Antimicrobial effect of ozone in the food industry

Identification

Key words  ozone, treatment, aqueous ozone, gaseous ozone, modified atmosphere packaging, microbial quality, spray-washing, decontamination, food application, inactivation

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How does it work?

Primary objective  Ozone has a strong oxidizing effect. Due to the antimicrobial effects of ozonated water and gas, use of this technology in the food industry to decrease microbial populations is very effective. Applications such as decontamination of water, cleaning stainless steel surfaces of bacterial load as well as for food preservation would all result in shelf life extension [1].
Ozone is able to reduce membrane fouling and has an effect to the complex nature of the natural organic matter. This is an important feature for the fouling reduction of membrane filtration in water treatment [2].

Working principle  Ozone is generated on site. The corona discharge method is usually used to generate commercial levels of ozone. If air is passed through the generator as a feed gas, 1-3% ozone can be produced. Two electrodes dissociate the diatomic oxygen molecule. Fractions of these collisions occur and a molecule of ozone can be formed from each oxygen atom. Practical carrier of ozone is liquid (best water) in which the ozone can be partly dissolved [3]. Technology is available for dissolution of ozone into the liquid. Ozone is partially soluble in water but ozone is more stable in the gaseous than in the aqueous phase. It is possible to use ozone as a disinfectant because of the high oxidation potential. Different categories of contaminants can all be treated with ozone:
• Bacteria—all known
• Fungi and yeast—all known
• Protozoa (including parasites and amoebae)—all known.
• Its effectiveness against “Cryptosporidium” has some limitations, yet is still the most effective of all known sanitation agents for this organism [4].
Therefore ozone is effective against microorganisms on food-contact surfaces such as fresh fruits, vegetables, grains, seeds, nuts, legumes. In addition yeast and mold spores that float in the air in food processing plants were inactivated.
Inactivation by ozone is a complex process. It appears that ozone damages the following cellular constituents: Unsaturated lipids in the microbial cell envelope, the lipopolysaccharide layer of Gram negative bacteria, intracellular enzymes and cellular structures. Gaseous ozone treatment can extend the shelf life. The efficacy to reduce bacterial populations in food components depends on the food composition and surface structure of the food [5, 6]. High fat and protein content or areas that are not freely exposed to ozone can cause treatment inefficacy [7, 8].
Ozonated water is being used successfully to clean and disinfect surfaces and equipment (barrel cleaning, tank sanitation and clean-in-place operations) [9].
Additional effects
Ozone interacts with processing equipment (compatibility of stainless steel is good, but rubber in seals, pipes and other components reacts actively with ozone, leading to a total disintegration)
Toxicity, depending on the concentration. Symptoms resulting from exposure to ozone at 0.1-1.0 ppm. Ozone must be monitored in the workplace. Sensors trigger an alarm when the concentration rises above 0.1 ppm [10]. No pathogen can survive 1.5 milligrams of ozone per liter for 5 minutes at normal drinking water pH and temperatures. Ozone is unstable and breaks down without leaving residues. Some additional benefits of ozone in the food preparation industry are that it:
• Extends the shelf life of food products
• Is much safer for employees than any conventional chemicals
• Eliminates all chemical usage and is chemical-free, without the chemical byproducts of chlorination
• Eliminates the use of hot water and conventional sanitizer
• Is generated on site, thus eliminating the transporting, storing and handling of otherwise hazardous materials
• Running costs are low. But total costs have to be calculated: generator depreciation, repair, energy etc.
• Permits recycling of wastewater

Important process parameters
ozone concentration, temperature, treatment time

Important product parameters
Solid treatment: surface structure, food properties affect the activity of ozone (ineffective for disinfection of food products when extraneous organic matter is present), pH value
Liquid treatment: temperature, pH value, metal ions, impurities, protein-burden, exposure to UV radiation [9, 10]

What can it be used for?

Products
Fresh vegetables and fruits with intact surfaces, sanitation of food plant equipment, disinfectant stage in CIP-systems, refrigerated room atmosphere

Operations
surface decontamination and food storage applications

Solutions for short comings
Process to preserve fresh products, water treatment, plant equipment, bottle washing, treating wastewater, reduce membrane fouling

What can it NOT be used for?

Products
product with extraneous organic matter

Operations
Application of ozone systems as “USDA approved” for sanitation of food contact and non-food-contact surfaces.

Other limitations
Loss of product quality limits uses of ozone and depends on the chemical composition of food, ozone dose and treatment conditions.

Risks or hazards
After contact, ozone can cause toxicity symptoms like headache, dizziness, a burning sensation in the eyes and throat [10]. Fortunately, low concentrations in air are quickly detectable
Implementation

Maturity
Ozone has been used by the European food industry as a standard and as a sanitizer for their public water for over a century. Commercially available up to treatment capacities of 70 – 735 g Ozone/ hour.

Modularity /Implementation
Easy implementation into existing equipment. Mobile ozone surface sanitation system available

Consumer aspects
User perceive the technique as environmentally friendly, because ozone reduces the need to use and store hazardous substances. Ozone breaks down without leaving residues [11].

Legal aspects
In Germany the use of ozone as a processing agent is approved. To date there has been no approval available for the use of ozone as a surface sanitizer for food processing equipment and environment (Art. 14 VO (EG) Nr. 178/2002; Art. 3 VO (EG) Nr. 1935/2004 i.V.m. §§ 30, 31 LFGB) [12].

In June 2001 the Food and Drug Administration's final ruling published in their Federal Register, approved ozone as an additive to kill food-borne pathogens “as an antimicrobial agent on food, including meat and poultry.”

Environmental aspects
Waste free technique.
Ozone is a greenhouse gas. About 10% of the atmospheric ozone is present in the troposphere but a very small concentration of ozone occurs naturally at the earth’s surface [13]

Facilities that might be interesting for you

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<th>Title</th>
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<tr>
<td>Auditorium IRTA</td>
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<td>Clean room – Histocell</td>
<td>Noray</td>
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<td>Video observation system for market research and product development tasks - Keki</td>
<td>NAIK EKI</td>
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Further Information

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<td>DIL, TTZ, ParqueTecnológico de Valencia</td>
<td>NORMEX AS, BWT Wassertechnik, Hydro-Elektrik GmbH</td>
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References

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10. Pascual A., Llorcal.,Canut A. Use of ozone in food industries for reducing the environmental impact of cleaning and disinfection activities. Trends in food science & technology, (18) 2007: 29-35

Source: