What are the By-Products Formed by Odorox® Hydroxyls and Are They Safe?

Air is naturally full of volatile organic and inorganic chemicals from both natural and man-made sources. Plants, animals and people respire and produce huge quantities of isoprene, methane and other hydrocarbons. Ozone and other atmospheric gases are generated by the sun's photochemical processes. Industrial processes and motor vehicles pour chemicals into the air.

The chemicals in our atmosphere are constantly being transformed to maintain safe, breathable air by oxidation processes that are driven by the sun's UV radiation. Of all the oxidants produced by the sun, hydroxyls are the most important. Dubbed "nature's broom", hydroxyls react with and decompose the widest range of organic and inorganic compounds of any oxidant. The by-products that result are a steady state mixture of organic compounds and inorganic gases that nature has evolved to tolerate – and even benefit from. Humans, animals and plants live symbiotically in an environment rich in hydroxyls and their by-products. There are over 2 million hydroxyls in every cubic centimeter of fresh air on a sunny day. Take them away, and the air will gradually become toxic. Another benefit of hydroxyls is that they destroy bacteria, virus and mold, which would otherwise flood our environment. The body actually produces hydroxyl radicals internally to kill bacteria and virus when the immune system's initial response is ineffective.

Hydroxyls react with organic compounds by removing an H atom. Rates of reaction with volatile organic compounds are incredibly fast – on the order of 20-50 milliseconds; over one million times faster than the average reaction rate of ozone and other oxidants. Hydroxyls react so fast that they do not accumulate. As compounds are oxidized by the hydroxyls, the organic free radical that is formed by the removal of the H atom goes through a series of complex reactions whose intermediates include aldehydes, ketones and organic acids. All these compounds have oxygen attached to a carbon atom. These compounds react even more rapidly with hydroxyls at the carbon atom next to the carbon bearing the oxygen atom. Oxygen draws electrons to it strongly and weakens the nearby C-H bonds, making it easier for hydroxyls to abstract the H. The net result is that aldehydes and ketones and acids react even more rapidly with hydroxyls than hydrocarbons, so they do not accumulate when optimal levels of hydroxyls are available. The organic compounds tend to undergo chain scission near the points of oxidation…becoming shorter and shorter until they finally produce carbon dioxide and water.

At any given time there is a continuum of interim oxidized organic compounds. These by-products are never completely gone. As by-products are formed, they immediately begin a decomposition process whereby they get smaller and smaller, until they are consumed. New by-products are being formed constantly…and they too immediately begin to decompose. The condition that results is called a steady state. The steady state concentration of VOCs was measured at Columbia Labs for several different Odorox® machines and the results were that initial VOC levels dropped up to 40% and the oxidation by-products (aldehydes, ketones etc.) were essentially consumed as their levels remained at ambient levels. That means that the hydroxyls were effective decomposing the initial VOCs AND the by-products as the by-product levels did not increase. The Odorox® systems were designed to produce optimal levels of hydroxyls inside the photolysis chamber to accomplish these results. Once the hydroxyls and

by-products are distributed around the treatment space, the concentrations are diluted to levels found in nature. Not all hydroxyl air cleansing devices perform to this level of efficiency. For example, a study of Photo Catalytic Oxidation systems conducted at Berkeley Laboratories determined that they yielded levels of aldehydes and ketones that were 4 to 5 times higher than ambient levels after treatment. In that case, there was oxidation occurring on the catalyst surface, but the by-products were not effectively consumed and therefore accumulated.

What is even more important to consider is that this entire process is exactly what occurs outdoors. We are bathed in the by-products of the reaction of hydroxyls with VOCs outdoors, and have evolved to tolerate them. When normal levels of ventilation are maintained, indoor air treated with Odorox® systems should equilibrate with the outdoor air that it mixes with and there should be little difference.

The oxidants and by-products have proven to be safe based on what is found in nature and toxicology studies that HGI has conducted. HGI had an independent clinical laboratory, Comparative Biosciences, conduct an FDA Good Laboratory Practices toxicology study to evaluate the effect of hydroxyl radicals and the by-products of their reaction with ambient volatile organic compounds on rats. The animals were exposed to twice the normal levels of oxidants continuously over a 13-week test period. A broad range of physical, behavioral and neurological parameters were measured. The animals were sacrificed and extensive tissue and histology studies were conducted. There was no measurable difference between the control and exposed animals; a result that the FDA would consider sufficient to establish that the exposure to Odorox® hydroxyls and any intermediate by-products was safe.