

Primer on Hydroxyl Radicals

Background

Generally speaking, people love to be in the sunshine; we seek it out and frequently, our vacation destinations are in the sun. The absence of sunlight in our lives can cause depressive disorders; commonly referred to as Seasonal Affective Disorder (SAD).

We thrive in sunlight. Viruses, bacteria and molds do not. It is in fact the absence of hydroxyl radicals within our homes and work places that lead to 'Sick Building Syndrome' (SBS) and 'Building Related Illness' (BRI). Wherever the Sun's rays meet with reasonably high relative humidity you will find an abundance of vibrant life. While areas that are in shadows and darkness breed bacteria and disease.

Hydroxyl radicals are well known as a sanitizing agent, second only to fluorine in sanitizing strength. Table 1 provides relative sanitizing strengths of various substances compared with chlorine.

The three most important oxidizing species that occur in nature are:

- the hydroxyl radical - **OH**
- the ozone molecule **O₃**
- the nitrate radical **NO₃**

Of these, the single most important oxidizing species is the hydroxyl radical (OH). It is extremely reactive and able to oxidize most of the chemicals found in the troposphere.

Oxidizing agent	Electrochemical oxidation potential (EOP), V	EOP relative to chlorine
Fluorine	3.06	2.25
→ Hydroxyl radical	2.80	2.05
Oxygen (atomic)	2.42	1.78
Ozone	2.08	1.52
Hydrogen peroxide	1.78	1.30
Hypochlorite	1.49	1.10
Chlorine	1.36	1.00
Chlorine dioxide	1.27	0.93
Oxygen (molecular)	1.23	0.90

Table 1 Oxidizing Agents

In the early 1970s', Leeds University, in Great Britain, embarked on a program that asked the question, "What do hydroxyl radicals do?" A University study found that, the activity of atmospheric hydroxyls was responsible for neutralizing some 2500 atmospheric chemicals by way of some 7000 reactions. For this reason, hydroxyl radicals found in the atmosphere have been called "nature's detergent" or "Mother Nature's broom".

Hydroxyl radicals also attack the porous cell walls of bacteria and viruses which destroys them through the process known as cell lysing. Human, animal and plant cells

are “designed” to be in the sunlight and have cell walls that are less porous and are not harmed by atmospheric hydroxyl radicals.

Note: Oxidation in a chemical sense does not necessarily mean a reaction with oxygen compounds; in the general sense oxidation means the loss of electrons. In the air, oxidation does generally involve the reaction of a chemical species with an oxygen containing compound.

Creating Hydroxyls Synthetically

The challenge was how to produce or generate sufficient quantities of hydroxyl radicals so they could be applied to solve a range of issues. HGI Industries developed a process and commercialized synthetically produced hydroxyl radicals.

The HGI process proved successful and therefore American and Canadian patents were filed. This technology has been successful across a variety of industries.

Several other prestigious organizations and universities have tried to generate atmospheric hydroxyls, and all have failed or have not been able to produce reliable concentrations of hydroxyls that provide prospective customer organizations with an appropriate return on investment. Hydroxyl Generators have been running safely and effectively for over 10 years now.

HGI Industries ODOROX Hydroxyl Generators produce only atmospheric hydroxyls. The other three of these are not produced by our technology. Below we will discuss each of the four places where hydroxyl radicals are found.

Where Have Hydroxyl Radicals Been Applied?

Applications for hydroxyl radical treatment include odor control, sanitation and mold remediation. Some of the specific industries that have deployed hydroxyl radical technology include:

- NASA Space Program
- Facility HVAC; odor, mold/mildew and bacteria/virus control
- Food & Beverage; sanitation and odor control
- Wastewater Treatment; odor control, corrosion control
- Restoration; odor, mold, bacteria, virus control
- Hospitals & Clinics; bacteria and virus control
- Hog and Poultry; bacteria/virus and odor control
- Banks; bacteria/virus control during currency counting
- Nail Salons; elimination of VOCs from nail polish/remover
- Pool Supply Stores; corrosion and odor control

Hydroxyl radicals can be effective in many applications. Anywhere that odors, bacteria, viruses, mold or mildew present problems are a potential application for hydroxyl radicals.

Where are Hydroxyl Radicals Found?

As a base of understanding, there are four environments where hydroxyl radicals are found.

