AIRPHX Technology Overview
November 20, 2020

AIRPHX uses a proprietary non-thermal plasma technology to create a number of oxidizing molecules that are excellent disinfecting agents.

AIRPHX Oxidizing Molecules

The oxidizing molecules created by AIRPHX include oxygen ions, free radicals and peroxides that are highly reactive due to the presence of an unpaired valence shell electron. Importantly, the amount of energy present in the AIRPHX plasma is not strong enough to alter the nitrogen in the air. These oxidizing molecules can generate a disinfection smell close to the output of the unit, which dissipates as the molecules disperse and interact with microorganisms and other pathogens. When the units are deployed consistent with the user guide,[1] any smell should be minimal, although the existence of the smell confirms the molecules are actively engaged in disinfection.

Measurable levels of gas-phase hydrogen peroxide, ozone and other types of oxidizing molecules are produced within an AIRPHX proprietary and patented plasma chamber. The hydrogen peroxide produced is different than vaporized or aerosolized hydrogen peroxide. Gas-phase hydrogen peroxide has a more acute bond angle and a variable half-life measured in hours. Ozone has a half-life of approximately 20 minutes, but as explained below, is effectively removed using a patent pending catalyst prior to exiting the unit. As a result, gas-phase hydrogen peroxide is the only oxidizing molecule that exits the unit at any meaningful level.

A number of other oxidizing molecules are created within the plasma chamber but do not leave it (or exist only momentarily after leaving it) due their short half-lives. These include: atomic oxygen (O), singlet oxygen (O_2 with displaced electron), hydroxyl radicals and superoxide (O^{2-}). Even though they do not as a practical matter leave the unit, within the unit they are additional highly-effective oxidizing agents.

Regulation of AIRPHX Oxidizing Molecules

Gas-phase hydrogen peroxide is an excellent disinfecting agent with a very long half-life and occurs naturally in the air.[2] The National Institute of Health confirms the efficacy of hydrogen peroxide: "Although nonflammable, hydrogen peroxide is a powerful oxidizing agent …." https://pubchem.ncbi.nlm.nih.gov/compound/Hydrogen-peroxide. Hydrogen peroxide is seen as an environmentally safe alternative to chlorine-based bleaches, as it degrades to form oxygen and water and it is generally regarded as safe (GRAS) as an anti-microbial by the Food and Drug Administration (FDA). CFR, Title 21 Part 184, Sec. 184.1366. Hydrogen peroxide has no known carcinogenic potential.

[1] The user guide contains guidance on appropriate use of the units, including instructions on mounting the units (elevated), the requirement that there be constant and consistent airflow to disperse the oxidizing molecules and the minimum size of the treatment space. Note that each installation location is different in size, layout, type of HVAC system, composition of ambient air due to, among other things, other cleaning protocols, humidity level, etc., so it may be appropriate in some instances to operate AIRPHX units less than 24 hours a day using the seven-day timer function to reduce the levels of oxidizing molecules released into the treatment space.

[2] AIRPHX units have been verified by the Washington State Department of Agriculture to comply with USDA National Organic Standards (7 CFR Part 205).

Hydrogen peroxide is regulated by the Occupational Safety and Health Administration (OSHA) and, at elevated levels, it can become an irritant but not at the levels created by an AIRPHX unit used consistent with the user guide. The hydrogen peroxide produced is different from vaporized or aerosolized hydrogen peroxide (H_2O_2). This gas is a by-product of the disinfecting process that takes place within an AIRPHX unit and is not hazardous based on OSHA limits. AIRPHX technology relies on electricity to create a plasma field and the oxygen present in ambient air to produce marginal levels of H_2O_2 where it is stabilized within a treatment space at levels that are a very small fraction of the OSHA limits. Treatment spaces should have consistent and constant airflow to provide a uniform distribution of the disinfecting air. The gas-phase hydrogen peroxide limit established by OSHA for General Industry is 1.0 parts per million (ppm) and the Center for Disease Control (CDC) through The National Institute for Occupational Safety and Health (NIOSH) limit is also 1.0 ppm.[3]

None of the other oxidizing molecules created by AIRPHX are regulated by governmental entities, except ozone. Ozone is regulated by OSHA and, at elevated levels, it can become an irritant but not at the levels created by an AIRPHX units used consistent with the user guide. OSHA's limits are 0.1 ppm. Ozone is also regulated by the California Air Regulatory Board (CARB), which has established limits of 0.05 ppm.

Removal of Ozone

Earlier generations of AIRPHX units released ozone into the treatment space at levels that, when deployed consistent with the user guide, stabilized below the limits established by OSHA and CARB. In response to general market concerns about ozone (as opposed to complaints from AIRPHX customers about irritation from ozone), AIRPHX developed a catalyst that removes ozone produced by the AIRPHX unit through a thermal conversion process. [4] Since deployment of the patent pending ozone-removing catalyst, AIRPHX has tested for ozone levels using an Aeroqual Ozone Monitor confirming that only negligible levels of ozone are observed when AIRPHX units are operated in accordance with the user guide. AIRPHX is in the process of seeking CARB certification for units that now include the ozone stripping technology. In the meantime, AIRPHX has conducted its own testing using the testing methodology mandated by CARB. AIRPHX internal results show ozone levels well below those levels needed for CARB certification because, when operated in accordance with the user guide, any ozone molecules dissipate quickly to negligible levels.

Reduction of Hydrogen Peroxide

An additional impact of the ozone-removing catalyst was that it lowered the level of gas-phase hydrogen peroxide released into the treatment space. When operated in accordance with the user guide, the hydrogen peroxide molecules dissipate quickly. Since deployment of the patent pending ozone-removing catalyst, AIRPHX has tested for hydrogen peroxide levels using the Interscan Hydrogen Peroxide Analyzer generally registering levels of less than 0.02 ppm of hydrogen peroxide (1/50 the OSHA limit) when AIRPHX units are operated in accordance with the user guide. Importantly, the impact on the effectiveness of AIRPHX units in reducing airborne and surface pathogens as a result of the

[3] Regulation limits established by governmental entities do not necessarily mean that levels of regulated gases well below the prescribed limits will not be noticed by people, including those with heightened sensitivities. AIRPHX units may be operated less than 24 hours a day using the seven-day timer function in that case to reduce the amount of these gases in the treatment space.

[4] AIRPHX has filed a patent on the plasma cell incorporating this ozone removing technology that is currently being reviewed by the US Patent and Trademark Office.

deployment of the ozone-removing catalyst has been minimal. AIRPHX is aware of no CDC, FDA or Environmental Protection Agency guidelines or any other studies suggesting that gas-phase hydrogen peroxide at these low levels raise any health concerns.

Summary

AIRPHX units are safe when operated in accordance with the user guide. AIRPHX technology is operating safely in over a thousand installations such as commercial gyms, college athletic programs, hospitals (including wards of hospitals with immune-challenged patient populations), casinos, military bases, police and fire stations, food processing facilities, commercial buildings, residences, dental offices and country clubs.