rightarrow H_2O^* + e^- \quad (2)$$

$$H_2O^* + H_2O \rightarrow H_2O + OH\bullet + H\bullet \quad (3)$$

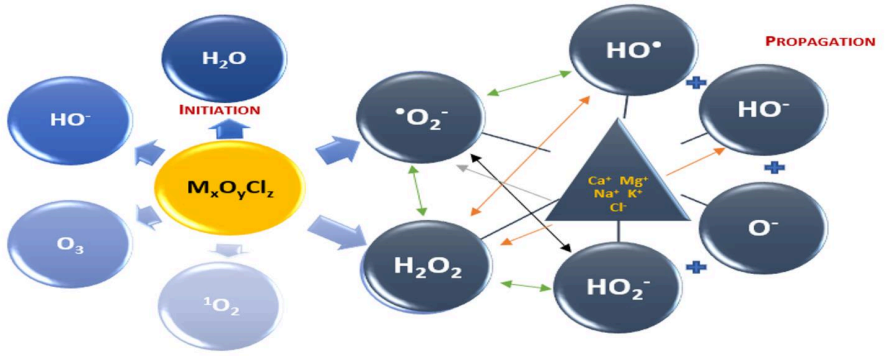
IONIZATION

$$H_2O + e^- \rightarrow H_2O^+ + 2e^- \quad (4)$$

$$H_2O^+ + H_2O \rightarrow H_3O^+ + OH\bullet \quad (5)$$

OXIDATION POTENTIAL OF COMMON OXIDANTS

REAGENT	FORMULA	VOLTS
Fluorine	F_2	3.06
Mineral Oxychloride	$M_xO_yCl_t$	2.8–2.9
Hydroxyl Radical	OH•	2.80
Oxygen Ion	O^-	2.42
Ozone	O_3	2.07
Hydrogen Peroxide	H_2O_2	1.78
Perhydroxyl Radical	HO_2	1.70
Chlorine Dioxide	ClO_2	1.57
Hypochlorous Acid	HOCl	1.49
Chlorine Gas	Cl_2	1.36
Oxygen (Molecule)	O_2	1.23
Hypochlorite Ion	OCl^-	0.94
Sodium Hypochlorite	NaOCl	0.94
Hydroperoxide Anion	HO_2^-	−0.88
Superoxide Radical	O_2^-	−2.40



Degradation of Pollutants

Degradation of organic and inorganic compounds by hydroxyl radicals is robust and extremely fast. Oxidation reactions with organic pollutants proceed by the addition or elimination of hydrogen atoms, electrophilic substitution of unsaturated bonds, and electron transfer — yielding carbon-centered radicals (R•) that react with molecular oxygen to form organic peroxyl radicals (ROO•) and, ultimately, ketones, aldehydes, and alcohols.

Hydrogen peroxide is generated as an intermediate and reacts, in the presence of the mineral catalysts, to produce fresh hydroxyl radicals in second-rate reactions. The pollutants disintegrate into non-reactive, biodegradable intermediates that undergo further mineralization, yielding CO_2 and H_2O.

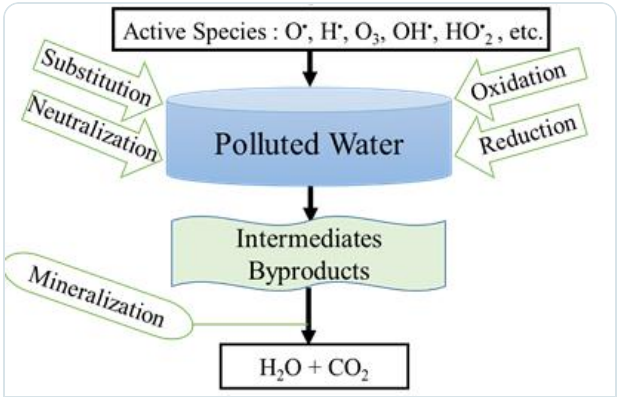


Figure 4 — Degradation of pollutants in water by advanced oxidation, ending in $H_2O + CO_2$.

pH ↔ ORP Relationship

As pH falls, ORP rises. In traditional chlorination, disinfection efficacy is set by pH: hypochlorous acid (HOCl) peaks at pH 4–5.5, and ideal disinfection occurs at pH 5–7. In advanced oxidation with mineral oxychlorides a lower pH enhances the process, yet the reactive oxygen species — led by the hydroxyl radical — always dominate over chlorine species.

