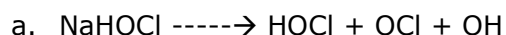


Explanation of chemistry

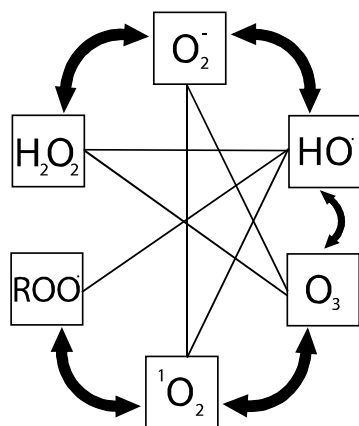
1. Oxygen and its various radicals are utilized in nature to be both anabolic and catabolic. **OXYBOM™** has been developed to emphasize the catabolic properties of oxygen radicals
2. The purpose and function of **OXYBOM™** is to improve oxidation energy, i.e. improve the oxidation potential (ORP), of a liquid oxidizer when added to a water stream. The ionic nature of minerals is to generate complex conformations of ionically-bound (chelated) ions. When introduced into a water stream, the properties and behavior of this chemistry is that of "biologic water". That is, in biologic processes, these active ions interact with water and substrates they come in contact with to provide greater oxidation energy.
3. Sodium Hypochlorite dissociates into various active ions: Hypochlorous acid, Hypochlorite, Hydroxyl radical



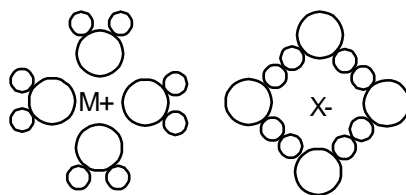
OXYBOM's technology increases the availability of active ions plus the generation of multiple oxygen radical complexes.



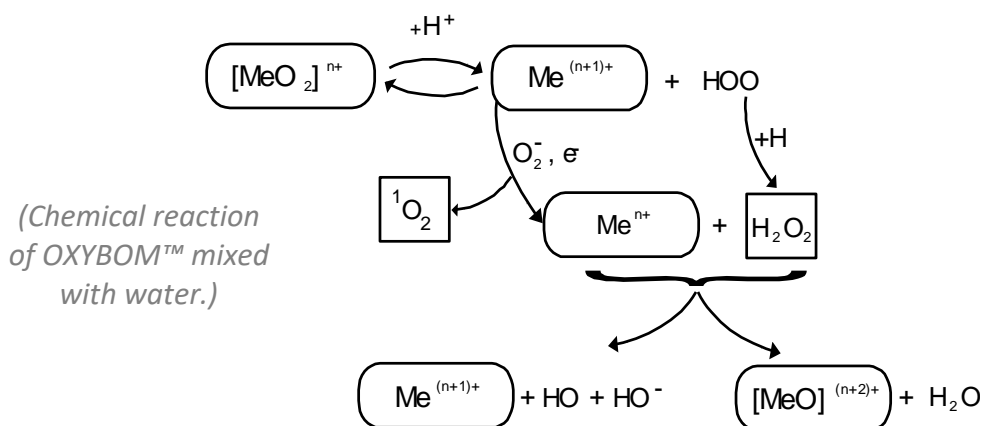
4. The decomposition of water, and oxo-compounds, generate several oxygen products. These oxygen products are various oxidation states of oxygen called: superoxide [O_2^-], hydroxyl [OH^\cdot], nascent oxygen [$^1\text{O}_2$], hydroperoxyl [HO_2^-], and peroxide [O_2^{2-}].



5. Within biologic systems, oxygen species are generated to oxidize and be anti-oxidants. The production, delivery, and attenuation of oxygen specie reaction rates, is dependent on the biochemical properties of water and the other ions carried with it. Because water auto-ionizes, forms polymers, encapsulates (forms shells) simple and complex ions, it attenuates the oxidation potential and reaction rates of ion complexes.



