# What is Ozone

Ozone is a naturally occurring trace constituent in the atmosphere. When a molecule of Oxygen, $O^2$, is bound via oxidation to a third oxygen atom, it becomes ozone, or $0^3$. Ozone is an unstable bluish water-soluble gas with a very characteristic scent that is easy to recognize. In low levels it makes the air smell fresh and its color makes the sky blue. Ozone is second only to fluorine as the strongest known oxidizer in the world, and the most powerful readily available water sanitizer. Ozone inactivates bacteria and viruses 3,125 times faster and is a 50% stronger oxidizer than chlorine. It is unsurpassed for control of many types of common bacteria such as E. Coli and fecal coliforms as well as the de-activation of virus, fungus, mold, mildew and cysts, and is noncarcinogenic.

The name **"ozone"** was given due to the characteristic odor and derived from the Greek word **"ozien"** which means, "to smell". It has been used to purify water since 1893, and is also used for disinfecting, detoxification, and air deodorization, as well as food preservation.

# What is Ozone Alert

Ozone is used as an indicator of pollution.  Ozone alerts in cities are a result of high pollution levels of hydrocarbons, produced by the burning of fossil fuels. When ultraviolet rays from the sun strike the hydrocarbon, O3 is one of the by products. Ozone is more easily detected and is used as a reference point for the level of pollution.

# Misconceptions About Ozone

Misinformed people compare ozone to smog or pollution, and many have propagated the myths about the dangers of ozone. Some mistakenly call "smog" ozone, which is in fact formaldehyde, the combination engine exhaust and UV light from the sun. Ozone's benefits, widely accepted throughout the world, have been ignored in the United States because it's so simple and natural. It's also a market threat to many air filtration products because it will replace them once the public becomes educated relative to the real benefits of ozone.

What some refer to as "ozone" in the ground level air quality are really hydrocarbons: $CO^2$ CO, and $SO^2$ that react with UV rays from the sun to form nitric oxides (NOX), halogenated by-products, lead and sulfur compounds. These composites cause offensive odors, which aggravate respiratory problems and burn eyes. Ozone does not come out of automobile exhaust, as some would like you to believe. Currently, there are many State Universities now doing research on ozone while others are planning to research it soon.

New uses are being discovered every day and will be a big part in everyone's life in the very near future. Most ozone research by the EPA and others who show negative results have been working with very high concentration levels. For that matter, anything in excess can be harmful to your health or to vegetation. If natural ozone ceased to exist, life on this planet would also cease to exist. Ozone is nature's way of

purifying the air we breathe. In the future, the use of ozone for food will be the only "natural alternative" to chemicals or gamma radiation to control pathogens and to increase shelf life.

# How does Ozone Work?

Ozone floats freely in the air and water. As ozone circulates and comes into contact with airborne pathogens, the third oxygen atom detaches itself from the ozone molecule, attaches itself to the pollutant and turns it into a safer compound. An example would be Formaldehyde (chemical formula HCHO) which breaks down into $CO^2$, water and oxygen. Ozone is nature's way of self-cleaning our environment. The cycle of oxygen and ozone is just like the cycle of water in nature.

***Oxygen Atoms bind to form Ozone;***

***the third oxygen atom detaches to oxidize the pollutant***

For more than 50 years, Ultraviolet has proven to be effective in destroying bacteria in water. UV is that band of light located in the spectrum between 2000 to 3000 Angstrom wavelengths. The most effective germicidal range is at 2537A (254nm) for destroying microorganisms, mold spores, protozoa, virus and yeast. The intensity of ultraviolet is expressed in micro-watt-seconds per square centimeter and is the product of the lamp output in watts, the length of time of exposure and volume of water being treated. Most water-borne pathogenic (disease-causing) microorganisms are destroyed under 10,000 MW Sec./$cm^2$. Cholera can be eliminated at 6500, dysentery at 4000, infectious hepatitis at 8000, infectious jaundice at 6000 and typhoid fever at 4100.

