



Odorox[®] System Effect on Microorganisms

General

Atmospheric hydroxyl radicals are continuously produced by the action of the sun's radiated energy on water vapor in our atmosphere. There are, on average, two (2) million hydroxyls in each cubic centimeter of ambient outdoor air during daylight hours. They are the main driving force behind the daytime reactions with hydrocarbons in the troposphere and neutralize most natural and man-made pollutants including greenhouse gases like methane, hydrogen sulfide and ozone.

Atmospheric hydroxyls are also proven to kill bacteria, virus and mold because they are able to react with the lipids, proteins, carbohydrates and other organic compounds that make up the cell membrane and disrupt their structure. The interior contents of the cells leak and the organism is destroyed. Conversely, humans, animals and plants have evolved symbiotically with atmospheric hydroxyls and developed outer surfaces and mucosa that are essentially impervious to their effect. Atmospheric hydroxyls are a critical component of nature's dynamic ability to provide environments that are free of harmful chemicals and pathogens. (D. E. Heard, "Analytical Techniques for Atmospheric Measurement", Blackwell Publishing, 2006 – professor at the University of Leeds, UK).

Hydroxyl Radical Sanitization Process

The HGI Odorox[®] irradiation process is fundamentally very simple. Ultraviolet (UV) radiation of various wavelengths reacts with the oxygen to generate a variety of reactive oxygen species, which remove a hydrogen atom from water vapor to generate atmospheric hydroxyl radicals (HO·). The short, most powerful wavelengths of UV light can generate hydroxyls from water directly. Another pathway is the formation of ozone, which is then immediately decomposed by UV light with a wavelength of 254 nm to generate additional hydroxyl radicals. HGI's Odorox[®] custom optics, patented reaction chamber design and active process controls result in the generation of safe and effective concentrations of atmospheric hydroxyls within the same range as those found in nature.

The HGI Odorox[®] hydroxyl radicals are highly reactive and excellent radical transfer agents. They rapidly react with microorganisms and with nearly every organic chemical available. They remove a hydrogen atom and form a cascade of organic radicals that is further oxidized to form peroxy (R-C-O-O·) and oxy (R-C-O·) free radicals, which are also good oxidizing and sanitizing agents. These by-products are stable enough to circulate under the influence of high velocity fans to completely sanitize air, surfaces and porous fabrics in even exceptionally large spaces.

Atmospheric hydroxyl radicals and their by-products are unstable species which do not linger in the air or on surfaces. As long as the Odorox[®] system is running, the chain reactions persist. When the system is shut off, the hydroxyl radicals and other free radicals dissipate within seconds.

Effect on Microorganisms and Germination

HGI Industries has completed a number of microbiological studies to evaluate the speed and effectiveness of their systems to eliminate a broad range of pathogens on non-porous / porous surfaces and on plant material. Results from a licensed testing laboratory, using pathogens commonly tracked by the EPA as representative of their type, indicated that substantially all of the following microorganisms were killed on stainless steel, glass and cotton fabric respectively, within the specified times summarized below.

- *C. difficile* – 99.8% and 98.6% within 48 hours
- *Listeria* – 94.7% and 98.6% within 48 hours
- *Aspergillus niger* – 99.9% and 97% within 48 hours
- Porcine Reproductive Respiratory Syndrome (PRRS) virus – 97.9% within 6 hours
- *Pseudomonas aeruginosa* – 91.9% within 4 hours
- Influenza A virus – 99.98% and 99.9% within 6 hours
- Methicillin Resistant Staph. Aureus (MRSA) – 65.1% and 94.4% within 48 hours
- *Klebsiella pneumoniae* (CRE) - 99.4% within 4 hours and 99.9% within 8 hours

The optimum method for achieving and maintaining these levels of sanitation is to use the Odorox[®] systems continuously. Air movement and human contact rapidly recontaminate air and surfaces. The dynamic action of airborne hydroxyl sanitization ensures that microorganisms continue to be killed 24/7.

Recent studies on the reduction of bacterial and fungal pathogens on plant material from raw and sprouted barley processing were also conducted. Random samples of raw barley and fresh barley sprouts (removed in the processing of sprouted barley) were exposed to Odorox[®] atmospheric hydroxyls and their by-products from an MVP14[™] unit over a period of 2 to 96 hours. Kill rates in excess of 99.9% were measured by a licensed testing laboratory for the following pathogens. No fungal growth was isolated on any samples after 6 hours of treatment with respect to the raw sprouted barley product.

Sprouted Barley Product: (plant material was stirred every two hours and appeared unchanged)

- *Aspergillus niger*
- *Candida krusei*
- *Trichosporum beigeli*
- *Rhodotorula glutinosa*
- *Acinetobacter baumannii*
- *Enterobacter agglomerans*
- *Enterobacter cloacae*
- *Bacillus sp.*

Raw Barley product: (plant material was not stirred)

- *Pantoea Agglomerans*
- *Acinetobacter Baumannii*
- *Bacillus SP*
- *Pseudomonas Fluorescens*

- Penicillium Citrinum, Mucor SP
- Fusarium SP
- Afusarium SP
- Aspergillus Flavus Group (GRP)
- Aspergillus Niger GRP
- Syncephalastrum SP (Zygomycete)
- Pithomyces SP

Note that the hydroxyl radical does not react with carbon dioxide and would thus not interfere with normal plant respiration. Hydroxyl radicals would however, react rapidly with plant respiration by-products like ethylene and neutralize them, which is beneficial.

Safety

As a category, the FDA does not regulate or require premarket 510(k) approval for UV irradiation air cleaning devices – such as HGI’s – that are used for commercial or consumer applications since they irradiate ambient air and cleanse in a manner similar to that found in nature. In medical facilities, Odorox[®] systems integrated with heating, ventilation and air conditioning systems may be used without approval. FDA approval is required for ultraviolet air sanitizing systems used within medical facilities. HGI is in the process of obtaining approval based on substantial equivalence to these devices, which use only ultraviolet radiation as the active sanitizing agent and are shielded. Devices that may be used in occupied spaces continuously require shielding so that the radiation is contained within the system.

The National Institute of Environmental Health Sciences searched the NIH files, PubMed and the National Library of Medicine and “cannot find any hard science or research indicating that hydroxyl radical generation is harmful to human health. That applies to both atmospheric and man-made generation” (Colleen Chandler, NIEHS Office of Communications and Public Liaison, 8-5-10).

Further, at HGI’s request, the CDC, FDA, OSHA and NIH researched their databases and did not find any data indicating that atmospheric hydroxyls were unsafe. None of these agencies indicated that their approval was required for commercial use. Hydroxyl systems have been in use for over ten years and no adverse effects have been reported.

Extensive toxicology studies conducted by HGI at an independent testing laboratory, using the FDA’s rigorous testing protocol called Good Laboratory Practices (GLP), have shown that exposure to hydroxyl radicals and the associated oxidation by-products is safe. The study results indicated that the test animals tolerated the exposure well with no abnormal clinical observations.

Green Technology at Work[®]

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