

# How Ozone Affects Bacteria, Fungus, Molds And Viruses



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Ozone is a naturally occurring gas created from oxygen atoms. The oxygen molecule is made up of 2 oxygen atoms. These oxygen molecules are broken into atoms by the corona discharge during lightning storms or by UV light from the Sun. Single oxygen atoms cannot exist alone without regrouping back into di-atomic oxygen molecules. During this recombination stage some atoms will regroup into loosely bonded tri-atomic oxygen. This new molecule is called Ozone, as seen to the right ( $d = 1.28 \text{ \AA}$ ,  $\Theta = 116.5^\circ$ ). Due to the loose bond in this oxygen molecule - ozone is a very strong oxidant and an ideal chemical-free purification and a disinfecting agent.

Ozone is frequently misdiagnosed and equated to low-altitude pollution. Nothing could be farther from the truth. In fact, Ozone breaks down pollutants and should be welcomed when found in the air.

The most effective way to produce Ozone commercially is through the use of pulse injected corona discharge.

Disinfection by tri-atomic oxygen (Ozone) occurs through the rupture of the cell wall. This is a more efficient method than Chlorine, which depends upon diffusion into the cell protoplasm and inactivation of the enzymes. An ozone level of 0.4 ppm for 4 minutes has been shown to kill any bacteria, virus, mold and fungus. 1 parts per million is equivalent to: 8.345 pounds per million gallons (US).

When the effectiveness of Ozone as a disinfectant was measured, there was little or no disinfection up to a certain dosage. At higher levels the sanitizing effect increased greatly. For complete disinfection a surplus or residual Ozone has to be maintained in the solution to assure that every living microorganism has been contacted.

There has yet to be discovered any antibiotic that is truly effective in the virus arena. There are indications that DNA viruses such as Herpes are implicated in human cancers, since they organize the genetic material of the host cell to produce new viruses. Ozone will inactivate viruses on contact, even at very low residual concentrations. In case of polio, only 0.012 ppm removes all viral cells in less than 10 seconds.

Mold and mildew are easily controlled by Ozone present in air and in water. Giardia and Cryptosporidium cysts are susceptible to Ozone but not affected by normal levels of Chlorine.

## The Effects of Ozone on Pathogens

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The antipathogenic effects of ozone have been substantiated for several decades. Its killing action upon bacteria, viruses, fungi, and in many species of protozoa, serve as the basis for its increasing use in disinfecting municipal water supplies in cities worldwide.

Bacteria are microscopically small single-cell creatures having a primitive structure. They take up foodstuffs and release metabolic products, and multiply by division. The bacteria body is sealed by a relatively solid cell membrane. Their vital processes are controlled by a complex enzymatic system. Ozone interferes with the metabolism of bacterium cells, most likely through inhibiting and blocking the operation of the enzymatic control system. A sufficient amount of ozone breaks through the cell membrane, and this leads to the destruction of the

bacteria.

Viruses are small, independent particles, built of crystals and macromolecules. Unlike bacteria, they multiply only within the host cell. Ozone destroys viruses by diffusing through the protein coat into the nucleic acid core, resulting in damage of the viral RNA. At higher concentrations, ozone destroys the capsid or exterior protein shell by oxidation.

Indicator bacteria in effluents, namely coliforms and pathogens such as Salmonella, show marked sensitivity to ozone inactivation. Other bacterial organisms susceptible to ozone's disinfecting properties include Streptococci, Shigella, Legionella pneumophila, Pseudomonas aeruginosa, Yersinia enterocolitica, Campylobacter jejuni, Mycobacteria, Klebsiella pneumoniae, and Escherichia coli. Ozone destroys both aerobic and, importantly, anaerobic bacteria which are mostly responsible for the devastating sequel of complicated infections, as exemplified by decubitus ulcers and gangrene.

The mechanisms of ozone bacterial destruction need to be further elucidated. It is known that the cell envelope of bacteria are made of polysaccharides and proteins and that in

Gram negative organisms, fatty acid alkyl chains and helical lipoproteins are present. In acid-fast bacteria, such as Mycobacterium tuberculosis, one third to one half of the capsule is formed of complex lipids (esterified mycolic acid, in addition to normal fatty acids), and glycolipids (sulfolipids, lipopolysaccharides, mycosides, trehalose mycolates). The high lipid content of the cell walls of these ubiquitous bacteria may explain their sensitivity, and eventual demise, subsequent to ozone exposure. Ozone may also penetrate the cellular envelope, directly affecting cytoplasmic integrity, disrupting any one of numerous levels of its metabolic complexities.