6. **OXYBOM™** is an ionic solution that mimics biochemical water in the production of oxygen species, and in the conservation of ionic energies (oxidation potential). **OXYBOM™**, like biochemical water, has pH and temperature sensitivities identical to biochemical water.

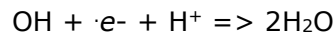
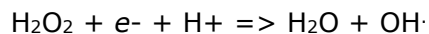
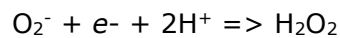
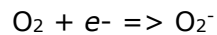


7. **OXYBOM™**-oxy-complexes cause an increase in the oxidation properties [ORP] of the oxygen complex compared to the oxygen molecule alone. The change in the reactivity behavior of the **OXYBOM™** ion, and its oxidation energy (ORP), results from the interaction with oxygen, the type of complex formed and its field geometry with water.
8. The spectrum of aerotolerance displayed by microorganisms, and all life, should be considered as the result of two contending sets of tendencies: (a) those that predispose to oxygen tolerance and (b) those that predispose to oxygen sensitivity. These tendencies are then defined by :
1. Possession or lack of specific protectives against toxic metabolites of oxygen, i.e., enzyme scavengers.
 2. Different degrees of reliance on oxygen sensitive cell constituents.
 3. Differences in the supply of reducing power for oxygen scavenging.
 4. Differences in the rates and mechanisms of oxygen consumption (which may alleviate or aggravate the threat posed by oxygen).
9. All living cells are prone to oxygen toxicity. However, some bacteria (microaerophiles), while aerointolerant, require a little oxygen for growth. This suggests that degrees of oxygen tolerance must be displayed even by anaerobes.

This conclusion awakened bacteriologists to the realization that among aerointolerant bacteria there exists a complete spectrum of oxygen tolerance ranging from the most exacting, *extremely oxygen sensitive* (EOS) obligate anaerobes, through moderate obligate anaerobes which are able to survive brief exposure to low concentrations of oxygen, to microaerophiles which can survive molecular oxygen at an atmospheric concentration less than 20% v/v (equivalent to 7 ppm dissolved oxygen) for several days.

10. CAUSES OF IRREVERSIBLE, PHASE 2 OXYGEN TOXICITY

Highly reactive and destructive by-products of oxygen radical reactions are invariably formed whenever oxygen is consumed by living cells and has the opportunity to react with many reduced cellular protein constituents i.e., most organic compounds. Oxygen by-products are: hydrogen peroxide (H_2O_2), superoxide anion (O_2^-), hydroxyl radical ($\text{OH}\cdot$) and singlet oxygen ($^1\text{O}_2$).



Both peroxide (H_2O_2) and superoxide (O_2^-) are not of themselves dramatically cytotoxic, but are particularly dangerous products of oxygen consumption because they can generate the more devastating hydroxyl radical ($\text{OH}\cdot$) via a biologically catalyzed sequence. The intracellular reduction of O_2 to $2\text{H}_2\text{O}$ requires addition of four electrons. This reduction usually occurs by single electron steps and the first product formed in the reduction of O_2 is *superoxide* anion, O_2^- .

11. A remedial DNA repair mechanism exists in all cells and microbes. The concentration of the invading radical will impact on the cells ability to keep up with the damage or fall too far behind and the DNA replication process becomes oxidized itself.

12. When oxygen and its by-products overwhelm a bacterium, the following sequence of events takes place.

1. Oxidation of scavengers.
2. Peroxidation/disruption of membrane layers.
3. Oxidation of thiol groups.
4. Enzyme inhibition.
5. Oxidation of nucleotides.
6. Impaired energy production.
7. Disruption of protein synthesis.
8. Cell death.

By mimicking nature, by utilizing high energy oxygen radicals, **OXYBOM™** easily breaks down microbes defense mechanisms. And by utilizing "micronutrients", **OXYBOM™** residues readily breakdown and are consumed by nature.