- Atmospheric
- Biological
- Interstellar
- Chemical

We will discuss atmospheric and biological hydroxyl radicals in detail because atmospheric hydroxyl radicals are the type generated by ODOROX Hydroxyl Generators and to distinguish them from biological hydroxyls. Biological hydroxyl are a separate field of study within the medical community; atmospheric hydroxyls cannot form or influence biological hydroxyls.

Interstellar and chemical hydroxyl radicals are not generated nor do they have an impact on how ODOROX Hydroxyl Generators function. Therefore we'll not spend much time on these two environments.

The Interstellar hydroxyls are found outside Earth's atmosphere in outer space. For obvious reasons no interstellar hydroxyls are produced by our technology.

Chemical hydroxyl radicals can be produced by various reactions. At present there are several American laboratories that are seeking to produce a chemical hydroxyl radical delivery system for medical purposes; to inject into a tumor to neutralize the mass. Medical patents were granted first in Great Britain and then in the United States. ODOROX Hydroxyl Generators do not require chemicals and do not produce chemical hydroxyls.

Atmospheric or Tropospheric¹ Hydroxyls

Hydroxyl radicals are known to be created in nature by the ultraviolet (UV) energy from the Sun. The Sun's energy reduces atmospheric water molecules (water vapor in the air; measured as relative humidity). The reduction of water molecules results in one positive hydrogen atom (H⁺) and one negative oxygen-hydrogen molecule (-OH). The -OH molecule is the hydroxyl radical.

It is the action of atmospheric hydroxyls that naturally cleans the air that we all breathe. Only a few compounds in the troposphere do not react at all or react only very slowly with the hydroxyl radical. These include the chlorofluorocarbons (CFC's), nitrous oxide

¹ The troposphere is the lower portion of Earth's atmosphere; from the Earth to approximately 11 to 15 km above the Earth.

(N₂O) and carbon dioxide (CO₂). The rate of methane (CH₄) oxidation by -OH is also very slow, between 100 and 1000 times slower than other organic compounds. This is why methane concentrations in the atmosphere can reach around 1.77 ppm (1.77 μmol mol⁻¹), a value significantly higher than the concentrations of other organic trace gas concentrations present which are generally below 1 ppb.

The outside environment has average concentrations of atmospheric hydroxyl molecules in the order of 2X10⁶ per cm³. That figure equates to trillions of hydroxyls within the size of a sugar cube. Figure 1 provides an example of the concentrations of hydroxyl radicals formed in the troposphere on the Island of Crete over several days. Concentrations of hydroxyl radicals vary across the Earth based on the location's latitude (amount of the Sun's energy) and the local relative humidity.

Human beings are designed to be in a hydroxyl-rich environment; atmospheric hydroxyls do not pass into human, animal or plant cells. Atmospheric hydroxyls therefore do not affect human internal cells in the way that biological hydroxyls effect internal cells (see the discussion on biological hydroxyls below).

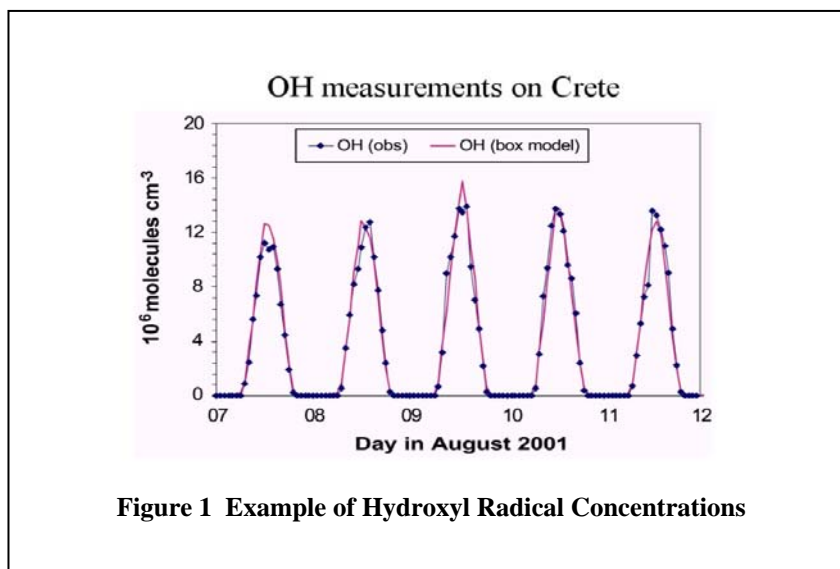


Figure 1 Example of Hydroxyl Radical Concentrations

Biological Hydroxyls

Biological hydroxyls are ONLY produced in humans as a response to invaders that the bodies' other defenses cannot normally address. The cellular etiology of biological hydroxyls is as follows:

