

## Disinfectant Actives Review, Part 2 of 5: “Quats”

# Peroxygens

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Peroxygens have enjoyed widespread use throughout the sanitation field, having first been unknowingly used as a biocide in the mid 1800s—prior to Pasteur’s work associating bacteria with disease. A peroxygen is a chemical containing a peroxide anion or an O-O single bond group, most often found in sanitizing formulations in the hydroperoxide form (-OOH).

Peroxides are part of a larger oxides chemical family that also contains superoxide, ozone (O<sub>3</sub>), and ozone’s UV catalysis product, hydroxide radical anion. For the purpose of this article on peroxygens and disinfection germane to animal health, we will focus on three peroxygens: hydrogen peroxide, peracetic acid and peroxymonosulfate. Solid percarbonate is also a peroxygen, but is limited to uses in foot pan powder (i.e. one of the two active ingredients in Sterilex<sup>®</sup> Ultra Step, see page 5).

### Hydrogen peroxide

Hydrogen peroxide (HP) [Fig. 1] has the chemical formula H<sub>2</sub>O<sub>2</sub>; it is the most widely used and available peroxygen. It has been commonly sold as technical grade and food grade solutions at both 35 and 50% concentrations, although

recent Department of Homeland Security regulations<sup>1</sup> have resulted in increased availability and sales of less concentrated solutions of between 30–34%. HP is sold in aqueous solutions and is colorless and essentially odorless, but is very aggressive chemically in these concentrated

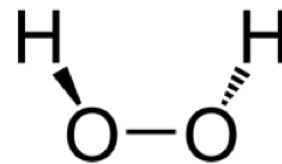


Fig. 1. Hydrogen peroxide

forms.

HP has been touted as nature’s own disinfectant and preservative, being found in milk and honey, in addition to saliva and other mucous membranes<sup>2</sup>. To protect from infection, HP is also generated biologically within diverse living systems by phagocytes via oxygen reduction and is used against primarily infectious anaerobic microbes. HP maintains GRAS (Generally Recognized As Safe) status by the FDA, and is used in various water, cosmetic and food treatments as both an oxidizer and antimicrobial<sup>3</sup>.

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Published: Poultry Outlook – Summer 2017

Its utility in animal health has been focused on formulations geared to water, air (mist) and water line treatments. The safe decomposition product (water) and speed of reaction after dilution and administration into contaminated water and water line environments have made it a favored chemical choice for poultry and swine formulators. Some silver-stabilized HP formulations (i.e., Siloxycide<sup>®</sup>, Neogen, Lexington, Ky.) have been approved for consumption by livestock and poultry, allowing water line cleaning and prophylactic protection while animals are present.

Technical grade HP has been used in very low concentrations at poultry hatcheries inside stainless steel and polymer humidity systems to prevent/control biological contaminants within the lines and to provide a very light biocidal aerosol and mist in hatcher and setter halls. This application should not be confused with vapor phase peroxide disinfection, which uses low-pressure vacuum systems and very concentrated HP solutions to achieve very targeted pathogen reductions. Again, the quick decomposition of HP into harmless water is a key safety factor for both hatchability and employee safety.

Because it is simply an oxidant, peroxide is active against a wide range of organisms: bacteria, yeasts, fungi, viruses and even many spores. Anaerobic pathogens are generally more susceptible to HP than aerobes, since anaerobes do not produce catalase (or peroxidase), an enzyme that breaks down peroxide. In general, HP has greater activity against gram-negative than gram-positive bacteria, is less affected by pH shifts than other disinfectants (i.e., quats, phenols), and is more quickly effective against vegetative microbes than spores—which also often require higher concentrations and increased temperature to achieve a sufficient kill<sup>2</sup>.

At use dilutions for disinfection, HP has not developed a following for surface disinfection in animal facilities, primarily due to its modest performance at reasonable and safe dilutions in the very high organic loads presented on the farm and in hatcheries. Generally a 3% solution of HP is the minimum level used to normally achieve microbial kills on surfaces—impractical for employee handling, insufficient for many surface microbial loads, and simply too expensive when considering volumes to be used in disinfecting barns. It seems that for animal production sanitation applications, simple HP has settled into its niche for cleaning

and disinfecting water lines, treating animal water, and controlling water biota (and air?).