13. Chlorine Compounds

Chlorine, at a pH of 4-5, produces hypochlorous acid, which is the desired disinfectant that is active against all microorganisms. To use chlorine correctly a water stream must be prepared to receive a chlorine compound to achieve optimum effectiveness.

Factors affecting Chlorine Activity:

1. **pH:** MUST be adjusted to pH of 4-5,. By adjusting the pH, the bicarbonates become carbonates and cease to scavenge oxidants (bicarbonates are oxidant scavengers).
2. **Temperature:** chlorine reactivity is temperature sensitive. Cold water slows down and requires more chlorine than warmer water (well vs surface, summer vs winter).
3. **Organics:** Organics will consume chlorine to form *chloramines and DBPs*.
4. **Ammonia & Nitrates:** these two compounds will slow the bacterial kill action of chlorine, increasing the contact time required for chlorine to work.

14. Reactivity of Chlorine Compounds

Chlorine was first discovered to be a disinfectant in 1787 and has been universally accepted and utilized ever since. The reactivity of chlorine has been well studied and general guide lines for its use are as follows:

1. **Inorganics:** Chlorine, used by itself, requires a concentration of *6 mg/L per 1.0 mg/L of inorganic at a pH of 8.5 –9.0*. If used in conjunction with permanganate this ratio will drop to below 1.0 mg/L per 1.0 mg/L of inorganic but will require tight instrumentation controls.
2. **Pathogens:** At a pH of 4-5, chlorine is effective as a disinfectant when used at a ratio of 1-3 mg/L per 0.5 mg/L pathogen *and requires a residence time of 45 – 60 minutes (12 time that for Ozone)*.
3. **Pathogens:** A 500 mg/L chlorine concentration will normally be effective against vegetative bacteria. At this concentration, chlorine has limited effect against viruses and is poorly effective against bacterial spores and fungi (*adverse effects on body chemistry/metabolism*).
4. **Pathogens:** A 1,000 mg/L chlorine concentration is effective against all bacteria, viruses and fungi yet requires 25-30 minute residence time (*adverse effects on body chemistry/metabolism*).
5. **Organics:** Practical applications of chlorine, even at 1000 mg/L have little effect on oxidizing organic material other than generating chlorinated organics, hence chlorine is not recommended for this use.
6. **Residual:** A chlorine residual can be provided only after the demand for chlorine by inorganic, bacteria and organics has been met

Chlorine can be effective for oxidizing inorganics and bacteria when pH, concentration and residence time are allowed for, **but** the chlorinated organic by-products are inevitable and only some may be filtered out. For agriculture applications, the important consideration for utilizing chlorine compounds is the amount of chlorides that will end up being consumed by an animal, the impact of the chlorinated organics on the animals' performance and toxic

residues absorbed into the tissues of the animal. If excess chlorides are produced, necessary steps should be taken to remove them as a last step in a water treatment program.

15. OXYBOM™: Minerals & Liquid Oxygen

OXYBOM™ is a chelation of minerals with oxygen in liquid form. The molecules are purposely designed to be weakly-bound together such that when it comes in contact with inorganics, microorganisms and organic matter, it readily gives off oxygen atoms that aggressively oxidizes all desired contaminants. The reactivity of **OXYBOM™** is closely matched to ozone but without the problems associated with dissolving a gas in water.

Reactivity of OXYBOM™

1. **Inorganics:** A concentration of less than 1.0mg/L per mg/L of inorganic.
2. **Pathogens:** A concentration of 1.0 mg/L per 1,000 – 10,000 mg/L pathogen.
3. **Organics:** A concentration of 1.0 – 8.0 mg/L per 1.0 mg/L organics.
4. **Residual:** The byproducts of **OXYBOM™** are mineral oxides that are effective against bacterial recontamination hence providing a protective residue that kills bacteria.

One uniqueness of **OXYBOM™** is that it releases single atoms of oxygen imbedded within the molecular structure of organic material and the molecular make up of pathogens. Therefore, **OXYBOM™** perpetuates the release of highly active atoms of oxygen.