The biocidal action of ozone results from its reaction with the double bonds of fatty acids in bacterial cell walls, membranes and the protein capsid of viruses. In bacteria, the oxidation results in a change in cell permeability and leakage of cell contents into solution. Ozone attacks these cell walls, breaking down membranes and ultra structural components of the organism. In more simple terms, the unstable electrons of ozone blast holes through the membranes. This occurs by cell lysine or rupturing the cell wall of viruses, bacteria, yeast, and abnormal tissue cells, thereby destroying them by inactivation of the microorganism's enzymes. In viruses, alteration of the protein capsid prevents the virus from being taken up by susceptible cells.

Ozone displays an all or nothing effect in terms of destroying bacteria. Ozone is such a strong germicide that only a few micrograms per liter are required to demonstrate germicidal action; it destroys all pathogenic and saprophytic microbes in water. Factors like humidity, temperature, pH, ozone concentration levels, type of organism and time, determine the kill rate for pathogens. The action of ozone gas in water is instantaneous. After oxidation, ozone returns to its original form of oxygen, with out leaving any toxic by-products or residues.

Ozone oxidizes natural organic compounds like acetic and oxalic acids, as well as synthetic substances like nitro and chloro-benzic compounds, detergents, herbicides

and composite pesticides like 0 Enstar, Mavrick, Blackleaf 40 and Resmethrin. Ozone oxidizes inorganics such as iron, manganese, heavy metals, cyanide, sulfides, and nitrates in water. It is possible that by washing fruits and vegetables in ozonated water, that lead levels could be reduced, along with many other contaminates in the soil and from air pollution. Ozone retards the ripening of fruits and vegetables by destroying ethylene gas and bad odors, which are produced by aging and decay.

Ozone is more cost-effective than ethylene filters, which are costly and have to be replaced each month. Filters only act on the air that happens to pass through them, and ionization machines put a negative charge on air particles in the air which cau ses them to gravitate to room surfaces. Unlike ozone, filters, ionizers and sprays do not eliminate the cause of odors. Once the cause has been eliminated, the odor does not come back unless the source that caused the odor is reintroduced, such as in the case of mildew.

## Ozone is Natural

Ozone occurs naturally in the environment. Oxygen is released from plants and sea plankton during photosynthesis. Oxygen floats upward into the atmosphere and the sun's ultraviolet radiation creates ozone by binding a third oxygen atom to normal oxygen's two. Ozone is also formed during thunder and lightening storms. Natural ozone in the atmosphere blocks harmful UV rays that cause skin cancer.

The EPA lists natural $0^3$ background concentration levels near sea level in the U.S. at 0.003 to 0.005 parts per million (ppm). These levels can be higher in the mountains and northern parts of the country or lower in some latitudes; it also varies by season. Because the natural production of ozone is dependent on the amount of the sun's energy, there is less ozone over the poles in the winter months when there is a lack of sunshine. Ozone can not be produced without the presence of oxygen; therefore ozone is not naturally available in water.

## Chemical Properties

The triangular-shaped ozone molecule has a bond angle of 11.6° x 49° between the three oxygen atoms according to microwave studies, or 127° according to electron studies. The actual structure of ozone is a resonance hybrid. Nordion Reaction Chambers produce 0.5 ppm (parts per million) of ozone in the smaller reactor and 0.7 ppm in the larger reactor. The two bond lengths are equivalent at 0.1278 run. The resonance forms do not show any unshared electrons: unlike oxygen, the ozone mol ecule does not show any paramagnetic properties. Para magnetism would impart free radical properties, but this has not been observed with ozone. The radical reactions by ozone involve the decomposition of peroxides formed by products of ozone reactions.

