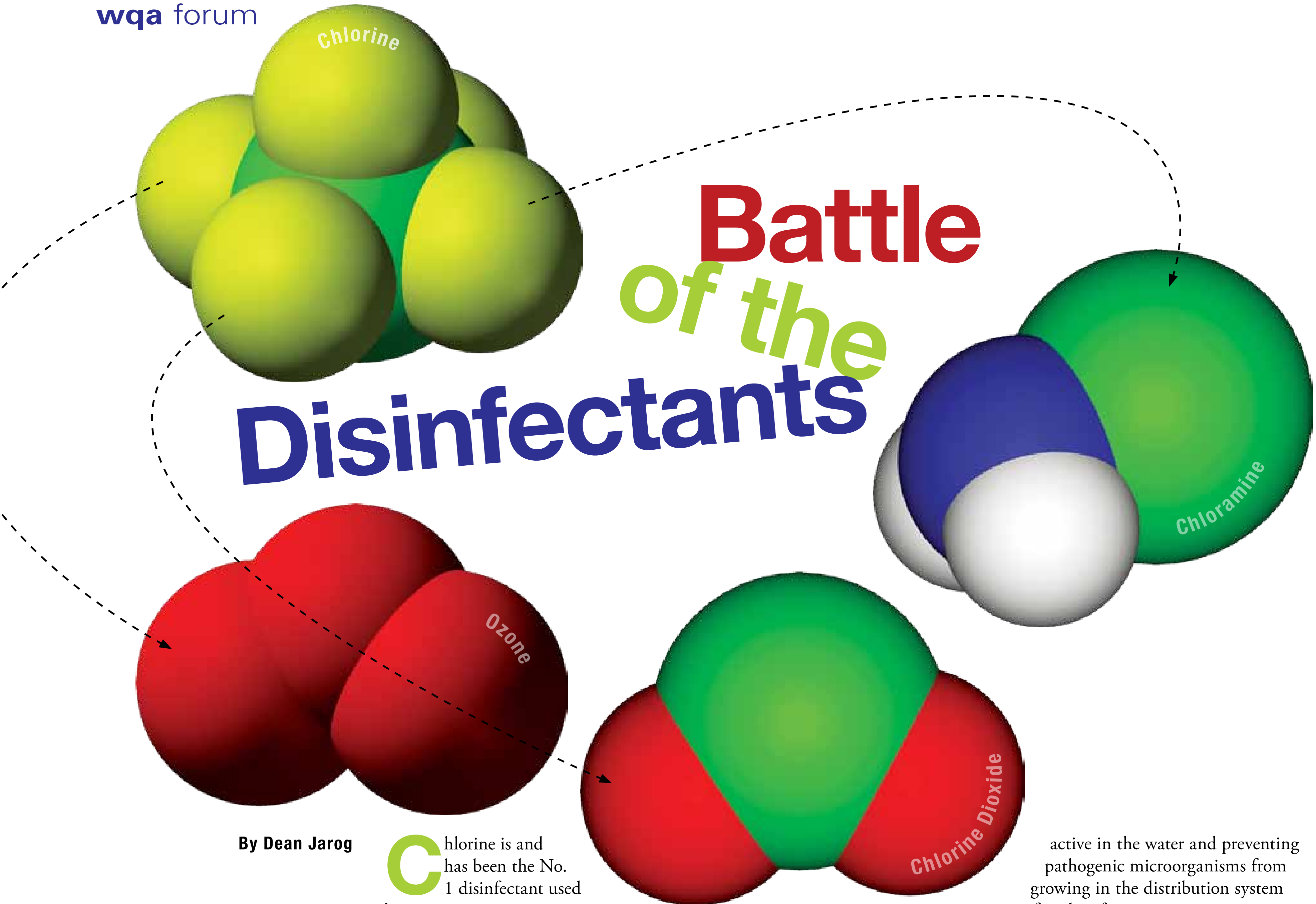

Battle of the Disinfectants

By Dean Jarog

New disinfection options may provide alternatives to traditional chlorine

Chlorine is and has been the No. 1 disinfectant used by water treatment systems throughout the world for more than 100 years. Currently, a majority of municipal water systems use chlorine to disinfect their drinking water. Recently, though, concerns over chlorine's limitations have emerged, and research into alternative disinfectants is ongoing.

To better understand the significance of chlorine as a disinfectant and the reasons why it remains such an effective choice for municipal water systems, a little history is in order, followed by an explanation of the issues and a look at some alternative disinfectants.

