

# Atmospheric Hydroxyl Radicals

## 1. The discovery of the 'Open Air Factor'

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Discovered by chance by the UK's Ministry of Defence in the early 1960s, hydroxyl radicals (originally called the 'Open Air Factor', often just called 'hydroxyls') are continually produced in abundance in outdoor air and wage a constant war of attrition against contaminants such as allergens, malodours, pollution, viruses or bacteria. Hydroxyl radicals are nature's way of decontaminating our environment and are the reason the environment remains safe for life.

Hydroxyl radicals are very unstable and within seconds seek out and react with contaminants in the air or on surfaces. This mixing typically breaks down larger molecules, whether chemicals like volatile organic compounds (VOC's) or minute structures such as virus and bacteria, so well that scientists have called hydroxyl radicals "Nature's Detergent" (a term first coined by Nobel Prize winner Paul Crutzen to describe this important cleansing role of OH).

## 2. The OH radical

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Oxygen ( $O_2$ ), although it makes up about a fifth of our atmosphere, is not the main oxidant. Other molecules that are produced naturally in the atmosphere, including ozone ( $O_3$ ), the nitrate radical ( $NO_3$ ), and the hydroxyl radical (OH), are much more reactive, even if their atmospheric concentrations are low. Radicals are highly reactive because they have unpaired electrons which tend to transfer to other molecules.

The OH radical is the most reactive and important oxidant in the troposphere (the lowest part of the atmosphere - below about 10 km). Most of the trace gases found in the troposphere are oxidised by OH into water-soluble products that are washed out by rain and snow.

## 3. Atmospheric creation of hydroxyl radicals

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In simple terms, hydroxyl radicals are created in the atmosphere by two principal reactions:

- During daylight hours a photochemical reaction occurs in the atmosphere where different wavelengths of light interact with water (and other chemicals) in the air and produce simpler by-products known as reactive oxygen species (ROS). One of the main types of ROS is hydroxyl radicals.

- In addition, during the entire 24 hour cycle, hydroxyl radicals are formed as part of the natural and continual reaction between ozone and terpene, a natural plant organic compound secreted into the air by plants everywhere.

There are, on average, two million hydroxyl radicals in each cubic centimeter of ambient outdoor air during daylight hours.

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## **4. The atmospheric cleansing and sanitising cycle**

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Hydroxyl radicals power the Earth's atmospheric cleansing and sanitising cycle and keep our atmosphere clean and livable:

- The surfaces of allergens, such as pollens, mould spores, dust mite excretions, pet dander and cat saliva are chemically and / or physically altered so that they no longer cause allergic reactions.
- All polluting gasses susceptible to oxidation (excepting CO<sub>2</sub>), including those problematic for humans, such as ammonia, carbon monoxide, ozone, nitrogen dioxide, nitrogen trioxide and formaldehyde, are broken down by hydroxyl radicals at varying speeds and thus removed from the atmosphere.
- Hydroxyl radicals will react in less than 100 milliseconds with VOCs. These reactions initiate a series of fast, free radical chain reactions that decompose VOCs and their by-products, keeping air safe to breathe.
- Hydroxyl radicals instantly kill all airborne human pathogens they come into contact with. Bacteria are killed by causing the thin, delicate cell walls to rupture through reaction with the lipids and proteins in them and pathogenic viruses suffer from oxidation of cell surface structures, losing their receptors and thus being rendered inactive.
- Hydroxyl radicals oxidise all long chain organic odours in seconds and, over a longer time scale, short chain and inorganic odours as well. Long chain molecules are broken down into shorter molecules which then are further oxidised to innocuous molecules.
- Vapourise carbon based ultra-fine particulates to carbon dioxide.



Humans, animals and plants have evolved symbiotically to tolerate these natural levels of hydroxyls and their reaction by-products. Atmospheric hydroxyls cannot enter the blood stream or tissues within the body. Skin and mucosal membranes have evolved to provide a barrier to entry and protect the body and are regenerated constantly to maintain their integrity and function.

## **5. Find out more**

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You can find out much more about our scientific journey, how we used internationally renowned testing organisations to demonstrate our claims and the science behind hydroxyl radicals on the Resources Page of our web site.