## Is Ozone Safe

Ozone is safe at low levels to humans, at very high concentrations it can be harmful; however, there have not been any human deaths attributed to ozone usage since

1885. There is no basis or evidence for concluding or supporting any significant amounts of bad residues or impurities left on foods after ozone oxidation. Ozone is not listed as a carcinogen by OSHA, NTP, or IARC. The human irritation threshold is about .06 parts per million (ppm) with no evidence of health damage by continuous exposure to lower concentrations. EPA level is .1 ppm, FDA and ASHRAE set level is .05 ppm, USDA set level is 0.1 ppm, OSHA level is 0.1 ppm for an 8 hour exposure, and the American Conference of Governmental Industrial Hygienists limit for 8 hour exposure, with no side effects, is 0.1 ppm. At a steady concentration between 0.01 to 0.045 ppm of ozone, the level used by most systems is well below safe limits. If higher levels are needed in special cases, the ozone could be controlled by a time clock or computer to run at night, or when humans are absent, for safety concerns.

In fact, the main benefit from using ozone is the reduction of various disease-producing microorganisms including fungus, molds, bacteria, spores and other single-cell creatures that cause spoilage of fresh foods. Ozone production removes nitrogen, thus removing nitrous oxides and nitric acids. There are no special health hazards, no additional labeling required, material safety, or special worker protection required for using ozone on perishable foods because of the low level intended for its use. Fire and explosive data are not applicable to its use. All tests results showing negative results are done at very "high and unsafe levels," and it seems the ones performing these tests might have been using smog instead of ozone. Any information of this type has no bearing and in no way whatsoever applies to the safety of ozone.

There are thousands of chemicals, along with thousands of others added to the soils by growers, added to the foods consumed by the public. There are over 700 chemicals found in city drinking water. Unlike chlorine, ozone does not produce trihalomethanes or chloroforms in water. Although chlorine can be blamed for hundreds of thousands of deaths worldwide, there is no evidence of any human deaths of over-exposure to ozone. Chemicals can cause severe personality changes, skin rashes, chronic cellular toxicity, cell damascene, aging, cancer etc; the use of ozone can help. It's estimated that 30 million people a year get sick on the foods they consume and some even die. The reduction and control of pathogens is essential on fresh food products like meats, fish, fruits and vegetables from farm to table. Bacteria, molds, spores, viruses and other single-cell creatures cause spoilage of fresh foods and decreases shelf life. Organic or bacterial growths on produce and refrigeration coils, pans and in drain lines that plug or restrict flow can cause cross-contamination to other foods in storage. Ozone has the capability of destroying bacteria in a matter of a few days. Ozone does not effect good cells or alter food chemistry the way radiation does. Ozone will actually enhance the taste of most foods by oxidizing pesticides and herbicides on fruits and vegetables and by neutralizing ammonia and ethylene off gases produced by ripening.

Ozone, like irradiation, could increase the world's food supply by lessening waste, and can increase the market exports to other countries because of extended shelf life to perishable foods. Unlike radiation, Ozone is a natural disinfectant and sterilizer; therefore much healthier. Benzene, which decreases vitamin B1 in all foods, is formed in large doses of radiation. Ozone changes the chemicals complex molecular structure back to its safe and original basic elements. There are no bad residues left

by the oxidation effect. Ozone always reverts back to its original form, oxygen, after oxidation. Without dispute, scientifically speaking, ozone is the most effective natural bactericide and viricide of all the disinfecting agents.

## Manufacturing Process

Ozone created electronically or through ultraviolet light converts molecules of oxygen into molecules of ozone, sometimes referred to as activated oxygen, triatomic allotropic form of oxygen or pure air. Being an unstable gas, its life span is about 2 0 minutes, depending on the temperature. After completing its job, it reverts back to oxygen. This means ozone cannot be bottled, stored or shipped to the consumer; it has to be produced on site. Present day technology makes Ozone generators more cost effective; in fact, there are many different types and variations of equipment for a wide range of applications.

Ozone is manufactured by compressing outside air and pushing is across an ultraviolet bulb mounted in 2" PVC tubing. Check valves are used between compressor and bulb and after the bulb. The bulb used in the PZV system is a cold cathode type. Large installations utilize the cold corona discharge method for ozone production. Pure oxygen from oxygen generators removes contaminants or impurities for a higher grade of ozone; this keeps equipment size and cost to a minimum.

