Water Technology

Pass the ozone — and hold the *E. coli*

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Technical Pages
Food industry turns to ozonation for packaging, facility disinfection.

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In 2006, several well-publicized outbreaks of food-borne illness spread across the United States, the most infamous being contaminations involving *E. coli* 0157:H7, a fecal coliform which hitchhiked on packaged spinach, infecting over 190 people in 26 states. The tragic outcome of this epidemic was three deaths from hemolytic uremic syndrome, a complication that occurs when the *E. coli* infection destroys red blood cells, leading to rapid kidney failure.

On the heels of the spinach-related *E. coli* incidents came an isolated case of botulism food poisoning from improperly stored carrot juice, resulting in the paralysis of a Florida woman.

Then, just in time for the 2006 Christmas holidays, came headlines announcing that *E. coli* had struck again. At first it was determined that the infection was spread by a batch of green onions, but further investigation by the US Food and Drug Administration (FDA) determined that the delivery vehicle was packaged iceberg lettuce. The lettuce found its way into a national restaurant chain's tacos, sickening over 60 people in four states.

Food industry looks to ozone

In the face of so much bad press, intense scrutiny by the FDA and the loss of millions of dollars in sales, growers and food processors have publicly committed to formulate a plan to protect the public against future outbreaks.

The good news is that there are those in the food industry who have already pioneered an advance in food sanitation and disinfection that will help ensure the safety of our food supply — an advance called ozone.

Ozone as a disinfectant

The use of ozone as a disinfectant is not a new idea. In 1840, a German chemist discovered that the passage of dry air through a field of electrical sparks produced a pale blue gas that contained molecules comprised of three oxygen atoms. This molecule was named ozone (O_3), an allotrope, or different form, of the common two-atom molecular form taken by oxygen (O_2).

It was later discovered that the transfer of ozone gas into water rapidly killed micro-organisms; the ozone then reverted back to the two-atom oxygen molecule. Since that time, purified ozone gas has become the primary water disinfectant used throughout western Europe.

Recent headway in US

In the US, the Sea World theme park was one of the earliest users of ozone as a water disinfectant, with the first installation occurring at its San Diego park in the mid-1960s. The aquarium began using ozone to eradicate fecal *E. coli* organisms that accumulated from the marine mammal population.

Unlike chlorine, which left behind a chemical residual that could harm tank inhabitants, ozone rapidly decayed back to its parent molecule, the conventional O_2 form of oxygen, after oxidizing the bacterial cells. Today, all US aquariums rely on ozone as their primary water disinfectant.

Ozone did not make much headway in US drinking water supplies until 1993, when contamination of the Milwaukee, WI, drinking water system by a chlorine-resistant pathogen, *Cryptosporidium parvum (C. parvum)*, sickened over 400,000 residents, resulting in 111 deaths.

From drinking water to foods

Following the Milwaukee outbreak, laboratory studies revealed that *C. parvum* was highly resistant to chlorine and able to infect after a 24-hour immersion in bleach. Additional research also discovered that ozone, at concentrations as low as 0.5 parts per million (ppm) would destroy the pathogen in less than 10 minutes.

The tragedy in Milwaukee resulted in a significant change in US Environmental Protection Agency drinking water regulations relating to disinfection. Today, residents in Dallas, Phoenix, Las Vegas and many other cities consume ozone-disinfected drinking water.

The emergence of ozone as an effective and safe drinking water disinfectant sparked research into other possible applications of this powerful disinfectant, one being the use of ozone as a food sanitizer.

Produce wash

Strickland Foods in Nashville, TN, a provider of packaged fresh-cut produce and salads, pioneered this use of ozone in the late 1990s. Data collected from the Strickland plant and other test sites led to the approval in 2001 by the FDA and US Department of Agriculture (USDA) for use of ozone as an antimicrobial agent on all foods.

Strickland continues to use ozone as a produce wash and has never experienced an incident of food-borne illness related to their fresh-cut produce and salads.

Extended to food handling

Today, even food handlers are using ozone to ensure against food contamination.

For example, Athens Seafood, a wholesaler-retailer in Athens, GA, has a small, centralized ozone system that supplies ozonated water throughout the store. The ozone-enriched water is used to wash down fish, cutting boards, floors and employees' hands.

The effectiveness of an ozone wash on sanitizing surfaces was first investigated by Air Liquide, an industrial gas technology company. In its research, surfaces were first inoculated with pathogenic or food-spoilage organisms, then exposed to an ozone wash from a portable ozone wash cart. The results were dramatic, with *E. coli* destroyed in less than 30 seconds.

In addition to surface sanitation, the store also uses the ozone-charged water to make ozone-enriched ice. Seafood in the store's display case is packed in this ice to retard spoilage and reduce store odors.

Typical ozone systems
Water treatment professionals interested in offering ozone disinfection to food processors should be familiar with effective ozone systems, which generally consist of the following key components (see photos):

1. A source of clean, oil-free, pressurized, dry air (dew point ≤ 60 degrees C [140 degrees F])
2. An (optional) oxygen concentrator (dries air and increases the air oxygen concentration to boost ozone production)
3. An ozone-generating cell or dielectric
4. A method to transfer the ozone gas into the water, followed by a method to degas the water (remove any undissolved ozone gas bubbles, followed by the passage of the removed gas through an ozone-destruct, which uses a catalyst to convert ozone back to oxygen)
5. An instrument to measure the amount of ozone in the water
6. An instrument to monitor the ambient air for concentrations of ozone gas that may have escaped into the immediate working environment. The unit will alarm and shut down the ozone generator if ambient air ozone reaches the US Occupational Safety and Health Administration (OSHA) threshold limit value (TLV) of 0.1 ppm (the recommended maximum concentration of ozone for continuous human exposure over an eight-hour period).

A small ozone system could contain components 1 through 4 on a single skid — measuring, for example, 24″ x 28″ — with items 5 and 6 installed as wall-mountable instruments.

Larger ozone systems generally require an external air compressor system, either plant air with additional filters and a dryer to prepare it for ozone generation, or a separate air compressor package.

Systems more compact
With the effectiveness of ozone now recognized by the US EPA, FDA and USDA, the ozone industry is producing smaller, more cost-effective ozone systems that can fit any space and budget.

From small ozone hand-wash stations for food plants and restaurants to skid-mounted equipment for centralized ozone wash systems, the use of ozone, generated from purified oxygen, is expected to grow exponentially in the years ahead.

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