

The Facts About Hydroxyl Radical Air Cleansing

There is a lot of “myth and legend” in the air cleaning marketplace about hydroxyl radicals. There is also a lot of scientific data. This is a list of frequently made statements from industry sources with responses based on scientific data provided by reputable third party scientists, research centers and government sources.

- **MYTH: Hydroxyls are not safe. By-products of the reaction of hydroxyls and ozone with volatile organic contaminants in air are incompletely oxidized and may not be safe.**

FACT: There is now sufficient independent, scientific and toxicological data to say unequivocally that the Odorox® hydroxyl radical cleansing technology is safe. HGI proved that Odorox® hydroxyl generators produce the same steady state levels of hydroxyl radicals and other oxidants as produced by the sun’s rays in our atmosphere. These oxidants react with volatile organic compounds (VOCs), water vapor and other chemicals in air to generate the same mixture of organic by-products produced in nature. These by-products continue to be oxidized until they yield O₂, CO₂, H₂O, etc., as found in nature. HGI further proved that the oxidants and by-products were safe by conducting independent toxicology studies which showed treated animals were no different than untreated animals.

- **U.S government regulators have reviewed HGI technology and judged it to be safe since it reproduces a process found in nature. This produces oxidants and organic by-products that are found in nature that we breathe and are exposed to daily without harm.** HGI has a formal statement from the National Institute of Health (NIH) that, after searching all government safety databases, no data was found to indicate that natural or man-made hydroxyls were unsafe. Hydroxyl radical generators are therefore not regulated.
- **HGI commissioned a study to measure the amounts of hydroxyl radicals (HO• or •OH) and ozone formed to prove that they matched natural outdoor levels.** When the HO• and ozone production rates match nature, then all the by-products formed would also match those found in nature. We know that these natural levels are safe....we do not know if lower or higher levels are safe without testing.
- **There is no data provided in the literature to prove that the hydroxyl radical organic oxidation by-products are irritating or toxic.** The concern was voiced by scientists Weschler and Shields in an article in which they speculated that the “expected oxidation products” ... from hydroxyl radicals with indoor volatile organic compounds...”are more irritating and corrosive than their precursors”. (C. Weschler and H. Shields, Environmental Science and Technology, Vol. 30, No. 11, 1996). They did not, however, have any data to support this speculation or reference any toxicology testing.

- **HGI took the initiative and commissioned a toxicology study to determine if everything being produced by their Odorox[®] technology is safe; both initial oxidants (HO• and ozone) and all the by-products.** The study of a statistically significant number of rats (there are many types of animals that can be tested...rats are the preferred type for this type of study) proved that **treated animals showed no signs of toxicity when exposed to high levels of Odorox[®] hydroxyls and oxidant by-products** for 13 weeks (24/7). The exposure levels were about twice as high as would be found normally using HGI systems. This data was collected according to strict Food and Drug Administration (FDA) toxicology good laboratory practices (GLP) guidelines and would be accepted by them if they decide in the future to regulate this family of devices. The results were completely satisfactory and do not warrant further testing according to FDA guidelines.

- **Other systems may not make this HGI claim.** The FDA requires data for each and every type of machine manufactured to be able to make the same claim. HGI was the first and so far the only manufacturer to actually measure what they produce. HGI commissioned an internationally recognized atmospheric chemistry research center to use special equipment in an ultra-clean room to verify that the Odorox[®] system is actually a hydroxyl generator. They measured the concentration of hydroxyls produced and proved that they react with and decompose a selected volatile organic compound proven to react specifically with hydroxyls (and not ozone). They also proved that the steady state amount of hydroxyls matched those produced in nature. If a machine produces too little HO•, the by-products will be partially oxidized and not natural. They could therefore not be as safe as those found in nature.

- **MYTH: There are many tissues on the surface of a person's body that can be affected by hydroxyls like mucous membranes, eyes, skin, etc. Hydroxyls can cause cellular damage to red blood cells along with damage to DNA, lipids, and proteins. This damage has been linked to diabetes, cancer, and cardiovascular disease.**

FACT: There are two types of hydroxyls – atmospheric and biological (sometimes called “in-vivo” hydroxyls). Atmospheric hydroxyls are generated by the sun's UV radiation as it reacts with water vapor. Atmospheric hydroxyls can also be produced artificially using UV optics; they are the same. Atmospheric hydroxyls interact with the lipids and proteins on the outer surface of skin and mucous membrane tissue, but do not damage their structure. They cannot enter the body and do not cause internal damage or disease. Biological hydroxyls are generated within the body and are an important, natural mechanism to control/kill pathogens when the immune system is overwhelmed.