## Peracetic acid

Peracetic acid (PAA) [Fig. 2] has the formula CH<sub>3</sub>CO<sub>3</sub>H; it is a more “advanced” form of hydrogen peroxide. It has all of the desirable properties of HP: wide germicidal range, no harmful decomposition products and infinite water solubility. However, PAA beats HP on two fronts—PAA has greater lipid solubility which increases its ability to interact with cell membranes, and PAA is not decomposed by peroxidase or catalase. It also has better biocidal properties in the presence of limited, minimum organic material when compared to HP<sup>2</sup>.

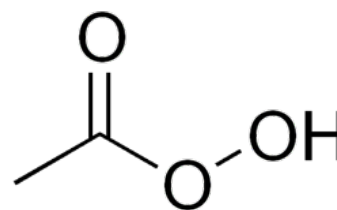


Fig. 2. Peracetic acid

PAA is more effective than HP due to its broad biocidal activity at lower concentrations, its sporicidal activity at lower temperature, and its increased effectiveness in organic matter challenges. As an acid, it is more biocidal at low pH, but maintains some germicidal activity at increased concentrations into the alkaline range as well. For a broad comparison to HP at 3%, PAA has been reported to be bactericidal at 0.001%, fungicidal at 0.003%, and sporicidal at 0.3%<sup>4</sup>.

Peracetic acid exists in every commercial formulation as an equilibrium of three key ingredients that all ultimately play a role in disinfectant efficacy: some of the acetic acid (vinegar) and hydrogen peroxide on the left side of the equation combine to form peracetic acid (and water) on the right side. All of the key ingredients exist simultaneously.



Because of the high reactivity (energy state) of peracetic acid, solutions of PAA are less stable than HP, with a ready-to-use dilution often losing up to half of its strength in six days. Commercial formulations also contain stabilizers to combat hydrolysis, and can include sequestering or chelating agents to remove metal cations or anionic surfactants.

The sporicidal, mycobacterial and oocyst killing properties of some PAA formulations can make it an excellent choice when combating non-vegetative bacterial species on cleaned surfaces. Certain manufacturers have also validated their formulas with EPA-approved testing and are registered as disinfectants (i.e., Peraside<sup>®</sup>, Neogen, Lexington, Ky.).

There are some considerations for poultry disinfection applications when using the combined oxidative and low pH properties of PAA. First, the product smells like vinegar—not bad, just like vinegar. Employees need to be told about the smell prior to its introduction into a cleaning and disinfection program, or a fogging program of hatcheries. Ventilation of work areas will be key to PAA adoption and correct usage.

Second, PAA is somewhat corrosive to carbon steel and other corrosion-sensitive metals/polymers—even at use dilutions—so for poultry hatcheries and other high frequency uses, it is best used as either a rotation disinfectant to be paired with acid soaps, and not to be used every hatch day, 208 days per year. It will also work well when paired with aluminum brightener soaps for trailer washout and disinfection.

Daily fogging is common for egg rooms in hatcheries, with limited, 15–30-minute maximum daily fogging times. As with any disinfectant, you should always read the label for disinfection certification of the commercial formula, any “final rinse required” on the label, and for PPE instructions.

### Potassium peroxymonosulfate

The third antimicrobial in the peroxygen family is the potassium salt of peroxymonosulfuric acid. This potassium salt is manufactured as a component of a triple salt with the formula  $2\text{KHSO}_5 \cdot \text{KHSO}_4 \cdot \text{K}_2\text{SO}_4$  and is a principal ingredient in Virkon S<sup>®</sup> Disinfectant (DuPont). The peroxymonosulfuric acid chemical is an unstable liquid at room temperature as Caro’s acid and, thus, has to be stabilized as a potassium salt. Virkon S<sup>®</sup> is a commercial powdered formulation in the

U.S. livestock health sector, and also contains organic acids (i.e., sulfamic and malic), surfactant (and sodium dodecyl benzene sulphonate), simple table salt (sodium chloride) and a buffer (sodium hexametaphosphate). The product stores very well in its powdered form, but has a very limited shelf life once diluted for use.