ROS are so fast-acting that they satisfy the oxidative and biocidal demand ahead of the reactive chlorine species, raising the free-chlorine residual through unused HOCl and OCl^-. HOCl can then open a further pathway that augments hydroxyl radicals from second-rate reactions.

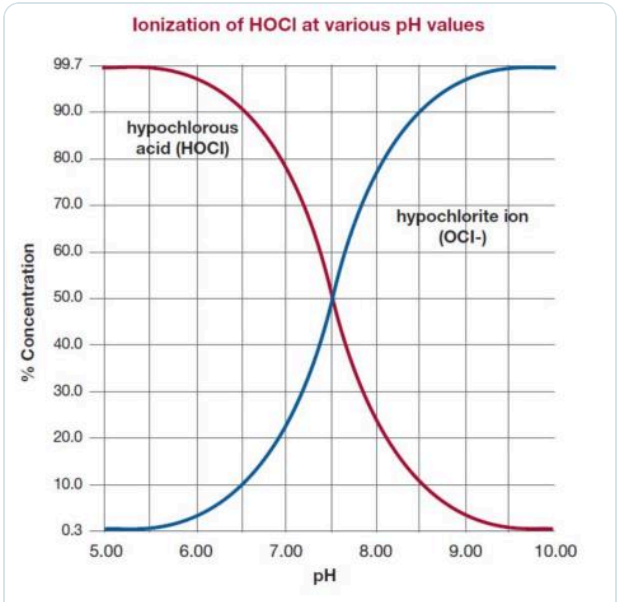


Figure 5 — Ionization of reactive chlorine species (HOCl / OCl^-) across pH.

Biocidal Mechanism

The biocidal function of the hydroxyl radical is driven by oxidative stress that damages DNA, proteins, and lipids, causing cell death by lysis — effective against biofilm and planktonic life with minimal contact time. Biological membranes are built from unsaturated fatty-acid chains; OH• attacks their double bonds, leaving an unpaired electron that binds oxygen to form a peroxyl radical. This lipid peroxidation irreversibly degrades membrane function by altering spatial distribution. ROS also cross-link proteins via disulfide bonds and mutate genetic material, and destroy biofilm by oxidizing its extracellular polysaccharide (EPS) matrix and disrupting cell signaling.

Implementation & Effectiveness

The mineral oxychloride reagent delivers the highest level of disinfection and water purification at almost the same cost as traditional chlorination — ready-to-use, easy to scale up or down, and able to retrofit ozonation and UV systems to boost performance while cutting energy demand.

IMPLEMENTATION FACTOR	DETAIL
Capital investment	Often negligible — only a liquid dosing system with an automatic ORP controller.
Complexity of operation	Very simple with ORP monitoring; no specially trained personnel required.
Maintenance	Very low maintenance on equipment and system.
Hazards	Highly corrosive in concentrated form, but not flammable and no risk of explosion.
Stability	Minimum shelf life of 6 months for maximum performance.
Physical blueprint	Very small — dosing and monitoring systems can be wall-mounted.
Storage	Normal storage conditions, protected from direct sunlight.

EFFECTIVENESS PARAMETER	PERFORMANCE
Oxidation of contaminants	Excellent AOP at 2.8–2.9 V; <1 mg/L per mg/L inorganics, 1–8 mg/L per mg/L organics.
Taste, color & odor	Excellent. Oxidizes taste/odor compounds from ORP +350 mV; higher ORP removes color.
BOD & COD	Excellent. In industrial effluents, roughly 1 mg/L per 5–15 mg/L of COD.
H_2S, iron & manganese	Excellent. Eliminates hydrogen sulfide at 1 mg/L per 2 mg/L H_2S.
Disinfection of pathogens	Excellent, very fast via oxidative stress and lysis — 1 mg/L per 1,000–10,000 mg/L bacteria, viruses, parasites, amoeba & protozoa.
Biofilm control	Excellent. Oxidizes the EPS matrix, disturbing its integrity and cell signaling.
Solubility in water	100% instant solubility.
Disinfection byproducts	Reduces precursors and creates no DBPs; breaks down existing organic DBPs. No bromate; negligible chlorite/chlorate even with a chlorine residual.
pH sensitivity	Effective across an ample range of pH 4–9.
High temperature	Higher temperature increases reactivity; will not degrade or gas off from water.
Residual protection	Excellent. At ORP +700 mV and above the system is clean; residual is held by oxidative energy, measurable as free chlorine.

NSF Certified | US EPA 2018 Approved | 12/12 Green-Chemistry Principles | Produces No Bromate | Effective pH 4–9

CONTACT JENFITCH

For additional information, visit www.jenfitch.com or email charles@jenfitch.com.