Microorganism: **Salmonella enterica 10708**

<i>Solution</i>	<i>PPM</i>	<i>CFU/ml : Time Zero</i>	<i>CFU/ml : 30 min</i>	<i>Log Reduction</i>
Hypochlorite	10	2.00 E +07	1.89E +05	2.02
Hypochlorite	100	1.58 E +07	<5	6.49
OXYBOM™	2	2.00 E +07	<5	6.60

16. Versus conventional disinfectants, **OXYBOM™** enables ORP as a practical tool to ensure desired results, can accomplish a desired disinfection with less product, and because of the effectiveness of **OXYBOM™**, its residues fall well below FDA MCL (maximum contaminant level).

17. Comparison of Oxidants

	<i>Ozone</i>	OXYBOM™	<i>Chlorine Compounds</i>	<i>Hydrogen peroxide</i>	<i>Potassium Permanganate</i>
<i>Hydrogen Sulfide</i>	Good	Excellent	Good	Excellent	Good
<i>Ferrous ion</i>	Good	Excellent	Good	Good	Good
<i>Manganous Ion</i>	Fair	Excellent	Fair	Fair	Good
<i>Color</i>	Excellent	Good	Good	Good	Fair
<i>Reduce precursors to Cl Organics</i>	Poor	Good	Unacceptable	Poor	Poor
<i>Common odors</i>	Excellent	Excellent	Good	Good	Good
<i>Earthy - Musty Odors</i>	Good/ Excellent	Excellent	Unacceptable	Poor	Fair
<i>Enhance Coagulation</i>	Good/ Excellent	Excellent	Good	Fair	Fair
<i>Residual Maintenance</i>	Unacceptable	Excellent	Good	Unacceptable	Unacceptable
<i>Overall rating</i>	Good/ Excellent	Excellent	Fair	Good	Fair

Role of Reactive Oxygen Species (ROS) in Drinking Water Treatment

Among advanced physical and chemical treatments such as disinfection, flocculation, chlorination, coagulation, sedimentation, filtration, refining, UV irradiation and ozonation, irradiation with UV, ozonation, chlorination, and **OXYBOM™** generate various active oxygen species which react with bacteria, humic acids and chemical pollutants.

In this respect oxygen active species (hydroxide, superoxide, hydroperoxide, singlet oxygen) provided by "Advanced Oxidation Process" and **OXYBOM™** are very good oxidizers. The utilization of these active oxygen radicals in advanced oxidation processes, as water treatment systems for reduction of pollutant (inorganics, microorganisms and organic contaminants) levels are more effective than chlorine compounds.

Additionally, HO radicals and singlet oxygen, generated as reactant byproducts, exhibit very high values of reactivity for a variety of organic compounds. Oxygen radicals and singlet oxygen in advanced oxidation processes are generated during the combinations of the primary oxidants or the introduction of **OXYBOM™**.

Ozone shows bactericidal effects and is widely used in water treatment. The reaction involves multi-step chain reactions leading to hydroxyl radical generation and its reactions with water pollutants. It is estimated that about 50% of the ozone concentration in water is transformed into hydroxyl radicals. Ozone reacts directly with inorganic compounds such as *chlorite ion, nitrite ion, ammonia, sulfites and sulfates, oxidized metal ions and hydrazines*, but for most organic compounds, even saturated ones, indirect ozonation is needed, which involves

generation of hydroxyl radicals. In this case the combination of ozone with other oxidants can be successfully used with **OXYBOM™**.

OXYBOM™ generates highly reactive oxygen intermediates, especially hydroxyl radicals and singlet oxygen for the oxidation and destruction of inorganic, microbiological and hazardous organic compounds in drinking water, are recognized for dramatic reductions of toxic byproducts. In short, **OXYBOM™** behaves just like Ozone...only better.



OXYBOM.com