Potassium peroxymonosulfate (PPMS) [Fig. 3] is a somewhat newer player in the peroxygen disinfectants arena and, due to U.S. and international patents and private sector development, information on much of the basic research, mode of action and formulation stability of solid or neat PPMS is not easily accessible. There have been many field and laboratory efficacy studies performed using commercial Virkon S<sup>®</sup> (Lanxess, Cologne, Germany) disinfectant and it has generally performed well in most conventional cleaning and disinfection protocols against diverse pathogens. The diluted formulation foams well, but its practical use is challenged by the inability to use common liquid-dilution foaming devices to apply onto surfaces as a foam. The formula must be used at a full 1% or 2% concentration. For the layperson, one might think of Virkon as a “powdered PAA” without the vinegar smell, although the technical similarities are probably outnumbered by the differences between the two formulations. At least we can recognize that both Virkon S<sup>®</sup> and PAA are both acidic (low pH) and are both peroxygens.

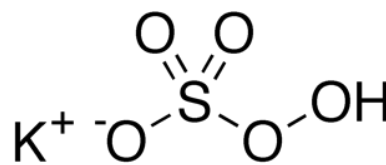


Fig. 3. Potassium peroxymonosulfate

A very new, somewhat similar liquid formulation of a low pH, foaming peroxygen is Intervention<sup>®</sup> (Virox, Toronto, Canada). Intervention may be thought of as an acidic peroxide with surfactants to aid in disinfection and foaming. Like Virkon, this chemistry combination has proven to be very successful for disinfecting surfaces and controlling diverse pathogens. However, the low concentration of the commercial concentrate and common dilution rates of 1:16 to 1:64 (expensive to use) have made commercial success challenging compared to most U.S. disinfectants used at a dilution rate of 1:256 (lower cost to use).

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## Peroxygens and poultry production

There are some key things to remember and questions to ask when considering the use of peroxygens as antimicrobials in your facility:

- **What is the target?** “Have I selected the best disinfectant for the disease-causing pathogen of concern, and why isn’t my current program working?”
- **What is the environment?** “Am I going to ask my peroxygen compound, which is likely low to moderately effective in high organic environments, to solve my disease problem without first addressing the cleaning stage?”
- **Who is doing the cleaning, fogging?** “Have I sufficiently trained and set expectations accurately and clearly to the person doing the work, and does he/she understand the safety/PPE requirements needed to be successful with a peroxygen product?”
- **Do I understand the label?** “Is the disinfectant EPA-registered (to include water line disinfectants), or is the commercial product not complete enough to achieve disinfection and only being marketed as a cleaner based on an MSDS and list of similar active ingredients? Does the product have a consumption label if there is either a risk or intent to have animals drink the peroxygen formula?”
- **How will I be using the peroxygen?** “Do I want the product to clean and disinfect my water lines and inactivate or kill pathogens, or do I want the product to disinfect surfaces within my facility? If I choose to use an acidic peroxygen, will I need to rinse the disinfectant based on the label?”
- **How is the product packaged?** “If the HP is in a translucent package instead of a dark packaging material, how is the HP protected from easy catalytic breakdown by light? What is the shelf life of the product and how much will I use in a given month/quarter?”

There are certainly many circumstances where a peroxygen-based product can really make a difference to an operation’s drinking water quality, water line maintenance, egg room fogging program, and surface sanitation program. Making the right product choices for the application is only the first step—execution of a program, measurement of your criteria of success, proper training and understanding the equipment needed to deliver the product(s) will ultimately determine the peroxygen product’s success.

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### References

<sup>1</sup>[http://www.dhs.gov/xlibrary/assets/chemsec\\_appendixafinalrule.pdf](http://www.dhs.gov/xlibrary/assets/chemsec_appendixafinalrule.pdf)

<sup>2</sup>Block, S., “Peroxygen Compounds” in *Disinfection, Sterilization, and Preservation*, S. Block, Ed., 5th Ed. (2001), pp 185-204.

<sup>3</sup>“Sec. 184.1366 Hydrogen peroxide”. U.S. Government Printing Office via GPO Access.

<sup>4</sup>Greenspan, F.P., and MacKellar, D.G., “The application of peracetic acid germicidal washes to mold control of tomatoes,” *Food Technology*, 1951, 5:95-97.