1. The foreign cell/pathogen is identified by the bodies' immune defense system and then an attempt to neutralize the invader is initiated.
2. Should this primary effort fail, other responses are brought to bear, such as enveloping of the invader and emitting H₂O₂ (Hydrogen Peroxide).
3. In the unlikely event that this protocol should fail, the last line of defense is brought to bear. A reaction between the H₂O₂ and from either Iron or Copper results in the formation of -OH. The Sole purpose of which is to destroy the life threatening pathogen.

This biological hydroxyl will destroy the invader cell's DNA and other elements, and therefore it's' ability to replicate. Because hydroxyl radicals are extremely reactive,

biological hydroxyls are only effective within a few angstroms² from where they are produced.

The result is that aberrant cells are affected in this manner; normal cellular structures are not attacked. There is research being conducted on hydroxyl radicals and their relationship to the formation of tumors and other diseases.

As stated earlier, atmospheric hydroxyl radicals do not infiltrate the body and must not be confused with biological hydroxyl actions.

As a point of interest, we are aware of one hydroxyl radical application being used medically. The 3M Corporation has been granted a 'Medical Patent' to produce a hydroxyl-based atmospheric delivery system (Proventil HFA inhaler) for asthmatics. Long years and millions of research dollars have been expended so that this 'safe and effective' formulation could be developed to deliver hydroxyls into the lungs of asthmatics. This group of people already has a formidable respiratory challenge. If this delivery/medication system were flawed, in any way, it could not be released to the general public. The FDA would not sanction a product that would further burden the respiratory system of asthmatics.

Incidentally, those who use the 3M Puffer are amazed at how well it works. They acknowledge that this technology is quite a leap forward from traditional medication/delivery systems. Please note that hydroxyls provide nearly half the molecular weight of the patented formulation.

HGI Industries and the ODOROX Brand

ODOROX Hydroxyl Generators have been designed, engineered and built by HGI Industries Inc., and carries the distinctive ODOROX brand name. It provides an innovation and rightly referred to as, 'Green Technology at Work'. No harmful chemicals, no residue, no offensive odors and low energy consumption are key green factors. Therefore, we flourish, and pathogens do not.

Additionally, using hydroxyl radicals as a sanitizer can drastically reduce water and chemical usage for provide greater green benefits.

Our commitment to continuous field and laboratory testing shows that the technology is both safe and effective. To that effect we have engaged the most stringent air quality testing laboratory in the United States to verify the that there are no adverse affects from the discharge air flow; nothing that could harm people or animals, including the very young nor the severely health challenged. The ODOROX Hydroxyl Generator passed all testing with flying colors. These lab reports are available on HGI Industries web page: http://www.hgiind.com/index-4.html#lab_reports .

² An angstrom is a unit of length equal to one hundred-millionth of a centimeter

It has been our experience that informed clients expect nothing less than reliable technical expertise. Our clients expect a high aptitude for both site specific engineering knowledge and hands-on experience from their ODOROX consultant. We are experienced and knowledge-based professionals. We are often consulting with clients ranging from other engineering professionals to, liability insurers, military, livestock husbandry and the medical profession.

We provide comprehensive and field-proven engineering expertise, technical advice and complete aerobiological project management of field and plant operations. Our decade of expertise has led us to expand from our large commercial projects to include portable processors that are easily manageable for hospital/extended care, restoration/remediation and home use.

- All ODOROX Hydroxyl Generators are certified:
 - UL (United States),
 - CSA (Canada),
 - ETL (Europe).

- Current laboratory reports can be provided that unequivocally show the efficacy of the generation of hydroxyls on bacteria, viruses and mold. These test reports bare out the fact that, for the first time anywhere, a device, could safely and effectively outperform chemicals, foams, sprays and misters.