Numerous families of viruses including poliovirus I and 2, human rotaviruses, Norwalk virus, Parvoviruses, and Hepatitis A, B and non-A non-B?, among many others, are susceptible to the virucidal actions of ozone.

Most research efforts on ozone's virucidal effects have centered upon ozone's propensity to break apart lipid molecules at sites of multiple bond configuration. Indeed, once the lipid envelope of the virus is fragmented, its DNA or RNA core cannot survive.

Non-enveloped viruses (Adenoviridae, Picornaviridae, namely poliovirus, Coxsackie, Echovirus, Rhinovirus, Hepatitis A and E, and Reoviridae (Rotavirus), have also begun to be studied. Viruses that do not have an envelope are called "naked viruses." They are constituted of a nucleic acid core (made of DNA or RNA) and a nucleic acid coat, or capsid, made of protein. Ozone, however, aside from its well-recognized action upon unsaturated lipids, can also interact with certain proteins and their constituents, namely amino acids. Indeed, when ozone comes in contact with capsid proteins, protein hydroxides and protein hydroxides and protein hydroperoxides are formed.

Viruses have no protections against oxidative stress. Normal mammalian cells, on the other hand possess complex systems of enzymes (i.e., superoxide dismutase, catalase, peroxidase), which tend to ward off the nefarious effects of free radical species and oxidative challenge. It may thus be possible to treat infected tissues with ozone, respecting the homeostasis derived from their natural defenses, while neutralizing offending and attacking pathogen devoid of similar defenses.

The enveloped viruses are usually more sensitive to physico-chemical challenges than are naked virions. Although ozone's effects upon unsaturated lipids is one of its best documented biochemical actions, ozone is known to interact with proteins, carbohydrates, and nucleic acids. This becomes especially relevant when ozone inactivation of non-enveloped virions is

considered.

Fungi families inhibited and destroyed by exposure to ozone include *Candida*, *Aspergillus*, *Histoplasma*, *Actinomycoses*, and *Cryptococcus*. The walls of fungi are multilayered and re composed of approximately 80% carbohydrates and 10% of proteins and glycoproteins. The presence of many disulfide bonds had been noted, making this a possible site for oxidative inactivation by ozone.

In all likelihood, however, ozone has the capacity to diffuse through the fungal wall into the organismic cytoplasm, thus disrupting cellular organelles.

Protozoan organisms disrupted by ozone include *Giardia*, *Cryptosporidium*, and free-living amoebas, namely *Acanthamoeba*, *Hartmonella*, and *Negleria*. The anit-protozoal action has yet to be elucidated.

## Typical Dosage and Reaction Times

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- *Aspergillus Niger* (black Mound): Destroyed by 1.5 to 2 mg/1.
- *Bacillus Bacteria*: Destroyed by 0.2 mg/1 within 30 seconds
- *Bacillus Anthracis*: Causes anthrax in sheep, cattle and pigs. A human pathogen. Ozone susceptible.
- *Clostridium Bacteria*: Ozone-Susceptible.
- *Clostridium Botulinum Spores*: Its toxin paralyzes the central nervous system, being a poison multiplying in food and meals. 0.4 to 0.5 mg/1.
- *Diphtheria Pathogen*: Destroyed by 1.5 to 2 mg/1.
- *Eberth Bacillus* (*Typhus abdominalis*): Destroyed by 1.5 to 2 mg/1.
- *Echo Virus 29*: This virus most sensitive to ozone. After a contact time of 1 Minute at 1 mg/1 of ozone, 99.999% killed.
- *Escheriachia Coli Bacteria* (from feces): Destroyed by 0.2 mg/1 within 30 seconds.
- *Encephalomyocarditis Virus*: Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/1.
- *Enterovirus Virus*: Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/1.
- *GDVII Virus*: Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/1.
- *Herpes Virus*: Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/1.
- *Influenza Virus*: 0.4 to 0.5 mg/1.
- *Klebs-Loffler Virus*: Destroyed by 1.5 to 2 mg/1.
- *Poliomyelitis Virus*: Kill of 99.999% with 0.3 to 0.4 mg/1 in 3 to 4 minutes.
- *Proteus Bacteria*: Very Susceptible.
- *Pseudomonal Bacteria*: Very Susceptible.
- *Rhabdovirus Virus*: Destroyed to zero level in less than 30 seconds.
- *Salmonella Bacteria*: Very Susceptible.
- *Staphylococci*: Destroyed by 1.5 to 2 mg/1.
- *Stomatitis Virus*: Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/1.
- *Streptococcus Bacteria*: Destroyed by 0.2 mg/1 within 30 seconds

<http://www.mold-help.org/content/view/436/>