Discovering Disinfection

Chlorine was first used by a U.S. municipality in 1908, when Jersey City (N.J.) Water Works instituted permanent, wide-scale chlorination of its drinking water. Other cities and towns soon followed, and the waterborne diseases that had claimed tens of thousands of lives for centuries suddenly lost their deathly hold as chlorination gained its reputation as a disinfectant.

Interestingly, the path leading to discovering that certain illnesses were caused by pathogens was long and arduous, but the use of chlorine to combat these microorganisms came quickly in the 19th century, before that association was widely accepted. Although British scientist John Snow observed a correlation between cholera and contaminated well water in 1854, it would be much later in that century before Louis Pasteur convinced the world of germ theory. Chlorine was being used as a germicide, however—albeit rarely—in the early 1800s, and Snow had conducted experiments using chlorine in drinking water to combat cholera before his death in 1858. Chlorine took the lead early and has never faltered in its effectiveness.

Chlorine is so effective as a disinfectant because, as one of the most reactive elements, it is an excellent disrupter of chemical bonds. Free chlorine (formed when chlorine is dissolved in water) breaks the chemical bonds in bacteria and viruses by exchanging one of its atoms for one or more of the hydrogen atoms in pathogens' enzymes, resulting in their destruction and death. In addition, chlorine creates a residual effect, remaining active in the water and preventing pathogenic microorganisms from growing in the distribution system after disinfection.

Chlorine does have limitations, however. While most pathogens have little resistance to chlorine, protozoan cysts like *Cryptospordium* and *Giardia lamblia* have molecular structures that resist its disruptive abilities. And because chlorine is effective due to its highly reactive nature, it also can react with naturally occurring organics in the water to form disinfection byproducts (DBPs), such as trihalomethanes and haloacetic acids, which may pose health risks when consumed over time at levels above the maximum contaminant level.

Alternative Options

Because of chlorine's limited ability to kill cysts and the health concerns associated with its production of DBPs, alternative disinfectants recently have received a great deal of attention. Chlorine dioxide, ozone, chloramine and ultraviolet (UV) light are all viable disinfectants, but they have their own limitations as well.

Chlorine dioxide is a powerful disinfectant and it can maintain a residual. However, the technology is relatively new and complex, so production costs can be high.

Ozone also is a potent disinfectant. It does not maintain a good residual in the distribution system, however, and is used only as a primary (treatment plant) disinfectant. Ozone technology can be costly and complex, and, when bromide is present, bromate—an undesirable DBP—is produced.

Chloramine, a mixture of chlorine and ammonia, provides a stable and long-lasting residual in the distribution system. It does not have the disinfecting power of chlorine, however, and therefore is not used as a primary disinfectant in treatment systems. Production issues with chloramine formation can lead to potential water quality problems, including nitrification (conversion of ammonia by bacteria to nitrate and nitrite), corrosion of lead and copper plumbing, and formation of nitrogen trichloride, which may be harmful to humans and creates negative tastes and odors.

UV light is a good disinfectant and is easy to maintain, but provides no residual effect. It is not good at inactivating protozoan cysts, and its effectiveness is reduced in the presence of suspended solids, turbidity, color or soluble organic matter in high levels.

The search for even better disinfectants has led to new research into other potential options, such as iodine, bromine, permanganate, hydrogen peroxide, ferrate and silver. Some of these oxidants may have applications in specialized water treatment technology, such as small water treatment systems, point-of-use or point-of-entry devices, and bottled water production. Inadequate data on their biocidal activity for various waterborne pathogens and their toxicity risk, as well as higher costs associated with installation and operation, have limited their use in public water supply treatment.

Disinfection & the Future

Chlorine remains the disinfectant of choice for municipal water treatment plants in the U.S. It kills a wide range of disease-causing microorganisms while creating a residual effect. It is widely available, easy to measure, relatively simple to handle and cost-effective. Water chlorination has saved many lives and was named the most important advancement in public health during the last millennium by *Life* magazine in 2008.

But this is a new millennium, and new challenges lie ahead. In addition to the health threats posed by DBPs, concerns about emerging chemical contaminants, including industrial solvent stabilizers, fuel oxygenates, pharmaceuticals and herbicides/pesticides, need to be addressed.

Unlike the easy fix that chlorine provided in the 19th century, there is no expectation that a simple solution for these contaminants is out there waiting to be discovered. Multi-treatment processes that combine chlorine or chlorine-based disinfectants with oxidizing processes look promising, as does pretreatment filtration. One thing is certain, though—chlorine is not being replaced as the primary disinfectant of municipal water systems any time soon. *wqp*

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