- **Humans, animals and plants have evolved symbiotically with atmospheric hydroxyl radicals and their by-products and tolerate them well.** There is no evidence that atmospheric hydroxyls cause disease or damage to tissues or organs. HGI's recent toxicology study is consistent with what is observed in nature.

- **Atmospheric hydroxyls – like the sun’s and HGI’s – cannot pass through skin or mucous membranes to enter the blood stream or attack organs.** Hydroxyls can react with the outer layer of skin and the mucosa, but the tissue as a whole is not damaged as it has many layers. Hydroxyls are blocked by the moisture barrier of mucous membrane tissue. The body regenerates skin and mucous membrane cells daily to slough off any that are damaged, thereby keeping these tissues healthy.
 - **Hydroxyls - even in the low parts-per-billion (ppb) range - are toxic to microorganisms.** The reaction of hydroxyls with the lipids and proteins in the cell walls is enough to cause the cells to “leak” and kill bacteria, virus, mold/fungus and yeast. This interaction helps keep us healthy.
 - **Inside the body “in-vivo” hydroxyls are actually generated when the immune system is not effective enough to deal with an assault by bacteria, viruses etc.** Various types of cells in blood, like mitochondria, produce hydroxyl radicals in the vicinity of the pathogens the body is targeting. It is true that other cells nearby are also killed; but the body is very selective in how and when they generate in-vivo hydroxyls.
- **MYTH: HGI systems generate high levels of ozone and are unsafe.**
FACT: HGI uses the same range of UV radiation as the sun to react with oxygen and water vapor to generate the same concentration of HO• as produced in nature. The role of HO• as nature’s principal air cleansing oxidant has been proven by years of study of atmospheric chemistry and is universally accepted. Ozone is a by-product of the process and is decomposed in various ways to generate more HO•. HGI systems are designed to further decompose ozone by exposing it to specific UV energy as it cycles through the system. Ozone plays a minor role in air cleansing as it is over one million times less reactive. HGI steady state levels of ozone are thousands of times lower than levels produced by ozone generators.
 - **When HGI systems are properly used, ozone levels are the same as those found outdoors. Natural ozone levels outdoors and indoors range from 20-100 parts-per-billion (ppb) depending on where you live (urban levels are higher).** Indoor ozone levels have been measured while HGI systems have been running and correspond to the same range or levels as found outdoors. This is because HGI systems both utilize and destroy ozone as they generate HO•. They do this by exposing the air stream to a particular wavelength of UV radiation that decomposes it. Residual ozone is also lost to reactions with VOCs and inorganic gases (like NO) and adhesion to surfaces. Ozone reaction with VOCs called alkenes, which are common indoors, regenerates more HO•.

- **There is no evidence that ozone levels are too high using HGI systems properly. HGI guidelines provide sensible use criteria and ventilation guidelines so that the steady state levels of oxidants remain safe.** The few manufacturers that produce useful levels of hydroxyls in the range of 20 to 100 ppb generate varying amounts of ozone. Some manufacturers are better at minimizing the residual amount of ozone – called the steady state concentration. HGI systems are very efficient at minimizing ozone based on competitive studies that have been conducted.
- **Some vendors have made claims about unsafe ozone levels using HGI systems by testing inappropriately (i.e. placing Odorox systems in small, unventilated boxes, closets etc.)** ALL systems that generate useful levels of hydroxyl radicals should be sized to the treatment space and used with a nominal level of ventilation. Using any such system in a very small, unventilated space will result in oxidant accumulation that may reach unsafe levels.

The same could be said for many other types of machines. We know not to run a car or a lawn mower in a garage with the doors closed. Does that make them unsafe ?

- **MYTH: Hydroxyls are not as effective as ozone. Ozone is faster than hydroxyls.**
FACT: Science proves hydroxyls are both faster and more effective and efficient oxidizers than ozone...by a significant margin.

- **These are two different statements;** the first is about oxidation potential or power and the second is about speed.
- **We know HO• is a much more effective oxidant based on published oxidation potentials (electron volts or eV).** Only atomic fluorine is stronger and it is too toxic and corrosive to use.

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| ▪ Fluorine | 3.06 eV |
| ▪ Hydroxyl radical | 2.80 eV |
| ▪ Oxygen (atomic) | 2.42 eV |
| ▪ Ozone | 2.08 eV |
| ▪ Chlorine | 1.36 eV |
- **The hydroxyl radical is not only a better oxidant, it is faster.** The fact that hydroxyls react over a million times faster with VOCs and with thousands of more compounds than ozone is well documented by the EPA and years of industry and scientific research.