## Ozone Usage

Any business involved in the gathering foodstuffs, storage, preparation, or serving can benefit from the use of ozone preservation. Some advantages of using ozone for food preservation are longer shelf-life, pathogen control, better visual and taste ap peal, bad odor elimination, fungus growth prevention, mold and mildew deterrent, ethylene gas destruction, algae growth prevention, and reduced food contamination. Some business advantages include promoting better growth and soil pH, preventing slime build-up on food and equipment, reducing pesticides and herbicides, cutting labor costs, and lower product losses. Consumers and industry alike benefit from the absence of  by-products or residues, environment enhancement and that it's a better alternative to chemical preservation.

Other uses include hotels/motels, funeral homes, athletic clubs, pool parlors, bus companies, RV rentals, restaurants, used car lots, nursing homes, locker rooms, jails, beauty parlors, auto rentals, day care centers, airlines, college dorms, grocery stores and florists. Because ozone is very effective in extending shelf life, any business with perishable inventories can, in some cases, double length of storage time.

The Agriculture Industry and Poultry Industry routinely incurs a high expense for water and chemicals to recycle processed wash water for cleaning and bacteria reduction. USDA has already approved ozone in Poultry chill water, so that wash water can b e recycled or reused. This results in reduced cost, eliminates chemical storage, handling and disposal problems, as well as less chemical off-gases inhaled by workers. Ozone reduces the corrosive action on equipment and plumbing.

## Any Negative Issues?

With very high concentrations of ozone, metals can be attacked and oxidized but are protected if they are varnished or painted. Ozone can attack natural rubber, but synthetic rubber shows a much higher resistance. The compatibility of ozone on materials like plastics, Teflon, hynar, tygone, likicone, Viton ® and others have no noticeable deterioration. Most processing equipment is made out of stainless steel, which also shows no effect. Package materials should not show any degradation from ozone; it is likely that the ozone would have decomposed by the time it reaches this point.

## History

Charles J. Kenworthy, MD first published ozone use in the United States in 1885 for the Florida Medical Association. The brief outlines the acceptance of ozone for Medical use before this date. Medical Ozone seems to be used in all other countries but not legally in the U.S. except for alternative medicines.

Although the U.S. only recently uses ozone to purify water, European countries have been doing so since 1903. The Germans first used ozone on meats in 1909 in Cologne, France. All foods are subjected to natural ozone, yet the FDA does still not approve it for food preservation. USDA declared on Dec. 12, 1994 that it has no objections to applied Ozone Systems in the air at all Federally Inspected Meat and Poultry Plants, at levels under 0. 1 ppm. Other research data culled over a long period of time supports the use of ozone in the United States and other countries.

## Legal Ramifications

Ozone has Grandfathered Legal Status and predates the 1906 pure Food and Drug Act. Ozone has prior GRAS (Generally Regarded as Safe) Affirmation as an Antimicrobial Agent in bottled water. The "Functional use of" code 170.3 (o) (2) supports ozone as an "Antimicrobial Agents Substance" used to preserve food by preventing growth of microorganisms and subsequent spoilage. This does not specify that the functional use is for water only, but it does affirm its use on food as safe. USDA Approval on Aug. 1 3, 1957 endorses ozone for use in meat aging coolers at a level of .1 ppm. USDA Approval for American Water Purification in 1991 approves ozone for Recycling Poultry chill water at a level of .7 to 1.7 ppm.

## Corona Discharge vs. UV Light

There are 2 main methods to producing ozone for air purification purposes. The following explanations are very simple.

**Corona Discharge** - When a wire mesh type of medium (made from stainless steel) is charged with electricity and
exposed to air (oxygen) produces ozone. The more electricity one subjects the medium the greater the ozone output.

**UV** - Ozone is manufactured by compressing outside air and pushing is across an ultraviolet bulb mounted in 2" PVC tubing. Check valves are used between compressor and bulb and after the bulb. The bulb used is a cold cathode type.