APPLICATION NOTE FB-100

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Ozone for Food and Agricultural Products Storage

There has been a lot of interest and many experimental projects for the use of ozone to improve the storage of fruits, vegetables, flowers, meat, fish, cheese, etc. This interest has turned to action recently when a special panel of food and ozone experts convened by the Electric Power Research Institute gave ozone GRAS (Generally Recognized As Safe) status for direct food contact applications. The most common uses of ozone for food treatment are: extension of market-quality storage life (preservation), control of pathogens (disinfection), and prolongation of the ripening time of fruits and vegetables (prolonged ripening). Most often, ozone is used to replace chlorine. Ozone is a strong oxidant, leaves no residue or known harmful by-products, and acts over a wide spectrum of organisms. Little has been published about the required ozone concentrations and other treatment procedures to achieve desired results.

Control of pathogens.

The control of pathogens is generally reported in the concentration of ozone, C (in mg/L or ppm) per unit of contact time, T (in minutes), to reduce the proportion of colony forming units, CFU. The process is called a log reduction because the population reduction is logarithmic. A formula for expressing this is:

$$CT = K \log (CFU_{start}/CFU_{finish})$$

Where K is a constant for the food in question, the units of measurement used, and for a given temperature and humidity. For example, if 5 mg/L of ozone applied for one minute will reduce the CFU levels by a factor of 10, then 5 mg/L of ozone applied for an additional minute will reduce the remaining CFU levels by another factor of 10. In other words, the constant application of ozone will continuously reduce the CFU levels but will not eliminate them. Also, 5 mg/L of ozone applied for one minute has the same CFU killing effect as one mg/L of ozone applied for 5 minutes. The ozone treatment could be in air or wash water although the value of K will depend on whether the carrier medium is air or water.

Treatment in Air

Typical ozone concentrations reported for treating foods in an air environment, such as a cold storage room, are 2-7 ppm. Some researchers feel that bacteria may actually be stimulated in low ozone levels somewhere below 0.1 ppm. High ozone levels can damage fruit with black spotting, etc., and this concentration starts at 6-7 ppm for some fruits. Temperatures in the treatment areas are typically a few degrees above freezing. Treatment time for significant reduction of pathogen levels ranges from hours to days. Virus and bacteria are the most easily controlled pathogens. Fungus and its byproducts such as molds require higher concentrations of ozone for longer periods of time.

The Eco Sensors model OS-4 monitor/controller is suitable for ozone concentrations in the 0.05-20 ppm range. It is designed for use in cold storage and other treatment rooms and have adjustable detection levels for controlling ozone generators or actuating alarms. The Eco Sensors models C-30ZX, EZ-1X, and A-21ZX are all recommended for monitoring residual ozone levels in the air for personnel safety. For very cold or humid areas, and where there are other gases present such as forklift fumes, our UV-100 UV absorption analyzer is recommended.

Ethylene and Ripening

Ripening of fruits and vegetables and the blooming of flowers will be delayed in an ozone atmosphere. This is because the ripening agent for all plant life is ethylene, a simple volatile organic compound (VOC) produced by all plant life, and the ethylene is oxidized to carbon dioxide and water when treated with sufficient ozone. After this reaction there will be less ethylene and less ozone. With less ethylene present, the ripening time is prolonged. Increases of about 50% are reported. The ozone concentration will be lower, however, near the fruit and vegetable surfaces emitting the ethylene and so the pathogen killing power will be less in those areas.

We recommend for general storage area monitoring that the ozone sensors be positioned at least 15 cm (6") from fruits or vegetables with strong ethylene emissions because the ethylene can cause reduced and confusing readings. Alternately our UV-100 UV absorption analyzer will give readings without interference from the ethylene.

Treatment in Water

Ozone has been used for many years to treat pathogens such as bacteria and algae in water for applications such as drinking water supplies and air conditioning system cooling water. More recently, most water bottlers have adopted ozone. Ozonated water for treatment of fruit, vegetables, fish, etc. in the U.S. awaited the GRAS approval. Now that has happened, and projects are emerging everywhere. A basic difference over other ozone-in-water applications is that the ozone contact time with the food product must be very short. The carrots, fresh fish fillets, or whatever must be processed in an assembly line in at most a few minutes.

Ozone concentrations in water of 1-10 ppm (1 ppm = 1 mg/L) are reported. About 2 ppm is a commonly reported concentration for treatment times of a few minutes. Tripling this concentration can reduce the treatment time to a minute or so in many cases. The concentration of ozone required to achieve a given reduction of CFU levels varies by fruit, vegetable, species of fish, etc. as well as ambient considerations. The concentration of the ozone in the water varies as a function of the feed gas ozone concentration (usually over 1% or over 10,000 ppm of ozone) and the water temperature (The maximum concentration increases with colder water). Ozone's effectiveness in wash water may be significantly reduced when the biological oxygen demand (BOD) of the water is more than 500 mg/L. In this case, the BOD must be reduced before the ozone treatment stage.

Eco Sensors ambient air monitoring instruments such as the C-30ZX, EZ-1X and A-21ZX are used in ozonated water installations to monitor for ozone leaks and generally excessive levels in the workplace. The EZ-10W is used for measuring concentrations of dissolved ozone, and the Eco Sensors DOM-1 is used for on-line dissolved ozone measurements, monitoring and control.

References

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